COETSEE, JOHANNES PETRUS

PHYTOSOCIOLOGY OF THE Ba AND Ib LAND TYPES IN THE PRETORIA-WITBANK-HEIDELBERG AREA

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PHYTOSOCIOLOGY OF THE Ba AND Ib LAND TYPES IN THE PRETORIA-WITBANK-HEIDELBERG AREA

by

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MAGISTER SCIENTIAE

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Supervisor: Prof. Dr. G.J. Bredenkamp

Co-supervisor: Dr. N. van Rooyen

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Ek wil ook nou, soos nog altyd, met alle vrymoedigheid deur my hele wese Christus verheerlik in lewe en in sterwe, want om te lewe, is vir my Christus, en om te sterwe, is vir my wins.

Fillippense 1 : 20 - 21.

Dedicated to my parents and Elriza

ABSTRACT

PHYTOSOCIOLOGY OF THE Ba AND Ib LAND TYPES
IN THE PRETORIA-WITBANK-HEIDELBERG AREA

by

JOHANNES PETRUS COETZEE

Supervisor: Prof. Dr. G.J. Bredenkamp
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The vegetation of the Ba and Ib land types of the Pretoria-Witbank-Heidelberg area was classified by means of Braun - Blanquet and TWINSPAN procedures. Relevés were compiled in 265 stratified random sample plots. Stratification was firstly done by means of land types and secondly by terrain units. In each sample plot the floristic composition was recorded and a cover-abundance value, according to the Braun - Blanquet scale, was allocated to each species. Information on various environmental variables was also collected. Two-way indicator species analysis (TWINSPAN) was applied to the floristic data set and the obtained phytosociological table was refined by the application of Braun - Blanquet procedures. The classification of the floristic data resulted in the recognition of eight vegetation units and several plant communities within these vegetation units. All identified plant communities were described and could be ecologically explained in terms of the physical environment.

UITTREKSEL

FITOSOSIOLOGIE VAN DIE Ba EN Ib LANDTIPES BINNE DIE PRETORIA-WITBANK-HEIDELBERG GEBIED

deur

JOHANNES PETRUS COETZEE

Studieleier: Prof. dr. G.J. Bredenkamp
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DEPARTEMENT PLANTKUNDE

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Die plantegroei van die Ba en Ib landtipes binne die Pretoria-Witbank-Heidelberg gebied is geklassifiseer deur die toepassing van Braun - Blanquet en TWINSPAN klassifikasie prosedures. Relevés is saamgestel in 265 gestratifïeerde ewekansig gekose monsterpersele. Stratifiëring is in die eerste plek op grond van landtipes en in die tweede plek op grond van terrein-eenhede gedoen. In elke monsterperseel is die spesiesamestelling, asook die bedekingswaarde vir elke spesie volgens die Braun - Blanquet skaal, aangeteken. Inligting omtrent verskeie omgewings veranderlikes is ook aangeteken. TWINSPAN was op die floristiese datamatriks uitgevoer en die voorlopige fitososiologiese tabel wat sodoende verkry is, verder deur middel van Braun - Blanquet prosedures verfyn. Die klassifisering van die floristiese data het gelei tot die onderskeiding van agt plantegroei-eenhede met die verdere onderskeiding van verskeie plantgemeenskappe binne elke plantegroei-eenheid. Al die geïdentifiseerde

plantgemeenskappe is beskryf en ekologies verklaar aan die hand van die fisiese omgewing.

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CHAPTER 1

INTRODUCTION

The grasslands of South Africa cover approximately 29% of the total land surface area of the country, predominantly on the highveld and escarpment. The Grassland Biome supports a major portion of the country's maize, dairy, beef and timber industry and is agriculturally the most productive biome in South Africa (Mentis & Huntley 1982). Tragically, because of technological progress resulting in large scale industrial development and mining activities and the increasing human population, the Grassland Biome is subjected to veld degradation. The lack of knowledge about the natural resources and management principles of these resources, accelerates this process of deterioration of the grassland ecosystem. Mentis & Huntley (1982) predicted that at the present rate of population growth, being higher in South Africa than for the world as a whole (2,6% vs 1,9% per year respectively), South Africans will have less cultivated land per person at the turn of the century than is now available to the average person on earth. This situation will lead to less natural pastures for cattle, sheep and game and the demands for the natural resources will still increase. Scientific knowledge about the natural resources and their subsequent management is therefore of cardinal importance for the conservation and maintenance of these resources. The necessity to describe the structures and functions of ecosystems to provide a theoretical basis for the management of natural resources, is further well stated by Edwards (1972), Mentis & Huntley (1982) and Scheepers (1986).

Regardless of the importance to describe plant communities for agricultural planning and

management purposes (Mentis & Huntley 1982; Scheepers 1986), the description of plant communities is essential to provide a scientific inventory for conservation and, in general, the preservation of biotic diversity (Westhoff 1971). Plant communities are conceived as vegetation units that are characterized by their relatively consistent floristic composition, uniform physiognomy and a distribution that is characteristic of a particular habitat (Whittaker 1978; Barbour *et al.* 1987). Each plant community may be regarded as an unique entity with its own species composition associated with a specific set of environmental factors and its own inherent forage production potential. The phenomenon that different stands of the same plant community occur throughout a landscape associated with a certain set of environment conditions, underlines that plant communities are individual recognisable entities. Trying to conserve biotic diversity is senseless and not possible if the entities that contribute to the diversity, be it at the species or community level, are not known.

The aim of this study was to provide a scientific basis for agricultural and conservational management of the grassland within the Pretoria-Witbank-Heidelberg area. It forms part of the Grassland Biome Project (Mentis & Huntley 1982; Scheepers 1986) with the aim to identify, classify, describe and interpret ecologically the vegetation units and associated plant communities. The vegetation units will be used to construct a vegetation map, and the different plant communities will be employed as management units and for the identification of conservation priority areas.

This thesis reports on the vegetation types of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area within the Grassland Biome, which also includes the

transitional zone between the Grassland and Savanna Biomes. Contributions are in the form of manuscripts, which have been submitted for publications in various scientific journals. Details of the study area, methods, results, discussion and references are presented as individual chapters. An overview of the principal findings as well as recommended conservational areas is presented in Chapter 9.

The manuscripts presented show some stylistic inconsistence and repetitions. These are primarily due to differences in layout and style required by various scientific journals and that each manuscript is an entity in itself.

CHAPTER 2

STUDY AREA

Location

The study area is situated in the central Transvaal Highveld around and between Pretoria, Witbank and Heidelberg, predominantly within the Grassland Biome of South Africa (Figure 1). A small portion of the northern parts of the study area is situated in the Savanna Biome (Rutherford & Westfall 1986). The study area is situated between 28°00' and 29°30' E longitude and 25°10' and 26°35' S latitude (Figure 1) and cover an area of approximately 11 250 km^2. The vegetation of the Ba and Ib land types (Land Type Survey Staff 1985, 1987) in this area was surveyed.

Acocks (1953, 1988) recognized five veld types in this region: Mixed Bushveld (Veld Type 18) in the extreme northern parts of the study area; Sourish Mixed Bushveld (Veld Type 19) bordering the Mixed Bushveld to the south; Sour Bushveld (Veld Type 20) north west of Pretoria and Bankenveld (Veld Type 61) in the central parts and *Cymbopogon - Themeda* Veld (Veld Type 48) to the south west (Figure 2). Werger (1978) classified these communities into four vegetation units with various variations namely the Upland (Temperate) Sub-humid Mountain Bushveld, the Moist Cool Temperate Grassland, the Moist Cold Temperate Grassland and Azonal vegetation.

Climate

The average annual rainfall for the study area varies from 630 to 750 mm (Weather

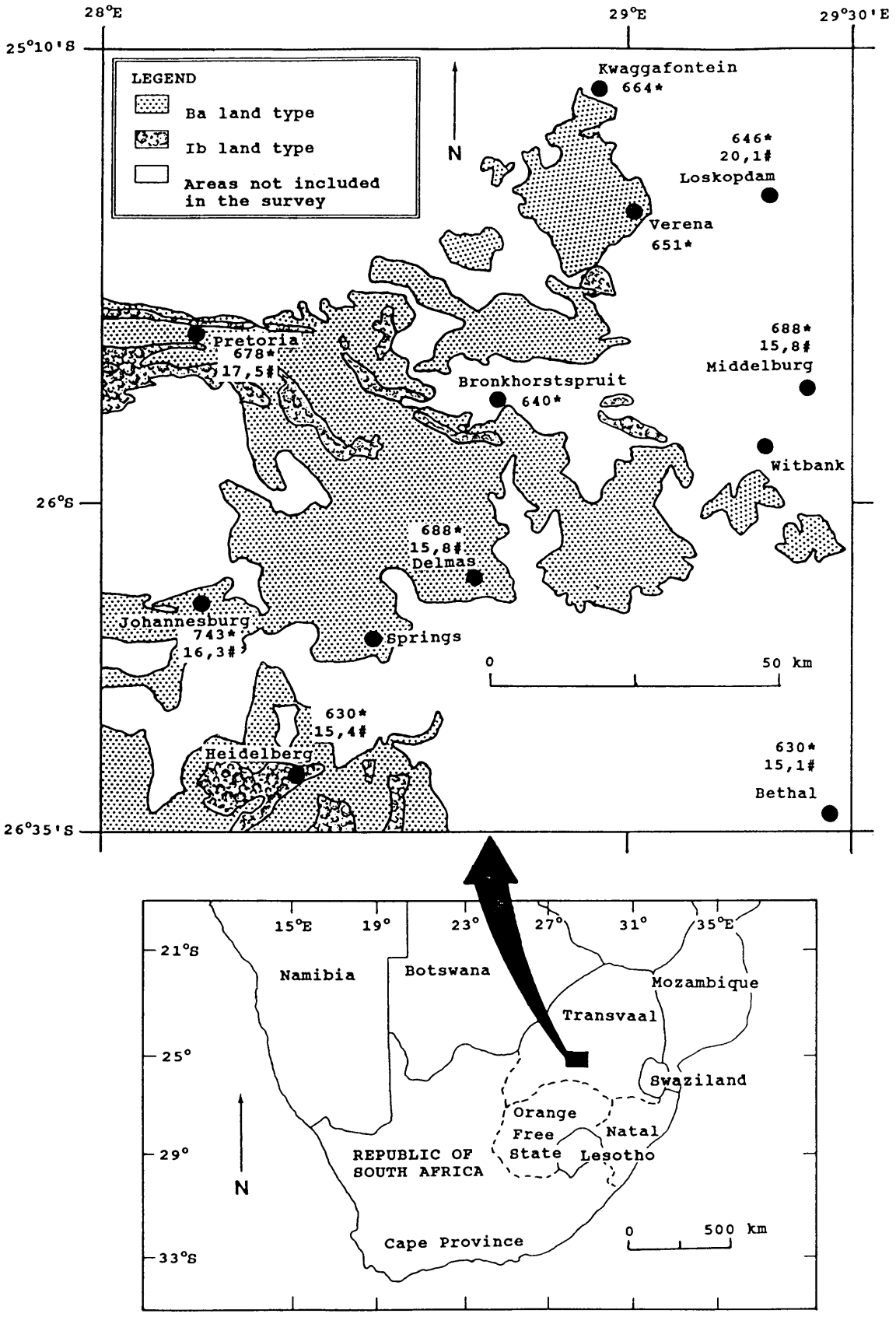

Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

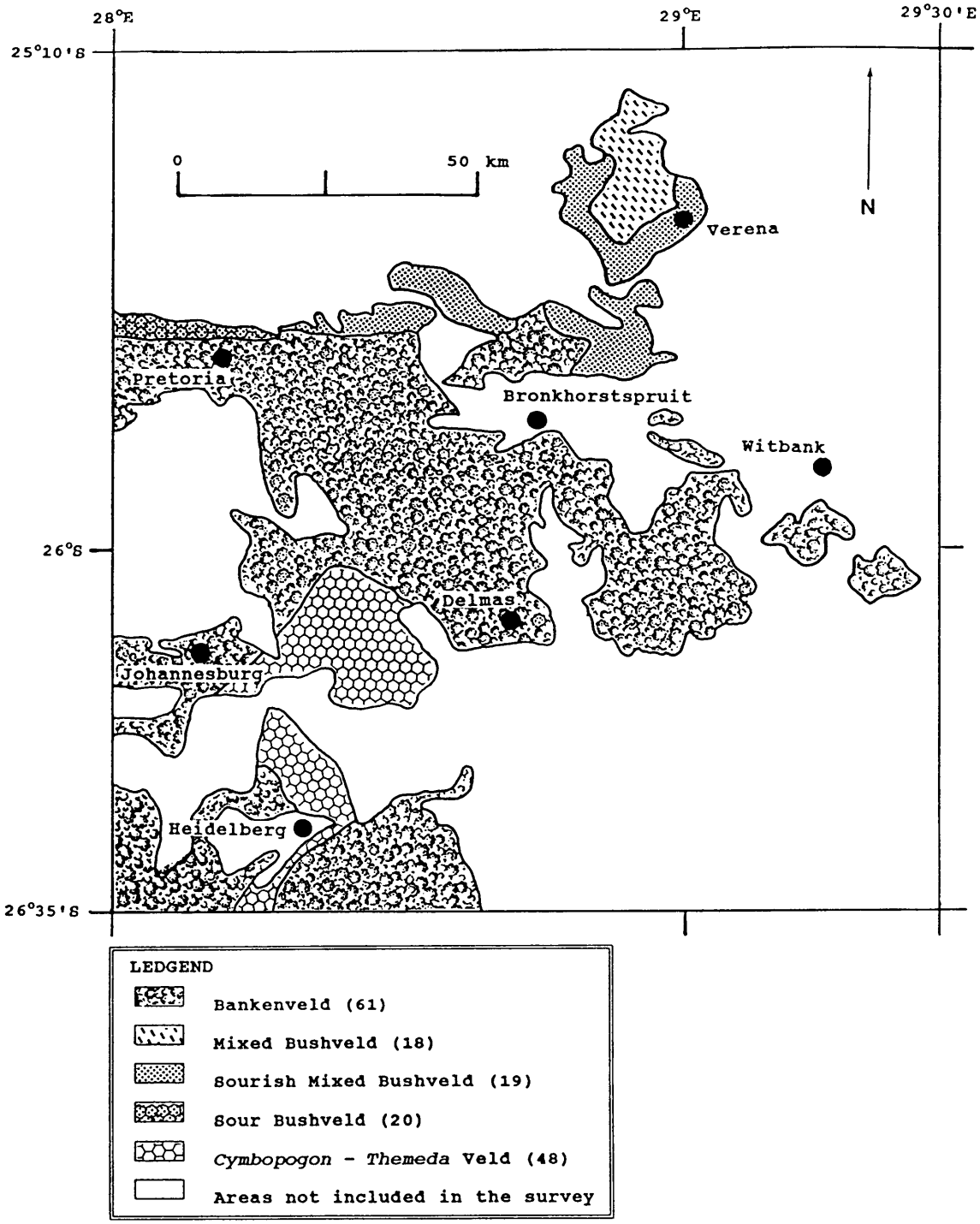

Figure 2. Veld types of Acocks within the Pretoria-Witbank-Heidelberg area (adapted from Acocks 1953, 1988).

Bureau 1986). The rainfall is generally erratic, but somewhat less variable in the south-eastern parts of the study area. The precipitation mainly consists of thundershowers of short duration which are restricted to the warm summer months of October to April. The lowest rainfall in the study area occurs in the south at Heidelberg (Figure 1) (Weather Bureau 1986), with a mean annual rainfall of 630 mm. The western and central parts of the study area, including Johannesburg, Delmas and Pretoria, have the highest mean annual rainfall of between 678 - 743 mm (Figure 1). Rainfall decreases again northwards to 651 mm per annum at Verena.

The mean daily temperature varies from 20,1°C at Loskopdam in the north and decreases to 15,4°C at Heidelberg in the south (Figure 1) (Weather Bureau 1986).

Drainage

The entire study area is well drained by a network of small streams which flow into a few major rivers. The main drainage lines (Figure 3) in the study area are: The Klip River, Blesbok Stream, Waterval River and the Suikerbosrand River in the southern and south-western part of the study area. The central areas around Delmas, are drained to the east by the Olifants and Wilge Rivers and their tributaries. The Pretoria area is drained to the north-west by the Hennops River and Edendal Stream. The Moses and Elands River drain the northern parts of the study area. Slow draining streams are common including a few permanent waterlogged soils, pans and vleis. A few seasonally waterlogged areas are found. The generally slow horizontal drainage prevents large-scale gully erosion in the area.

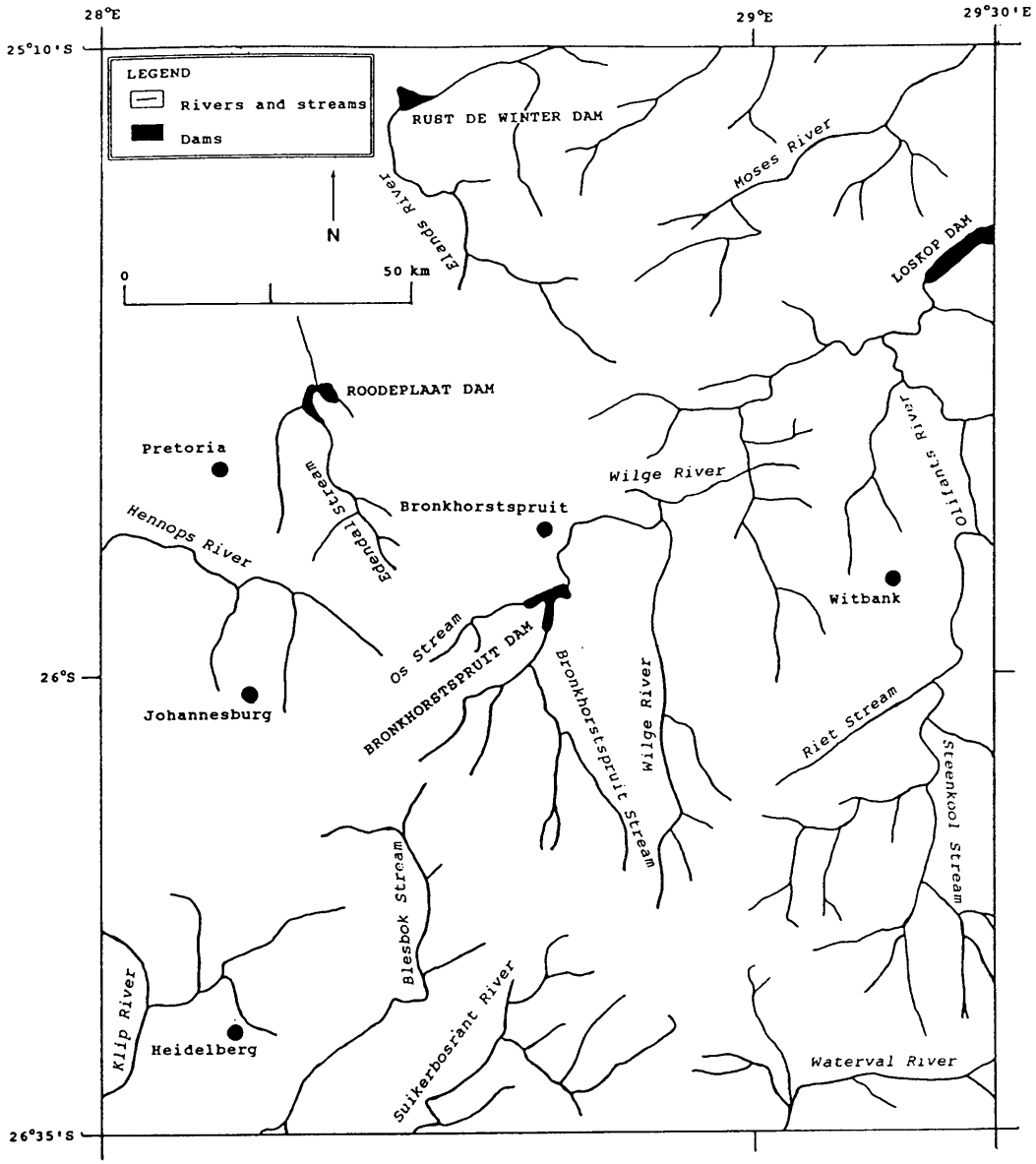

Figure 3. The main rivers and streams of the Pretoria-Witbank-Heidelberg area (adapted of Department of Mineral and Energy Affairs 1984).

Geology

The following main geological areas are found within the study area (Figure 4) (Department of Mineral and Energy Affairs 1984).

The Karoo Sequence in the south-western areas, the Waterberg Group between Witbank and Verena, the Bushveld Complex north of the Waterberg Group around Verena, the Transvaal Sequence between Pretoria and Delmas and the Ventersdorp and Witwatersrand Supergroups in the south-western parts of the study area between Johannesburg and Heidelberg.

Land types and soil

A land type denotes an area of specific uniformity of pattern with respect to terrain form, soil pattern and climate. Consequently one land type is distinguished from another in terms of one or a combination of the following parameters: terrain form, soil pattern or climate (Land Type Survey Staff 1985, 1987). Two different land types are distinguished in the study area, namely the Ba and Ib land types (Figure 1) (Land Type Survey Staff 1985, 1987). Soils are classified according to the Department of Agricultural Development (1991).

Soils and terrain of land type Ba

The Ba land type has a variety of terrain forms. The terrain and soil forms in this land

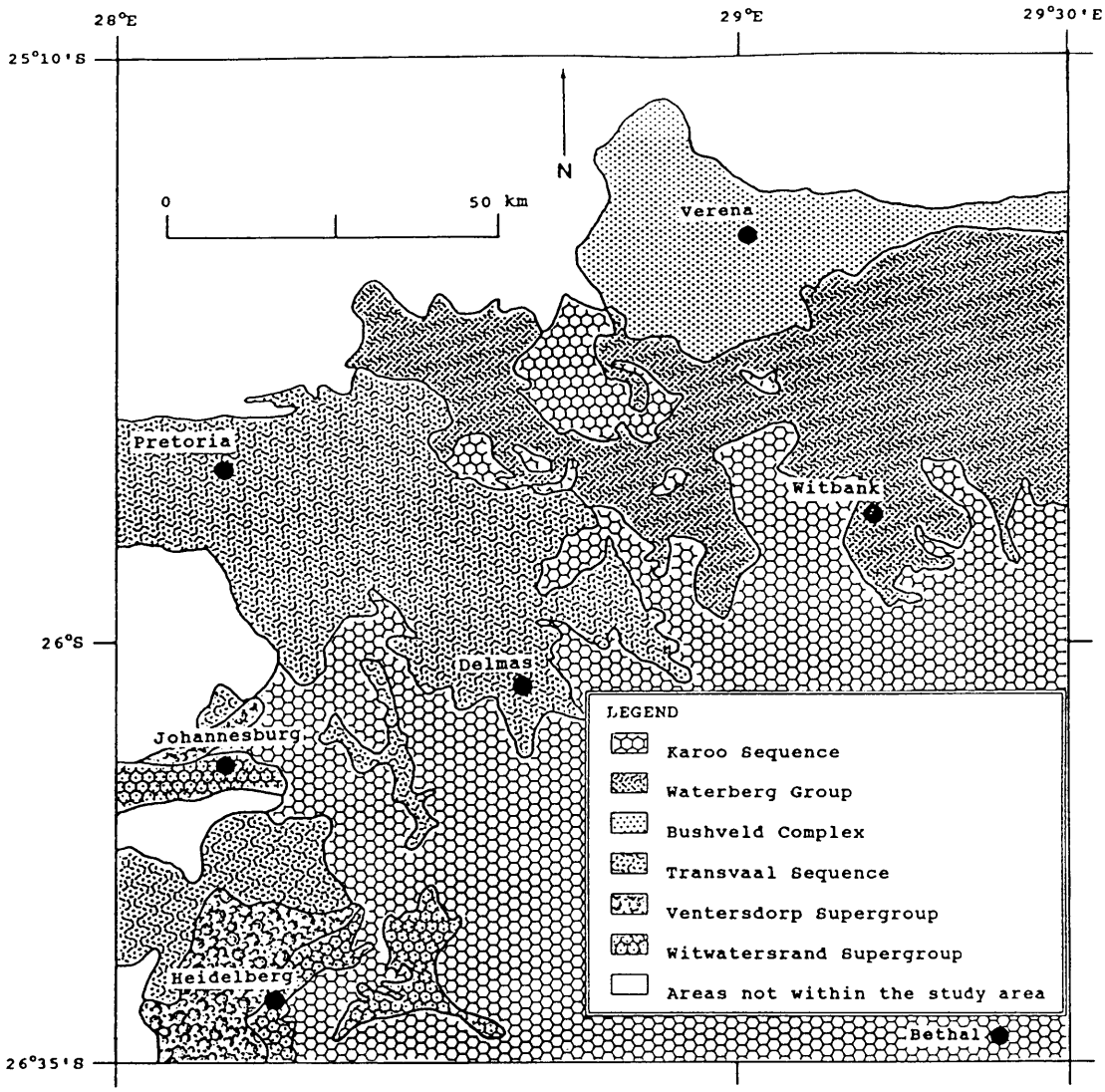

Figure 4. Geology of the Pretoria-Witbank-Heidelberg area (adapted from Department of Mineral and Energy Affairs 1984).

type are presented in Figures 5 and 6. The terrain form of the Ba land type is characterized by undulating landscapes with gentle slopes throughout (terrain units 1, 3, 4 and 5). Quartzite ridges occur occasionally resulting in steeper slopes which are not typical of the Ba land type. In the Ba land type distrophic and mesotrophic red soils are widespread while duplex and margalithic soils are rare. Approximately 71% of the land surface is suitable for tillage with no or few physical limitations (Land Type Survey Staff 1985, 1987). The soils are predominantly of the Glenrosa and Hutton soil forms.

Soils and terrain of land type Ib

A terrain form sketch of land type Ib together with associated soil forms is presented in Figure 7 (Land Type Survey Staff 1985, 1987). This land type is restricted to rocky outcrops within terrain units 1, 2 and 3 although terrain unit 2 may be absent in some areas. The predominant soil form is Mispah with rock sheets which occur abundantly, consisting mainly of quartzite. Only 7% of the Ib land type is suitable for tillage, with no or few physical limitations.

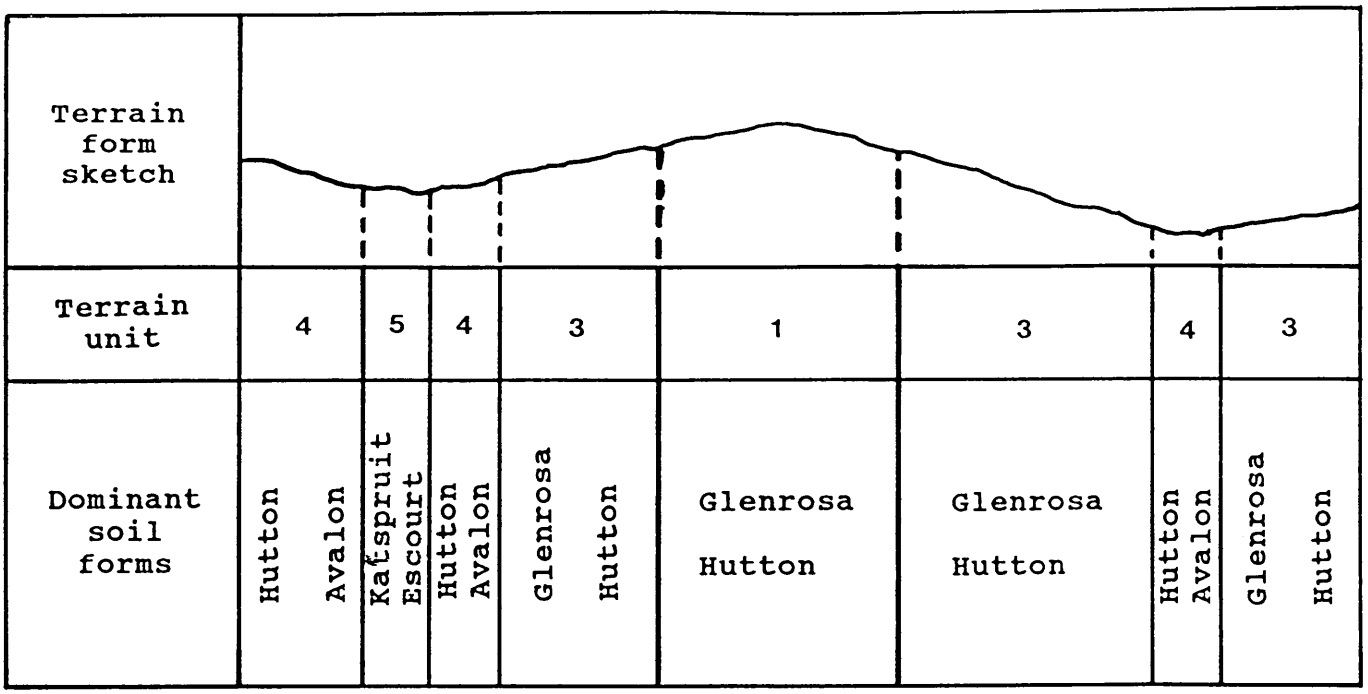

Figure 5. Terrain form sketch and associated dominant soil forms of the northern and southern parts of the Ba land type (adapted from Land Type Survey Staff 1985, 1987).

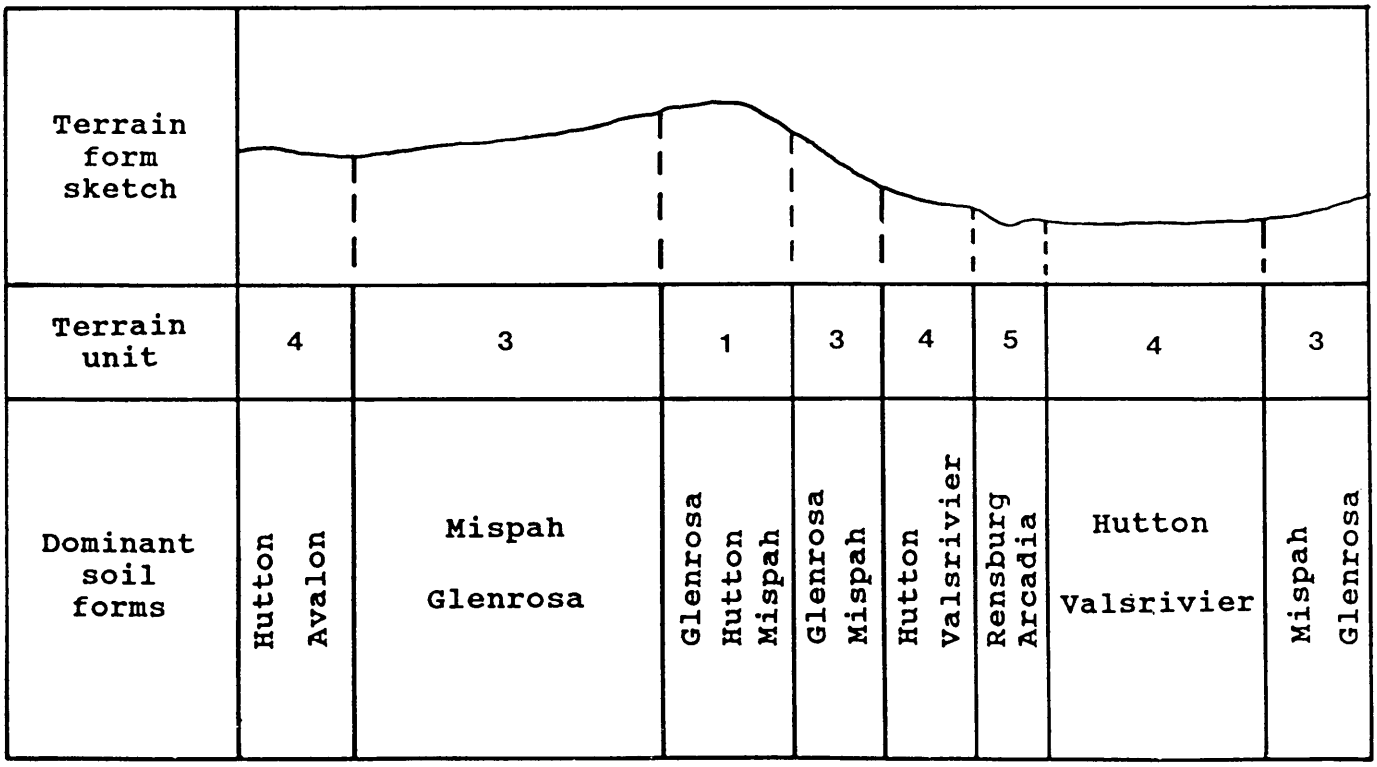

Figure 6. Terrain form sketch and associated dominant soil forms of the central rocky parts of the Ba land type (adapted from Land Type Survey Staff 1985, 1987).

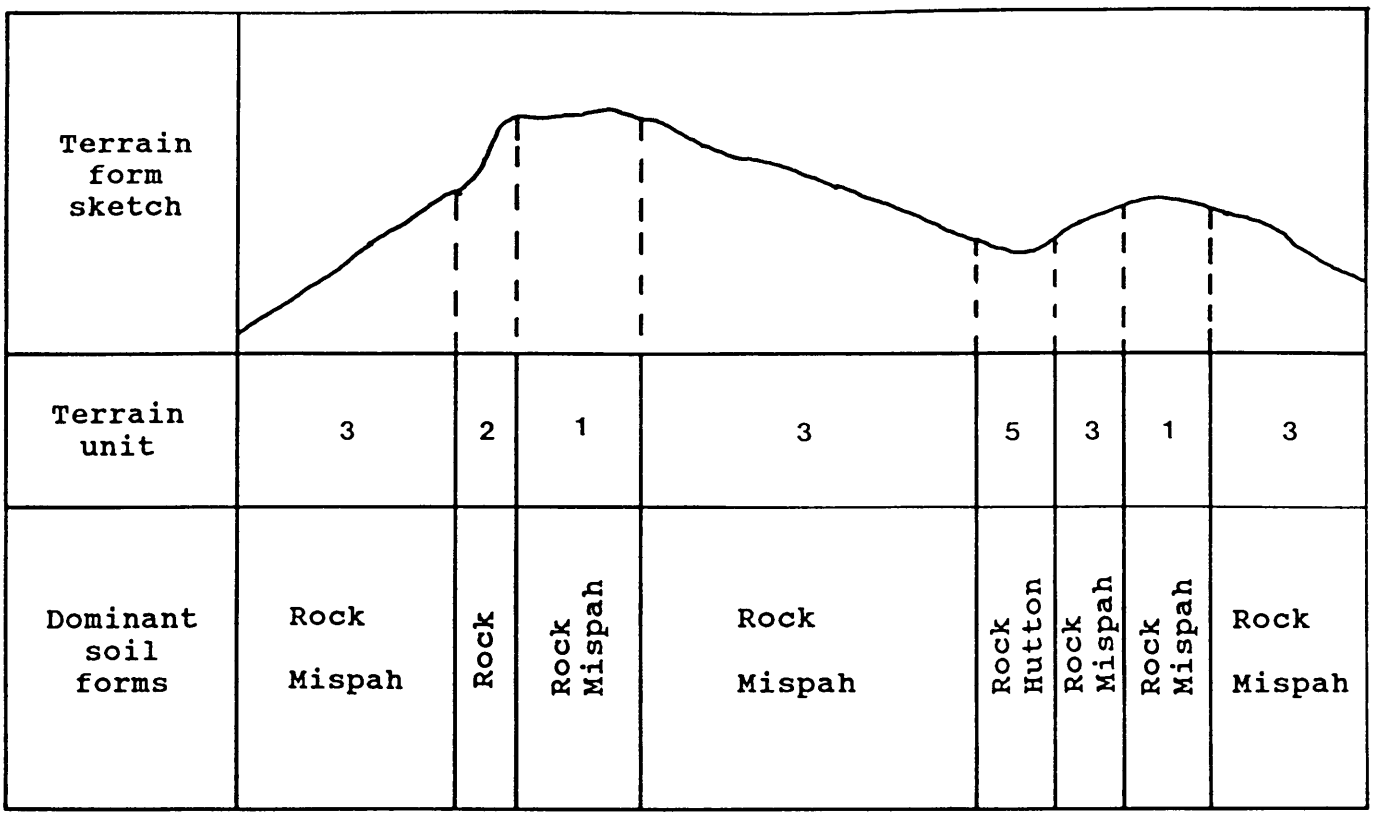

Figure 7. Terrain form sketch and associated dominant soil forms of the Ib land type (adapted from Land Type Survey Staff 1985, 1987).

CHAPTER 3

METHODS

Introduction

In this study the classification of the vegetation is done on the basis of the floristic-sociological approach with the essential viewpoint that plant communities are units of classification based primarily on species composition. This approach was developed by students in southern, northern and central Europe in the middle of the nineteenth century (Whittaker 1978). Further development of this approach, especially in Zürich and Montpellier (Whittaker 1978), lead to the Braun - Blanquet method with the following key ideas:

> The study of plant communities should be based on a fundamental vegetation unit. This unit should be the association, and associations should be defined by the presence of character species. The following definition of an association was presented to the Third International Botanical Congress in Brussels: "An association is a plant community of a definite floristic composition, presenting a uniform physiognomy, and growing in uniform habitat conditions. The association is the fundamental unit of synecology" (Whittaker 1978). Each association consists of stands, and the association can be described from samples of these stands. Each sample (relevé) should be chosen in order that it is representative of such stand, and it should include an analysis of the total species composition. Associations should be grouped into higher units based on floristic composition (Westhoff & Van der Maarel 1978).

Due to the present scanty synecological and syntaxonomical knowledge within the central-southern Transvaal grasslands, no attempt was made to formally fix names or ranks to syntaxa. Although formal syntaxonomical classifications were compiled for the grasslands of the south-eastern Orange Free State and western Transvaal, these plant communities often differ substantially from those of the grasslands of the Pretoria-Witbank-Heidelberg area. A formal syntaxonomical synthesis of the central, eastern and southern parts of the Transvaal should however be compiled when sufficient data are available.

The hierarchical classification used in this thesis were derived from the information in the phytosociological tables and is as follows:

Major vegetation unit

Vegetation unit

Major plant community

Plant community

Variation

The floristic-sociological or Braun - Blanquet method (Whittaker 1978) was used in this study because it is already well tested in South Africa (for example Werger 1973; Coetzee 1974, 1983; Bredenkamp 1975, 1982; Westfall 1981; Deall 1985 and Gertenbach 1987). It is considered as the most acceptable approach for vegetation classification in South Africa (Bredenkamp & Theron 1978, Van Rooyen 1978), as it provides an open ended syntaxonomical system.

The execution of the Braun - Blanquet method was divided into two phases namely the analytical research phase in which the data on species composition and the environmental variables were collected, and the synthetical research phase in which relevés were synthesized in table form to represent vegetation units, resulting in a phytosociological table.

Analytical research phase

Number and distribution of sample plots.

The sample plots were as far as possible, randomly distributed in stratification units. The stratification was based firstly on land types (Ba and Ib land types) and secondly on terrain units, namely 1 = crests, 2 = escarps, 3 = midslopes, 4 = footslopes and 5 = flood plains and water courses within each land type. The exact position of each sample plot within the relevant stratification unit was chosen subjectively in order to avoid obvious heterogeneity in the physical environment and floristic composition. According to the methodology of the Braun - Blanquet method, the homogeneity of the sample plot is essential (Whittaker 1978). This survey technique is strongly recommended by Werger (1973) and Bredenkamp (1982), due to the fact that it enables efficient sampling in heterogeneous vegetation (Braun - Blanquet 1964). This method of sampling has been successfully applied in many other phytosociological studies in the Grassland Biome in South Africa (eg. Bezuidenhout *et al.* 1988; Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989; Bezuidenhout & Bredenkamp 1990; Bredenkamp & Bezuidenhout 1990; Kooij *et al.* 1991).

The plot sizes varied from 200 m^2 in areas with woody vegetation to 16 m^2 in grassland vegetation in accordance with Bredenkamp & Theron (1978). As far as possible the shape of the plot was square, but in some cases it was necessary to adapt the shape to ensure that the vegetation sample was homogeneous, for example in narrow seepage lines, riparian vegetation and rocky outcrops. Sampling was carried out from January to April 1992. A total of 265 sample plots, distributed throughout the study area, were surveyed.

Floristic analysis

The floristic survey included a list of all the plant species present in a sample plot as well as the allocation of a cover-abundance value to each of these species, according to the Braun - Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974):

r - one or a few individuals (rare) with less than 1% cover of total sample plot area.

\+ - infrequent with less than 1% cover of total sample plot area.

1 - frequent with low cover, or infrequent but with higher cover; 1 - 5% of total plot area.

2 - abundant with between > 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.

Taxa names conform to those of Gibbs Russell *et al.* (1985, 1987).

Habitat analysis

According to Daubenmire (1968), there is a strong relationship between the species composition of a site and the physical environmental variables of that locality. Therefore, in order to detect environmental factors that is associated with specific plant communities, the following environmental factors were also recorded during the analytical research phase:

Geology

The 1 : 250 000 geological survey maps (Department of Mineral and Energy Affairs 1984) of the study area, were used as a guideline for the identification of the geological types.

Land type

The different land types were distinguished according to the 1 : 250 000 Land Type Maps

(Land Type Survey Staff 1985, 1987).

Rock cover

The percentage of the sample plot area covered by surface rock was estimated, as well as the size of surface rocks. The size in diameter was estimated as follows :

Small rocks = 0 - 100 mm

Medium rocks = > 100 - 500 mm

Large rocks = > 500 - 1 000 mm

Boulders = > 1 000 mm

Soil type and soil depth

The soil type and soil depth were determined by drilling a hole in the ground with a soil auger and matching the different soil horizons with the taxonomic system of soil classification for South Africa (Department of Agricultural Development 1991).

Percentage clay

The percentage clay in the soil was estimated within the following classes:

< 15 % clay

15 - 25 % clay

> 25 - 30 % clay

> 30 - 35 % clay

> 35 % clay

Topography

The following criteria were used to describe the topographical position of each sample plot:

1. The altitude of the plot was read from 1 : 50 000 topographical maps.
2. Topographical position based on terrain units, according to Land Type Survey Staff (1985. 1987) namely:
    1 - crests
    2 - escarps
    3 - midslopes
    4 - footslopes
    5 - flood plains and water courses
3. The slope degree by an inclination meter.
4. The slope aspect by means of a compass bearing.

Moistness

The degree of moistness was estimated on the following scale:

1 - dry

2 - intermediate dry

3 - wet

4 - intermediate wet

5 - water saturated and surface water

Utilization

The degree of utilization of the herbaceous (layer) vegetation by herbivores was estimated on the following scale:

0 - none

1 - slightly utilized

2 - moderately utilized

3 - moderately overutilized

4 - overutilized

5 - severely overutilized

Synthetical research phase

In order to derive a first approximation of the possible plant communities, a two-way indicator species analysis (TWINSPAN, Hill 1979b) was applied to the basic floristic data set. TWINSPAN is a computer program with a divisive-polythetic algorithm. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). This was attained by using the mainframe computer programme BBNEW, available at the Botany Department

of the University of Pretoria.

The results of the entire data analysis are presented in a synoptic table, compiled for all the recognised plant communities. In the synoptic table the entries represent the constancy of the species (to the nearest one percent) as follows: 1 = 1 - 20%, 2 = 21 - 40%, 3 = 41 - 60%, 4 = 61 - 80%, 5 = 81 - 100%. After an inspection of the table and floristic and ecological interpretation of the major vegetation types, the data matrix was divided into five smaller data sets, each representative of a specific vegetation type and associated environmental conditions. These five data sets were then separately refined by TWINSPAN and Braun - Blanquet procedures. The plant communities distinguished were described and ecologically interpreted. An ordination algorithm, Detrended Correspondence Analysis (DECORANA, Hill 1979a) was applied to certain data sets in order to determine possible vegetation and associated habitat gradients, as well as the floristic relationships among the plant communities.

As the resulting vegetation classification and descriptions are new contributions to phytosociological knowledge in South Africa, the results are presented in publication form.

CHAPTER 4

RESULTS

An overview of the physical environment and vegetation units of the Ba and Ib land types of the Pretoria-Witbank-Heidelberg area

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Submitted to South African Journal of Botany.

Abstract

Sustained optimal plant production combined with long-term conservation will only be attained if the natural resources of an area are known and if ecological boundaries are incorporated first and foremost into land-use planning and management. An analysis of the physical environment associated with the vegetation units in the study area is presented. Relevés were compiled in 265 stratified random plots. Care was taken to avoid severely disturbed areas and ecotones. A TWINSPAN classification, refined by Braun - Blanquet procedures, revealed eight vegetation units which can be regarded as distinct ecological units. A hierarchical classification, description and ecological interpretation of the eight vegetation units are presented. These ecological units should be taken into account in compilation of the management programmes for natural resources of the study area.

Uittreksel

Volgehoue optimale plantproduksie, tesame met langtermyn bewaring, kan slegs bereik word indien kennis oor die natuurlike hulpbronne van die gebied bestaan en homogene ekologiese gebiede in ag geneem word tydens die bestuur van natuurlike hulpbronne. 'n Analise van die fisiese omgewing, geassosieer met die plantgemeenskappe in die studiegebied, word aangebied. Relevés is in 265 gestratifiseerde ewekansig gekose monsterpersele saamgestel. Sorg is gedra dat oormatig versteurde gebiede en ekotone nie gemonster is nie. Deur middel van 'n TWINSPAN klassifikasie, wat verfyn is deur Braun - Blanquet prosedures, is agt plantegroei-eenhede onderskei wat as aparte ekologiese eenhede beskou kan word. 'n Hiërargiese klassifikasie, beskrywing en ekologiese interpretasie van die agt plantegroei-eenhede word verskaf. Hierdie ekologiese eenhede behoort in ag geneem te word tydens die opstel van bestuursprogramme van natuurlike hulpbronne binne die studiegebied.

Keywords: Braun - Blanquet, classification, synecology, syntaxonomy, TWINSPAN.

Introduction

The Pretoria-Witbank-Heidelberg area is one of the most important agricultural regions of southern Africa, both in terms of intensive crop production and extensive stock farming (Mentis & Huntley 1982; Scheepers 1986). Intensive agricultural practices and the effect of urbanization, industrialization, coal mining and the encroachment of exotic plant species, have had a profound negative influence on the condition and stability of the ecosystems in this area (Mentis & Huntley 1982). Little of the natural vegetation is left, and these vegetation remnants are poorly conserved. The necessity to identify and describe the vegetation units within the Grassland Biome (Rutherford & Westfall 1986) was stated by Mentis & Huntley (1982) and Scheepers (1986). Apart from the Suikerbosrand Nature Reserve (Bredenkamp & Theron 1978, 1980), very little is known about the vegetation and associated environments of the Pretoria-Witbank-Heidelberg area. This study is part of the Grassland Biome project (Scheepers 1986), with the aim to establish a classification of the vegetation which should form the basis for managing natural resources and the conservation of biotic diversity (Mentis & Huntley 1982; Scheepers 1986).

Study area

The largest part of the study area lies within the Grassland Biome of South Africa and is situated between 28°00' and 29°15' E longitude and 25°15' and 26°30' S latitude (Figure 1) and covers an area of approximately 11 250 km^2. Only a small portion of the northern parts of the study area is situated in the Savanna Biome (Rutherford &

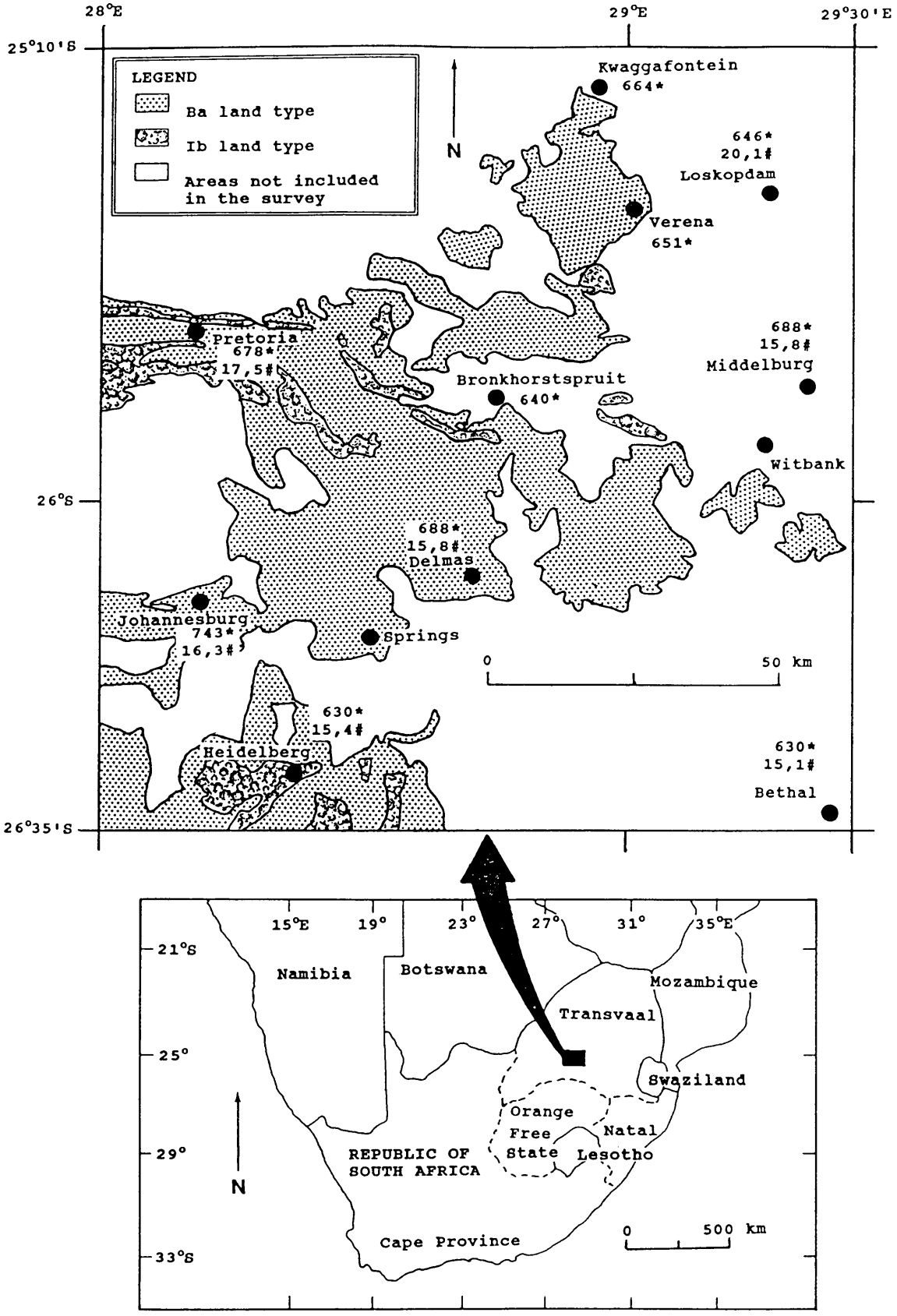

Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

Westfall 1986), because this area could be regarded as ecotonal between the two Biomes, some areas mapped by Acocks (1953, 1988) as Bankenveld rather seems to represent Mixed and Sourish Mixed Bushveld or *Cymbopogon - Themeda* Veld. The vegetation of the Ba and Ib land types (Land Type Survey Staff 1985, 1987) in this area was surveyed. Acocks (1953, 1988) recognized five veld types in this region: Mixed Bushveld (Veld Type 18) in the extreme northern parts of the study area; Sourish Mixed Bushveld (Veld Type 19) bordering the Mixed Bushveld to the south; the Sour Bushveld (Veld Type 20) north west of Pretoria; Bankenveld (Veld Type 61) in the central parts and *Cymbopogon - Themeda* Veld (Veld Type 48) to the south west. The vegetation within the study area show similarities with the classification of Werger (1978), namely the Upland (Temperate) Sub-humid Mountain Bushveld, the Moist Cool Temperate Grassland, the Moist Cold Temperate Grassland and Azonal vegetation.

Methods

Relevés were compiled in 265 stratified random sample plots. Stratification was based on land type and within land types on terrain units, namely 1 - crests, 2 - escarps, 3 - midslopes, 4 -footslopes, 5 - flood plains and water courses. Plot sizes varied from 200 m^2 in areas with woody plant species to 16 m^2 in grassland vegetation in accordance with Bredenkamp & Theron (1978). In each sample plot the total floristic composition, using the Braun - Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974) was recorded. Taxon names conform to those of Gibbs Russell *et al.* (1985, 1987). The environmental variables which was recorded, include geology, land type, terrain unit, aspect, slope, rockiness of the soil surface, soil type and depth, percentage clay, soil

moisture, erosion and degree of utilization by herbivores.

Two-way indicator species analysis (TWINSPAN) (Hill 1979b) was applied to the floristic data set in order to derive a first approximation of the vegetation units of the area. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). The results are presented in a synoptic table that was compiled for the vegetation units. In this table the entries represent the constancy of the species (to the nearest one percent) as follows: 1 = 1 - 20%, 2 = 21 - 40%, 3 = 41 - 60%, 4 = 61-80% and 5 = 81 - 100%.

In order to determine vegetation - environmental relationships, the multivariate ordination technique, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set.

Climate

The annual average rainfall for the study area varies from 630 - 750 mm (Weather Bureau 1986). The rainfall is generally erratic, but somewhat less variable in the south-eastern parts of the study area. The precipitation mainly consists of thundershowers of short duration which are restricted to the warm summer months of October to April. The lowest rainfall in the study area occurs in the south, at Heidelberg (Figure 1) (Weather Bureau 1986), with a mean annual rainfall of 630 mm. The western and central parts of the study area, including Johannesburg, Delmas and Pretoria, have the highest mean annual rainfall of between 678 - 743 mm (Figure 1). Rainfall decreases

again northwards to 651 mm per annum at Verena.

The mean daily temperature varies from 20,1°C at Loskopdam in the north and decreases to 15,4°C at Heidelberg in the south (Figure 1) (Weather Bureau 1986).

Geology

The main Geological Groups, Supergroups, Sequences and Complexes are presented in Figure 2 (Department of Mineral and Energy Affairs 1984).

Karoo Sequence

The south-eastern parts of the study area are situated within the Karoo Sequence. This area is primarily underlain by the Ecca Group of the Karoo Sequence (SACS 1980). The Ecca Group consists mainly of shale, shaly sandstone, grit, sandstone, conglomerate and coal.

Waterberg Group

Just to the north of Bronkhorstspruit and around Witbank and Middelburg lies the Wilge River Formation from the Waterberg Group. The Wilge River Formation consists predominantly of sandstone with quartzite in interspaced places. Remnants of the Dwyka Formation from the Karoo Sequence is found within the Wilge River Formation as well as south-east of Bronkhorstspruit (SACS 1980).

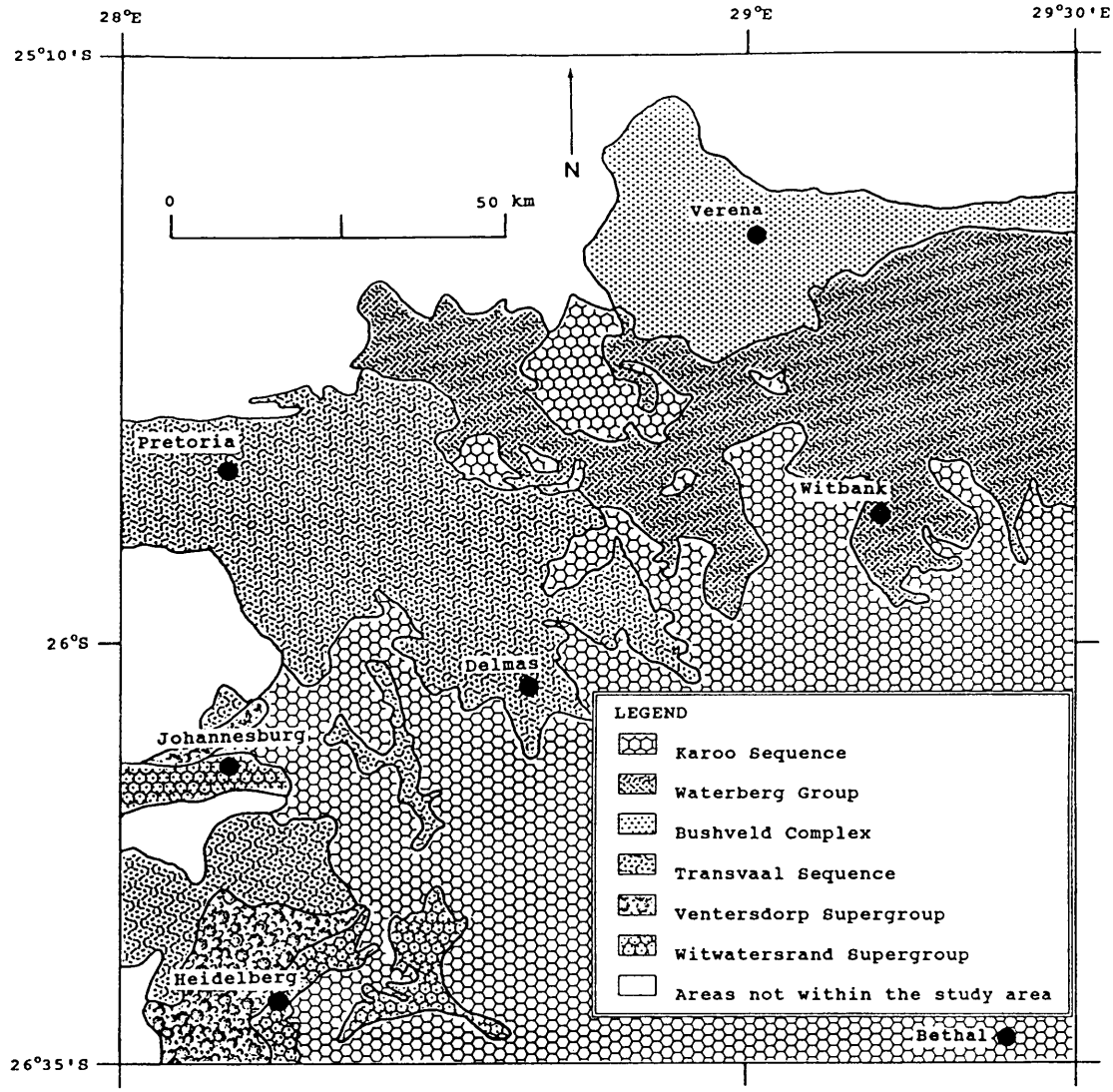

Figure 2. Geology of the Pretoria-Witbank-Heidelberg area (adapted from Department of Mineral and Energy Affairs 1984).

Bushveld Complex

The northern part of the study area falls within the Bushveld Complex and is primarily underlain by the Lebowa Granite Suite and the Rashoop Granophyre Suite (SACS 1980; Department of Mineral and Energy Affairs 1984). The Lebowa Granite Suite consists predominantly of nebo granite which is grey to pink and coarse-grained. The Rashoop Granophyre Granite consists mainly of granophyre and pseudogranophyre.

Transvaal Sequence

The area around Pretoria towards Delmas and Bronkhorstspruit falls within the Pretoria Group of the Transvaal Sequence. The Magaliesberg Formation which consists of quartzite and minor hornfels, occurs as a narrow belt from the northern parts of Pretoria and beyond the Bronkhorstspruit Dam. To the south, parallel to the Magaliesberg Formation, is the Daspoort Formation consisting of quartzite, with the Silverton Formation sandwitched inbetween. The Silverton Formation consists of shale, hornfels, chert and carbonaceous shale in places (SACS 1980). Numerous diabase intrusions are found at various levels in the Pretoria Group. The Daspoort Formation is underlain by the Hekpoort Andesite Formation. The Rooihoogte Formation lies in the southern part of the Pretoria Group in the Delmas area and south from Alberton. It consists of dolomite and chert. Between the Hekpoort and Rooihoogte Formations, towards the north-west of Delmas, lies the Timeball Hill Formation, consisting of ferruginous shale.

Ventersdorp Supergroup

Most of the Suikerbosrand area at Heidelberg consists of basaltic lawa, agglomerate and tuff from the Klipriviervberg Group. The Klipriviervberg Group is part of the Ventersdorp Supergroup.

Witwatersrand Supergroup

Two Groups are distinguished within the Witwatersrand Supergroup, namely the Central Rand Group and the West-Rand Group. Bordering the Ventersdorp Supergroup to the east around Heidelberg, lies the Turffontein Formation from the Central Rand Group. This Formation consists of quartzite, conglomerate and sandy shale. The Johannesburg Formation of the Central Rand Group lies south-east from the Turffontein Formation. This Formation consists of quartzite and conglomerate. Within the north and north-eastern parts of the Witwatersrand Supergroup lies the West-Rand Group, consisting of three Formations: The Hospital Hill Formation consists of shale that is partly ferruginous, quartzite and banded ironstone; the Government Formation consists of quartzite, greywacke conglomerate, shale and tillite, and the Jeppestown Formation consists of shale, quartzite, conglomerate and amygdaloidal lava.

Drainage

The entire study area is well drained by a network of small streams which flow into a few major rivers. The main drainage lines (Figure 3) in the study area are as follow: The

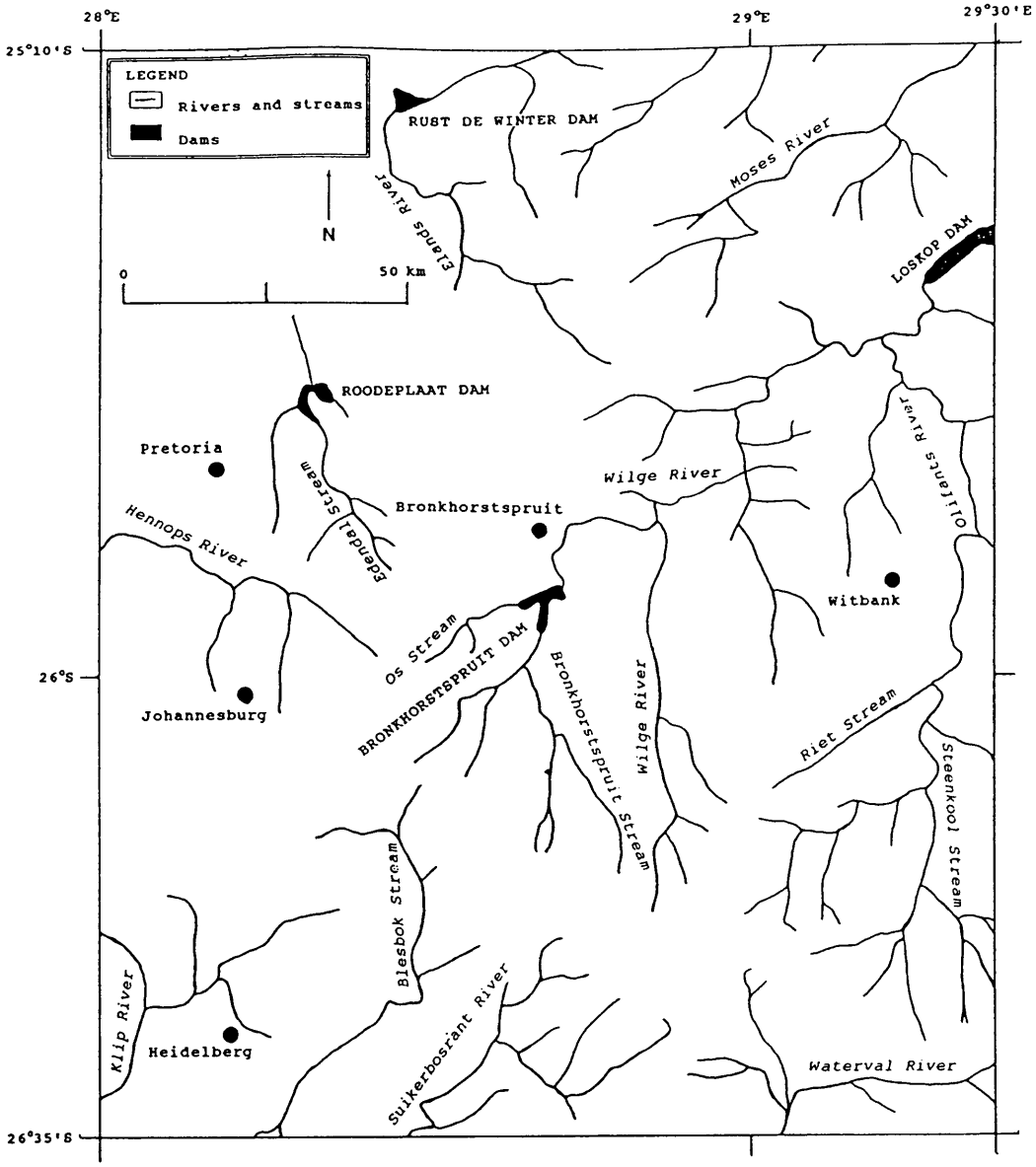

Figure 3. The main rivers and streams of the Pretoria-Witbank-Heidelberg area (adapted of Department of Mineral and Energy Affairs 1984).

Klip River, Blesbok Stream, Waterval River and the Suikerbosrand River drain the southern and south-western part of the study area. The central areas around Delmas, is drained to the east by the Olifants and Wilge Rivers and their tributaries. The Pretoria area is drained to the north-west by the Hennops River and Edendal Stream. The Moses and Elands Rivers drain the northern parts of the study area. Slow flowing streams are common with few permanent waterlogged soils, pans and vleis. The generally slow drainage prevents large-scale gully erosion in the area.

Land types and soil

A land type denotes an area of specific uniformity of pattern with respect to terrain form, soil pattern and climate. Consequently one land type is distinguished from another in terms of one or a combination of the following parameters: terrain form, soil pattern or climate (Land Type Survey Staff 1985, 1987). Two different land types are distinguished in the study area, namely the Ba and Ib land types (Figure 1) (Land Type Survey Staff 1985, 1987). Soils are classified according to the Department of Agricultural Development (1991).

Soils and terrain of the Ba land type

The Ba land type have a variety of terrain units. The terrain units and soil forms in this land type are presented in Figures 4 and 5. The Ba land type is characterized by undulating landscapes with gentle slopes throughout (terrain units 1, 3, 4 and 5). Quartzite ridges occur occasionally resulting in steeper slopes which are generally not

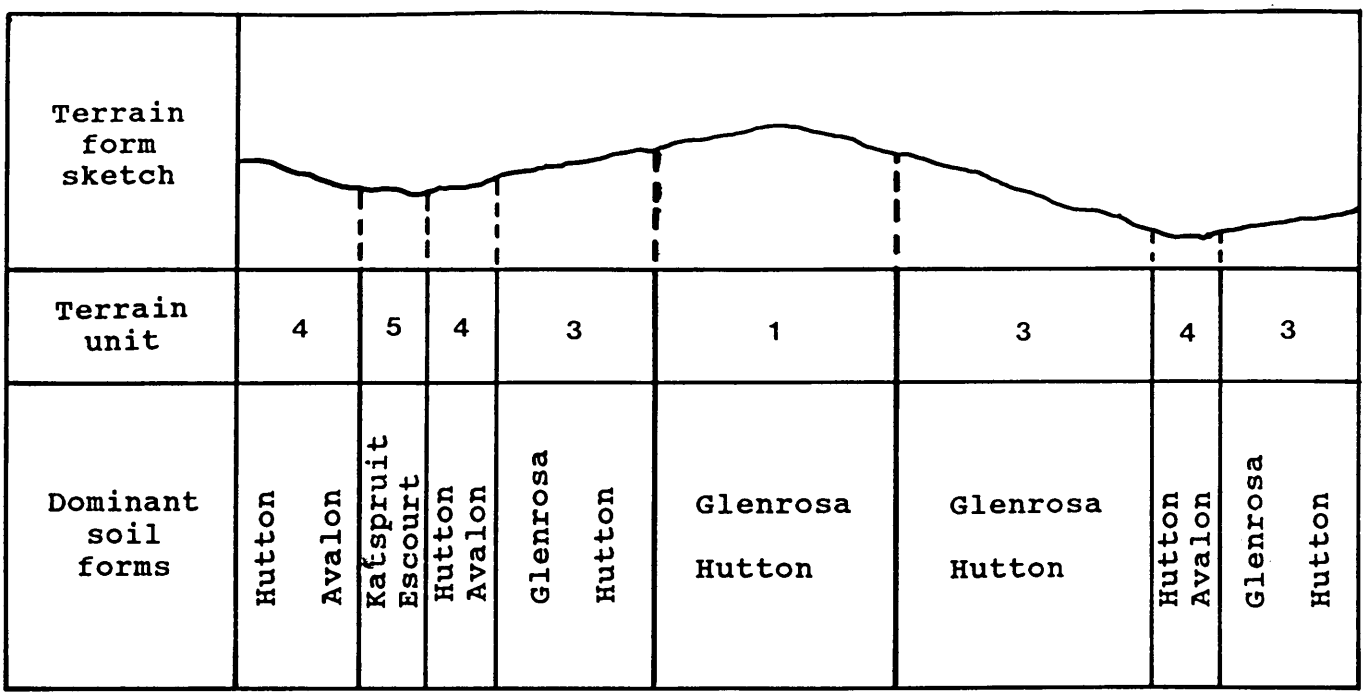

Figure 4. Terrain form sketch and associated dominant soil forms of the northern and southern parts of the Ba land type (adapted from Land Type Survey Staff 1985, 1987).

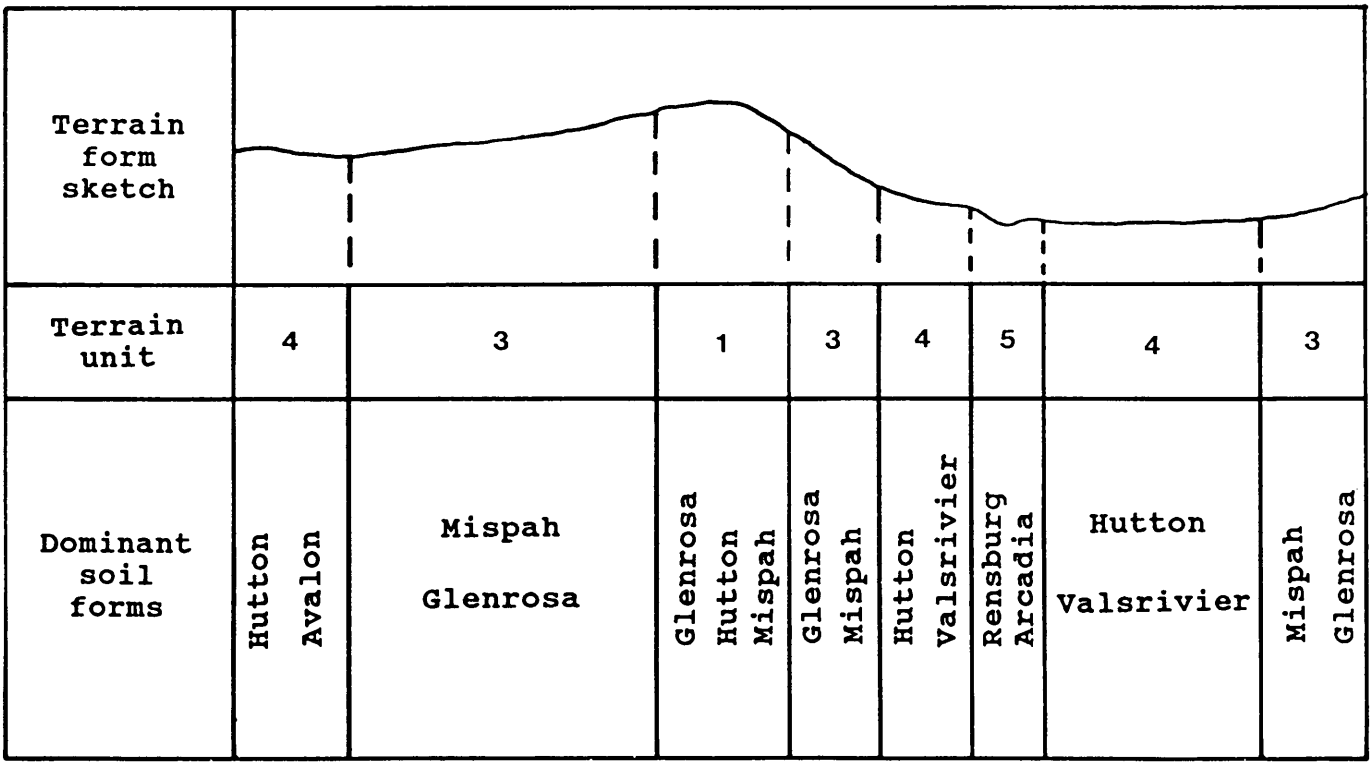

Figure 5. Terrain form sketch and associated dominant soil forms of the central rocky parts of the Ba land type (adapted from Land Type Survey Staff 1985, 1987).

typical of the Ba land type. In the Ba land type distrophic and mesotrophic red soils are widespread while duplex and margalithic soils are rare. Approximately 71% of the land surface is suitable for tillage with no or few physical limitations (Land Type Survey Staff 1985, 1987). The soils are predominantly of the Glenrosa and Hutton soil forms.

Soils and terrain of the Ib land type

A terrain form sketch of land type Ib, together with associated soil forms is presented in Figure 6 (Land Type Survey Staff 1985, 1987). This land type is restricted to rocky outcrops within terrain units 1, 2 and 3 (Figure 6), although terrain unit 2 may be absent in some areas. The predominant soil form is Mispah with rock sheets occurring abundantly, and consisting mainly of quartzite. Only 7% of the Ib land type is suitable for tillage, with no or few physical limitations.

Results

The following eight vegetation units were distinguished in the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area (Table 1):

1. *Acacia caffra - Euclea crispa* Woodland
2. *Burkea africana - Ochna pulchra* Woodland
   2.1. *Burkea africana - Faurea saligna* Closed Woodland
   2.2. *Burkea africana - Bequaertiodendron magalismontanum* Open Woodland
3. *Bewsia biflora - Digitaria brazzae* Grassland

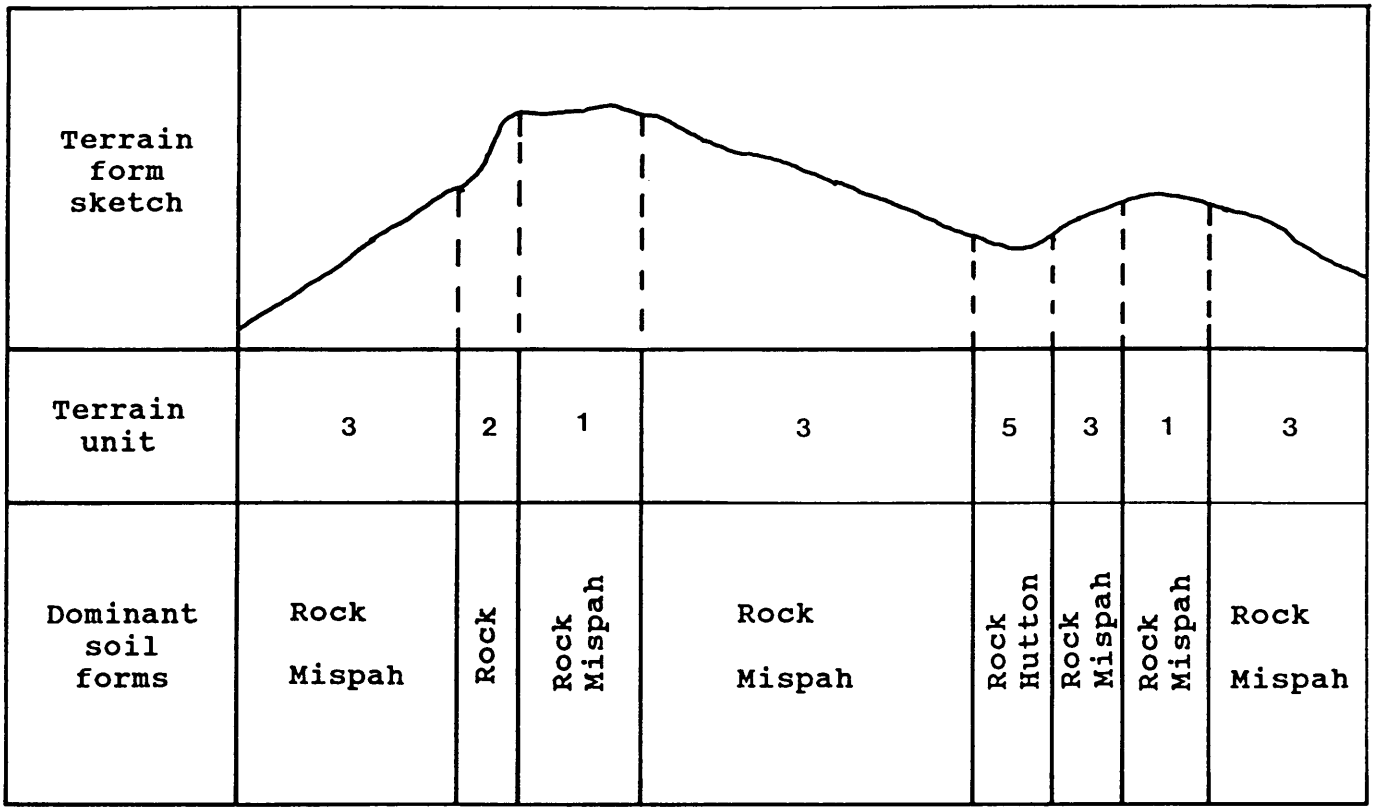

Figure 6. Terrain form sketch and associated dominant soil forms of the Ib land type (adapted from Land Type Survey Staff 1985, 1987).

Table 1. Synoptic phytosociological table of eight Vegetation Units.

Vegetation unit:	1	2		3		4	5	
		2.1	2.2	3.1	3.2		5.1	5.2
Species Group A								
Euclea crispa	4							
Diospyros lycioides	4		2					
Celtis africana	3							
Rhus pyroides	3							
Aloe transvaalensis	3							
Maytenus heterophylla	3							
Rhoicissus tridentata	3							
Cussonia paniculata	2							
Setaria lindenbergiana	2							
Protasparagus transvaalensis	2							
Protasparagus suaveolens	2							
Acacia karroo	2							
Ehretia rigida	2							
Pavetta gardeniifolia	2							
Zanthoxylum capense	2							
Species Group B								
Faurea saligna		5						
Digitaria eriantha		5	2					
Combretum apiculatum		4						
Terminalia sericea		4						
Trichoneura grandiglumis		3			2			
Dichrostachys cinerea		3						
Triumfetta sonderi		3						
Hyperthelia dissoluta		3						
Ozoroa paniculosa		3						
Eragrostis gummiflua		3						
Indigofera daleoides		3						
Felicia muricata		3						
Cymbopogon excavatus		3			2			
Pogonarthria squarrosa		2						
Lannea edulis		2						
Peltophorum africanum		2						
Species Group C								
Acacia caffra	4	3						
Rhus zeyheri	3	3						
Rhus leptodictya	2	3						
Lippia javanica	2	3						
Ziziphus mucronata	2	2						
Dombeya rotundifolia	2	2						
Species Group D								
Bequaertiodendron magalismontanum			4					
Pellaea calomelanos			4					
Xerophyta retinervis			4	2				
Landolphia capensis			3					
Aristida transvaalensis			3					
Tapiphyllum parvifolium			3					
Cymbopogon plurinodis			3					
Rhus magalismontana			3	2				
Vernonia poskeana			2					
Lopholaena coriifolia			2					
Crassula swaziensis			2					
Leonotis dysophylla			2					
Cheilanthes hirta			2					
Strychnos pungens			2					
Kalanchoe thyrsiflora			2					
Euphorbia schinzii			2					
Rhynchosia nitens			2					

Chaetacanthus setiger				2						
Dovyalis zeyheri				2						
Clutia pulchella				2						
Coleochloa setifera				2						
Combretum molle				2						
Canthium gilfillanii	2			2						
Species Group E										
Burkea africana		5	3							
Ochna pulchra		4	3							
Vangueria infausta	2	4	3							
Lannea discolor		4	2							
Mundulea sericea		3	3							
Eragrostis nindensis		2	2							
Boophane disticha		2	2							
Species Group F										
Monocymbium ceresiiforme					3					
Digitaria monodactyla					2					
Aristida junciformis					2					
Hypoxis obtusa					2					
Species Group G										
Loudetia simplex			4	4						
Bulbostylis burchellii			3	4						
Andropogon schirensis			3	3						
Sporobolus pectinatus			2	3						
Rhynchosia monophylla			2	2						
Species Group H										
Tristachya biseriata						2				
Elephantorrhiza elephantina						2				
Species Group I										
Tristachya rehmannii				2	4	2				
Panicum natalense					3	2				
Digitaria brazzae					3	2				
Bewsia biflora					2	3				
Justicia anagaloides					2	2				
Helichrysum coriaceum					2	2				
Urelytrum agropyroides					2	2				
Helichrysum cephaloideum		2			2	2				
Species Group J										
Trachypogon spicatus			2	2	3					
Senecio venosus			2	2	2					
Species Group K										
Schizachyrium sanguineum		3	3	3	2					
Parinari capensis		3	2	3	2					
Species Group L										
Diheteropogon amplectens	2	4	3	4	3					
Species Group M										
Helichrysum rugulosum						3				
Cynodon dactylon						2				
Anthospermum hispidulum						2				
Eragrostis capensis						2				
Hermannia depressa						2				

Conyza podocephala						2			
Species Group N									
Heteropogon contortus					2	2			
Species Group O									
Eragrostis racemosa			2	5	4	3			
Species Group P									
Eragrostis curvula	3	5	2	3	4	5			
Elionurus muticus	3	2	2	2	3	3			
Hypoxis rigidula	2	2			2	2			
Melinis repens		2	2		2				
Brachiaria serrata		4			3				
Aristida congesta		3			2	2			
Vernonia oligocephala	2				2	2			
Hyparrhenia hirta		2			2	3			
Stoebe vulgaris				2		2			
Thesium sp.		2		2					
Indigofera comosa		2		2					
Species Group Q									
Berkheya radula							3		
Setaria nigrirostris							2		
Centella coriacea							2		
Arundinella nepalensis							2		
Kyllinga erecta							2		
Pennisetum sphacelatum							2		
Species Group R									
Eragrostis plana						3	4		
Senecio inornatus						2	2		
Species Group S									
Themeda triandra	3	5	3	4	5	4	3		
Setaria sphacelata	3	4	2	2	4	3	2		
Species Group T									
Phragmites australis								4	
Typha capensis								3	
Cyperus longus								3	
Eragrostis planiculmis								2	
Eragrostis micrantha								2	
Cyperus marginatus								2	
Eleocharis palustris								2	
Species Group U									
Hemarthria altissima							2	3	
Paspalum dilatatum							3	3	
Leersia hexandra							2	4	
Mariscus congestus							2	2	
Polygonum salicifolium							2	2	
Sium repandum							2	2	

3.1. *Bewsia biflora - Monocymbium ceresiiforme* Grassland

3.2. *Bewsia biflora - Tristachya biseriata* Grassland

4. *Helichrysum rugulosum - Conyza podocephala* Grassland

5. *Hemarthria altissima - Paspalum dilatatum* Wetland

5.1. *Hemarthria altissima - Setaria nigrirostris* Seasonal Wetland

5.2. *Hemarthria altissima- Phragmites australis* Wetland

A schematic presentation of the hierarchical classification and associated environmental interpretation of the eight vegetation units is presented in Figure 7.

The most abundant and conspicuous species in the entire study area are the tufted grass species *Themeda triandra* and *Setaria sphacelata* (Species Group S, Table 1). Other graminoids with general occurrence are *Eragrostis curvula* and *Elionurus muticus* (Species Group P, Table 1).

1. *Acacia caffra - Euclea crispa* Woodland.

(Sub-humid Cool Temperate Mountain Bushveld)

This vegetation unit occurs on moderate to steep south and east facing slopes of rocky outcrops within the Ib land type as well as on undulating plains within the Ba land type from 1 250 m to 1 450 m above sea level, mainly on terrain unit 3. The inclination of the slopes of the rocky quartzite outcrops are from 8° to 20°, but those of the undulating sandstone areas do not exceed 5°.

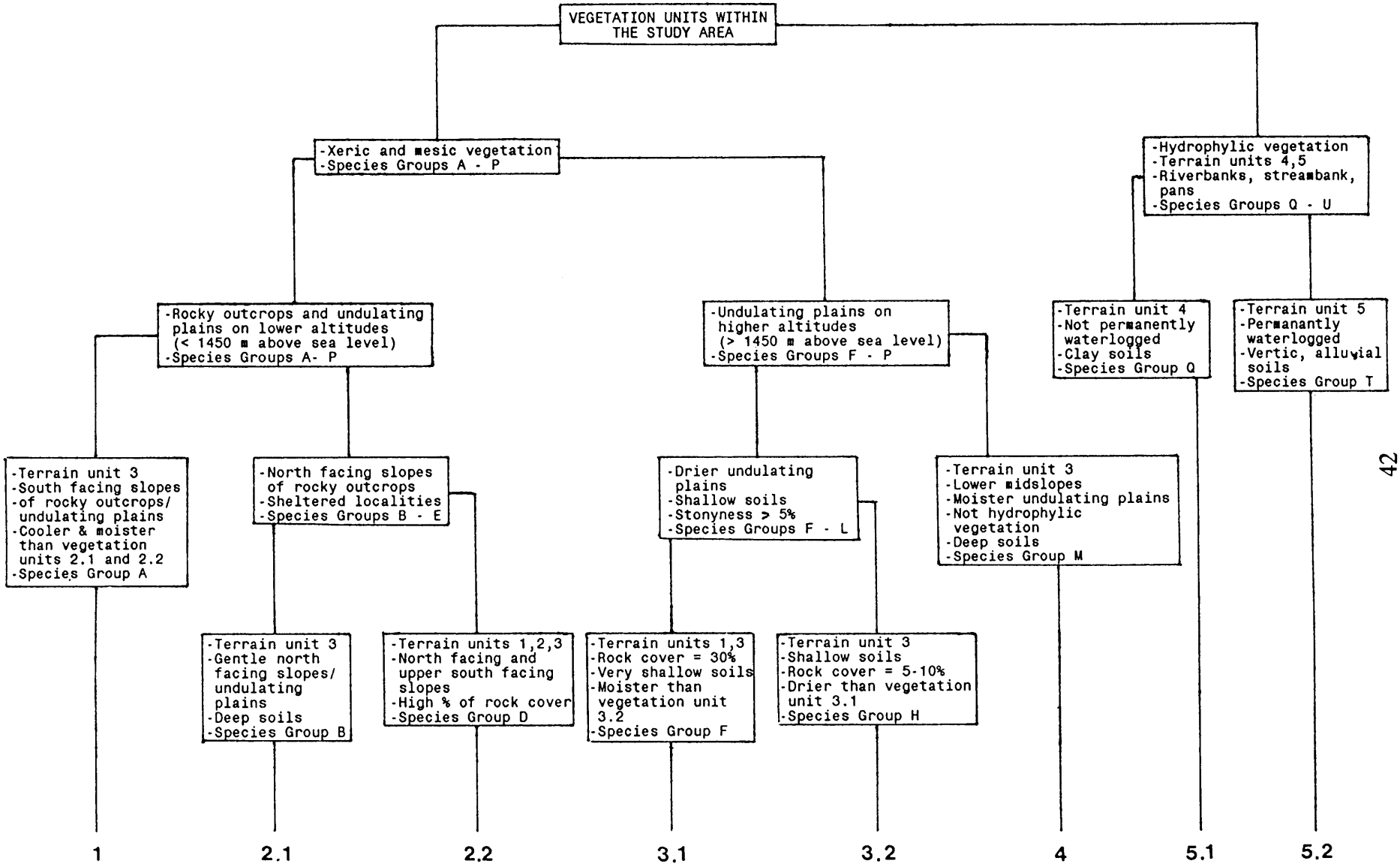

Figure 7. The hierarchical and habitat interpretation of the eight Vegetation Units of the study area. Community numbers correspond to vegetation unit descriptions in text.

The most conspicuous species are the trees *Acacia caffra,* various *Rhus* spp., *Ziziphus mucronata, Euclea crispa*; the grass species *Setaria lindenbergiana* and the semi-woody, shrubby *Protasparagus* spp. Diagnostic woody species are however *Euclea crispa, Diospyros lycioides, Celtis africana, Maytenus heterophylla, Acacia karroo, Ehretia rigida,* and *Zanthoxylum capense*, and the liana *Rhoicissus tridentata* (Species Group A, Table 1). The only diagnostic graminoid is *Setaria lindenbergiana* while the leaf succulent *Aloe transvaalensis* and the semi-woody *Protasparagus transvaalensis* and *Protasparagus suaveolens* are also diagnostic.

This vegetation unit is floristically related to the *Burkea africana - Faurea saligna* Closed Woodland (2.1) through the presence of the species of Species Group C (Table 1), indicating a floristic affinity to the vegetation on the north facing slopes. Areas representative of the *Acacia caffra - Euclea crispa* Woodland are mapped by Acocks (1953, 1988) as Bankenveld central variation. From the species composition (Species Group A, Table 1), these communities should rather be regarded as representing Sourish Mixed Bushveld or Sour Bushveld, but not Bankenveld. Werger (1978) classified this vegetation as two variations under the Upland (Temperate) Sub-humid Mountain Bushveld, namely the *Protea* - dominated Bushveld and the *Eustachys paspaloides - Acacia caffra* Mountain Bushveld. This vegetation unit occurs on the cooler south facing slopes of the Mountain Bushveld (Werger 1978) and is therefore called in this paper the Sub-humid Cool Temperate Mountain Bushveld.

2. *Burkea africana - Ochna pulchra* Woodland.

(Sub-humid Warm Temperate Mountain Bushveld)

This major vegetation unit is found on quartzite, granophyre and granite and occurs on north facing slopes, crests and upper south facing steep slopes of the rocky outcrops (terrain units 1, 2 and 3). It occurs mainly within the Ib land type.

Diagnostic and sometimes dominant woody species are *Burkea africana, Ochna pulchra, Vangueria infausta, Mundulea sericea* and *Lannea discolor*. The only diagnostic graminoid is *Eragrostis nindensis* while *Boophane disticha* is the only diagnostic geophyte (Species Group E, Table 1). This major vegetation unit occurs on the warmer north facing slopes of the Mountain Bushveld (Werger 1978) and is therefore referred to in this paper as the Sub-humid Warm Temperate Mountain Bushveld. This woodland can be divided into two distinct vegetation units.

2.1. *Burkea africana - Faurea saligna* Closed Woodland.

This vegetation unit falls within the Savanna Biome (Rutherford and Westfall 1986). According to the mapping and veld type description of Acocks (1953, 1988), this vegetation unit represents Sourish Mixed Bushveld (Veld Type 18). It occurs on the warmer gentle north facing foot slopes on the rocky outcrops in the northern parts of the study area. It is restricted to areas situated below 1 250 m above sea level.
The most prominent species are *Terminalia sericea, Combretum apiculatum, Acacia caffra, Dombeya rotundifolia* and *Faurea saligna*. Diagnostic and sometimes dominant tree

species (Species Group B, Table 1) are *Faurea saligna, Combretum apiculatum, Terminalia sericea, Peltophorum africanum* and *Ozoroa paniculosa.* Diagnostic shrubs are *Dichrostachys cinerea* and *Lannea edulis,* with *Digitaria eriantha, Trichoneura grandiglumis, Hyperthelia dissoluta, Eragrostis gummiflua, Cymbopogon excavatus* and *Pogonarthria squarrosa* as diagnostic graminoids. Diagnostic forbs and semi-woody dwarf shrubs are *Triumfetta sonderi, Indigofera daleoides* and *Felicia muricata.* Werger (1978) classified similar vegetation as *Faurea saligna - Burkea africana - Diplorhynchus condylocarpon* Mountain Bushveld under the Upland (Temperate) Sub-humid Mountain Bushveld.

2.2. *Burkea africana - Bequaertiodendron magalismontanum* Open Woodland.

This vegetation unit occurs on warm north and north - east facing slopes, crests and steep upper south facing slopes of the rocky outcrops.

The most conspicuous woody species are *Bequaertiodendron magalismontanum, Burkea africana, Combretum molle* and *Ochna pulchra*, and on the upper south facing slopes, the sedge *Coleochloa setifera.* Diagnostic grass species are *Aristida transvaalensis* and *Cymbopogon plurinodis.* Diagnostic woody species are *Bequaertiodendron magalismontanum, Rhus magalismontana, Tapiphyllum parvifolium, Lopholaena coriifolia, Strychnos pungens, Dovyalis zeyheri, Combretum molle* and *Canthium gilfillanii.* Other diagnostic species are listed under Species Group D (Table 1). The species composition of this vegetation unit corresponds with the Sour Bushveld of Acocks (1953, 1988) and the *Landolphia capensis - Bequaertiodendron magalismontanum* Shrub Bushveld, classified under the Upland (Temperate) Sub-humid Mountain Bushveld by

Werger (1978). It is interesting to note that similar plant communities described by Bredenkamp & Theron (1978) from the Suikerbosrand Nature Reserve, represent southern outliers of the Sour Bushveld, though mapped by Acocks (1953, 1988) as Bankenveld.

3. *Bewsia biflora - Digitaria brazzae* Grassland.

(Moist Cool Temperate Grassland)

This grassland occurs on undulating plains with shallow soil and on the south facing moderate slopes of the rocky outcrops, (terrain units 1 and 3). This major vegetation unit is restricted to areas above 1 450 m above sea level. This grassland occurs on both Ba and Ib land types.

The diagnostic grass species (Species Group I, Table 1) are *Tristachya rehmannii, Panicum natalense, Digitaria brazzae, Bewsia biflora* and *Monocymbium ceresiiforme.* The only diagnostic woody species encountered is the dwarf shrub *Elephantorrhiza elephantina* with the geophyte *Hypoxis obtusa* and forbs such as *Justicia anagalloides, Helichrysum coriaceum* and *Helichrysum cephaloideum.* There are no specific generally dominating grass species in this major vegetation unit but the most abundant species are *Themeda triandra, Trachypogon spicatus, Panicum natalense, Diheteropogon amplectens* and *Digitaria brazzae*. The *Burkea africana - Bequaertiodendron magalismontanum* Open Woodland (2.2) is floristically related to this vegetation unit (see Species Groups J & K, Table 1), indicating the transitional position of the grassland to Sour Bushveld communities. Based on the floristic composition this grassland falls within the Bankenveld of Acocks

(1953, 1988) and represents the Moist Cool Temperate Grassland (*Trachypogon spicatus - Diheteropogon amplectens* Grassland) of Werger (1978).

This major vegetation unit can be divided into two distinct vegetation units, both typical of the Bankenveld (Acocks 1953, 1988):

3.1. *Bewsia biflora - Monocymbium ceresiiforme* Grassland.

Diagnostic graminoids in this vegetation unit are *Monocymbium ceresiiforme, Digitaria monodactyla* and *Aristida junciformis* (Species Group F, Table 1), which occur on the rocky and stony slopes above an altitude of 1 450 m with a mean percentage rockiness of 30% and an inclination of 8-20°. The soils are shallow (mean depth is 100 mm) with Mispah and Glenrosa soil forms. Rocky outcrops are conspicuous in this area. The higher percentage of rockiness and outcrops in this vegetation unit provides a micro-habitat that prevents excessive evaporation of water . Thus this vegetation unit is more moist than those which have a lesser percentage of rockiness (Stuart -Hill 1984). This grassland is predominantly situated on the Ib land type. Although this vegetation unit is floristically related to the *Burkea africana - Bequaertiodendron magalismontanum* Open Woodland (Species Group G , Table 1) which also occurs on rocky slopes and shallow soil, no woody species occur in this Grassland, probably due to the cooler conditions at the higher altitudes.

3.2. *Bewsia biflora - Tristachya biseriata* Grassland.

This vegetation unit can be found on less stony undulating plains with a mean percentage rockiness on the soil surface of 5 - 10%, an inclination of 2-6° and with drier and deeper soils (mean depth is 200 mm), than the *Bewsia biflora - Monocymbium ceresiiforme* Grassland, representing a transitional position between vegetation units 3.1 and 4. This vegetation unit is predominantly situated on the Ba land type.

This vegetation unit does not have a distinct group of diagnostic species of its own but is rather characterized by the absence of species typically encountered in the *Bewsia biflora - Monocymbium ceresiiforme* Grassland, such as *Monocymbium ceresiiforme, Digitaria monodactyla, Aristida junciformis* and *Hypoxis obtusa.* Although *Tristachya biseriata* and *Elephantorrhiza elephantina* (Species Group H, Table 1) have a relative high occurrence in this vegetation unit, they cannot be regarded as diagnostic species because of their low presence in this vegetation unit in relation to the general occurrence of these species. Woody species are almost entirely absent in this Bankenveld vegetation.

4. *Helichrysum rugulosum - Conyza podocephala* Grassland.
(Moist Cold Temperate Grassland)

This grassland occurs on the gentle slopes of relatively lower lying bottomland areas of terrain unit 3 in the undulating plains, but still at a high altitude (above 1 450 m). This grassland is predominantly found on the Ba land type. The soil is deeper and moister than that of community 3. The average soil depth is more than 300 mm and the mean

percentage rockiness of the soil surface is less than 5%.

Diagnostic species of this vegetation unit are *Cynodon dactylon, Eragrostis capensis, Helichrysum rugulosum, Anthospermum hispidulum, Hermannia depressa* and *Conyza podocephala.* The most abundant and conspicuous species are *Themeda triandra, Eragrostis curvula, Setaria sphacelata* and *Eragrostis plana.* This vegetation unit falls within the mapping unit of the Bankenveld according to Acocks (1953, 1988). However the species composition (Species Groups M to P, Table 1), of this vegetation unit indicates that this community rather represents the *Cymbopogon - Themeda* Veld (Acocks 1953, 1988). According to the classification of Werger (1978), this community falls within the Moist Cold Temperate Grassland (*Tristachya leucothrix - Eragrostis chloromelas* Grassland).

5. *Hemarthria altissima - Paspalum dilatatum* Wetland.
(Azonal Floodplain Vegetation)

This major vegetation unit can be regarded as riparian vegetation of rivers and streams and can be found on river-banks or flood plains along streams and in pans, and thus are found exclusively on terrain units 4 and 5. The wetlands occur predominantly on the Ba land type but occur occasionally on the Ib land type where rivers and streams flow through quartzitic ridges.

Diagnostic species are *Hemarthria altissima, Paspalum dilatatum, Leersia hexandra, Mariscus congestus, Polygonum salicifolium* and *Sium repandum.* All the diagnostic

species (Species Group U, Table 1) are almost entirely restricted to this major vegetation unit, indicating the unique floristic composition and subsequent high conservation priority of this vegetation unit. This community, according to the classification of Werger (1978) represents a variation of Azonal vegetation namely Flood plain and dambo grasslands. Acocks (1953, 1988) did not classify similar vegetation as distinct veld types and this major vegetation unit falls within the Bankenveld and the *Cymbopogon - Themeda* Veld. Two distinct vegetation units can be recognized within this major vegetation unit:

5.1. *Hemarthria altissima - Setaria nigrirostris* Seasonal Wetland.

This vegetation unit is found on stream-banks or floodplains that are seasonally wet or waterlogged. It is restricted to terrain unit 4.

The most conspicuous species are *Berkheya radula, Eragrostis plana* and *Themeda triandra*. Diagnostic species are *Berkheya radula, Setaria nigrirostris, Centella coriacea, Arundinella nepalensis, Kyllinga erecta* and *Pennisetum sphacelatum* (Species Group Q, Table 1).

5.2. *Hemarthria altissima - Phragmites australis* Wetland.

This vegetation unit is restricted to terrain unit 5 and can be found in permanent and seasonally wet streams, pans and marshes.

Diagnostic and conspicuous species are *Phragmites australis, Typha capensis, Cyperus longus, Eragrostis planiculmis, Eragrostis micrantha, Cyperus marginatus* and *Eleocharis palustris* (Species Group T, Table 1). The only floristic and ecologic affinity is with the *Hemarthria altissima - Paspalum dilatatum* Seasonal Wetland (see Species Group U, Table 1).

Ordination

The result of the DECORANA ordination (Hill 1979a) is presented in Figure 8. The gradient identified corresponds to the general interpretation of the vegetation units derived from the classification. The left of the scatter diagram represents the dry, warm, woody Bushveld vegetation, while the cool to cold temperate Grassland is situated in the centre and the wetlands to the right of the diagram.

Discussion and concluding remarks

The study area includes parts of both the Savanna and the Grassland Biomes. In this area various vegetation units occur, ranging from bushveld to grassland communities, within a relatively small area . According to the map and veld type descriptions of Acocks (1953, 1988), most of these vegetation units are situated in the Bankenveld (Veld Type 61). The ecological interpretation of the parts of the Bankenveld has been a problem for many years. This study however indicates that the Bankenveld is represented by a mosaic of typical Mountain Bushveld and typical Cool or Cold Temperate Grassland (Werger 1978). The typical species composition of the Bankenveld

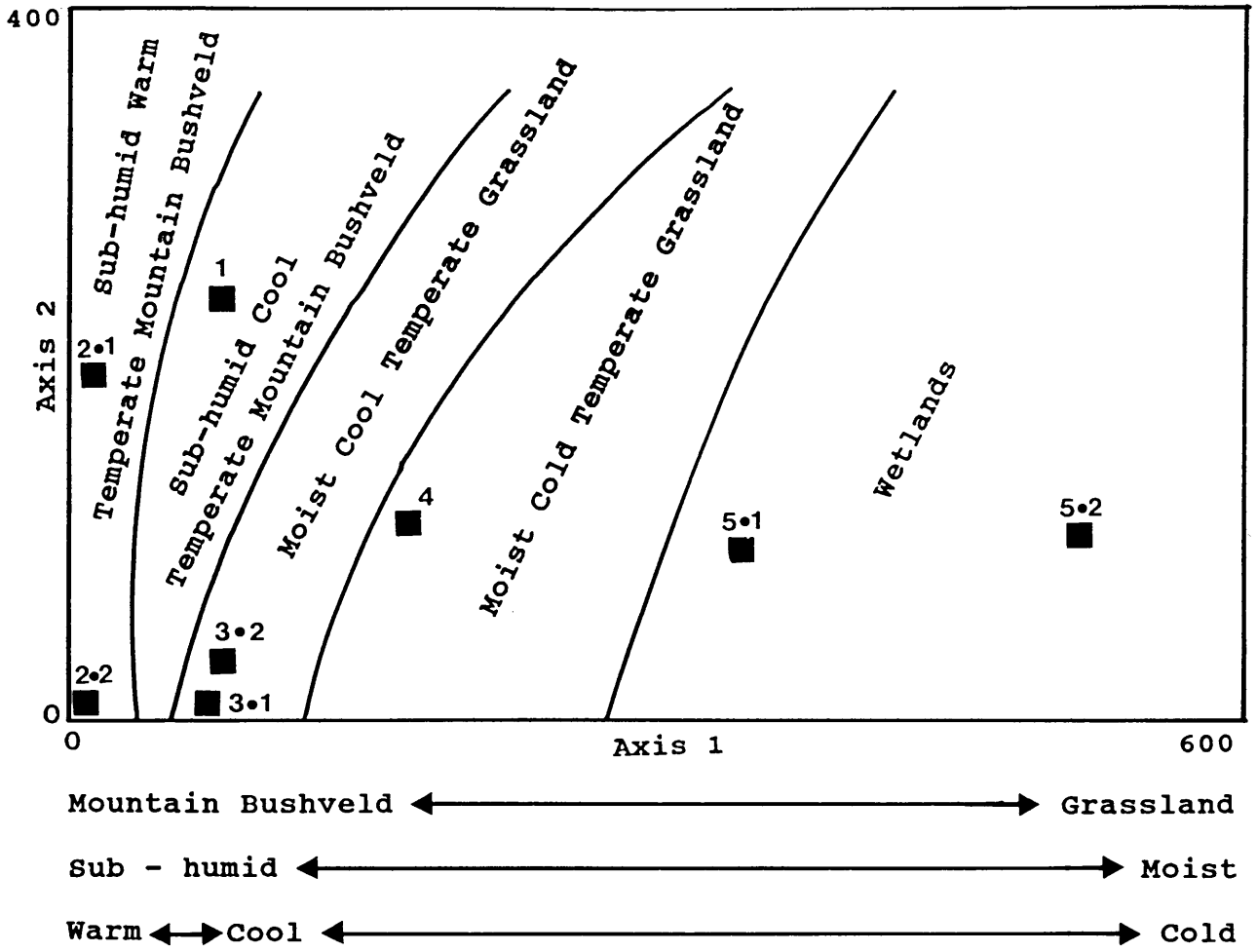

Figure 8. The DECORANA ordination diagram of the vegetation of the study area. 1 = *Acacia caffra - Euclea crispa* Vegetation Unit; 2.1 = *Burkea africana - Faurea saligna* Vegetation Unit; 2.2 = *Burkea africana - Bequartiodendron magalismontanum* Vegetation Unit; 3.1 = *Bewsia biflora - Monocymbium ceresiiforme* Vegetation Unit; 3.2 = *Bewsia biflora - Tristachya biseriata* Vegetation unit; 4 = *Helichrysum rugolosum - Conyza podocephala* Vegetation unit; 5.1 = *Hemartrhia altissima - Setaria nigrirostris* Vegetation Unit; 5.2 = *Hemarthria altissima - Phragmites australis* Vegetation unit.

(Acocks 1953, 1988) occurs only on the rocky, undulating plains with shallow soils and moderate slopes situated above 1 450 m above sea level. Many of the plant communities situated along the northern margins of the Central Variation of the Bankenveld rather represent Sour Bushveld (Acocks 1988). The deeper not-rocky soils of the high altitude plains, rather represents *Cymbopogon - Themeda* Veld. The vegetation units recognised in this study are in accordance to the classification of Werger (1978).

According to Acocks (1953, 1988), the northern border of the Bankenveld lies from Pretoria to Witbank in a fairly straight line (Figure 9). This study revealed that this is not the case. Acocks identified dominant species in the Mixed and Sourish Mixed Bushveld as *Acacia caffra, Combretum apiculatum, Dichrostachys cinerea, Lannea discolor, Terminalia sericea, Burkea africana, Sclerocarya birrea, Peltophorum africanum, Ochna pulchra, Digitaria eriantha* and *Eragrostis* spp. The part of the Ba land type that is situated in the Mixed Bushveld and Sourish Mixed Bushveld map units of Acocks (1953, 1988), to the north-and south west of Verena, should also be regarded as Bankenveld. The vegetation units that are found in those areas are classified within the *Bewsia biflora - Digitaria brazzae* Grassland (Species Group I), typical of the Bankenveld (Figure 9). Diagnostic species that were found in this area are *Tristachya rehmannii, Panicum natalense, Bewsia biflora, Trachypogon spicatus* and *Justicia anagalloides.* These species are not typical of the Mixed and Sourish Mixed Bushveld of Acocks (1953, 1988), and woody species are absent or rare in these communities.

Acocks (1953, 1988) stated that the Bankenveld is a False Grassland as a result of excessive burning. Although the role of fire in the suppression of bush and other woody

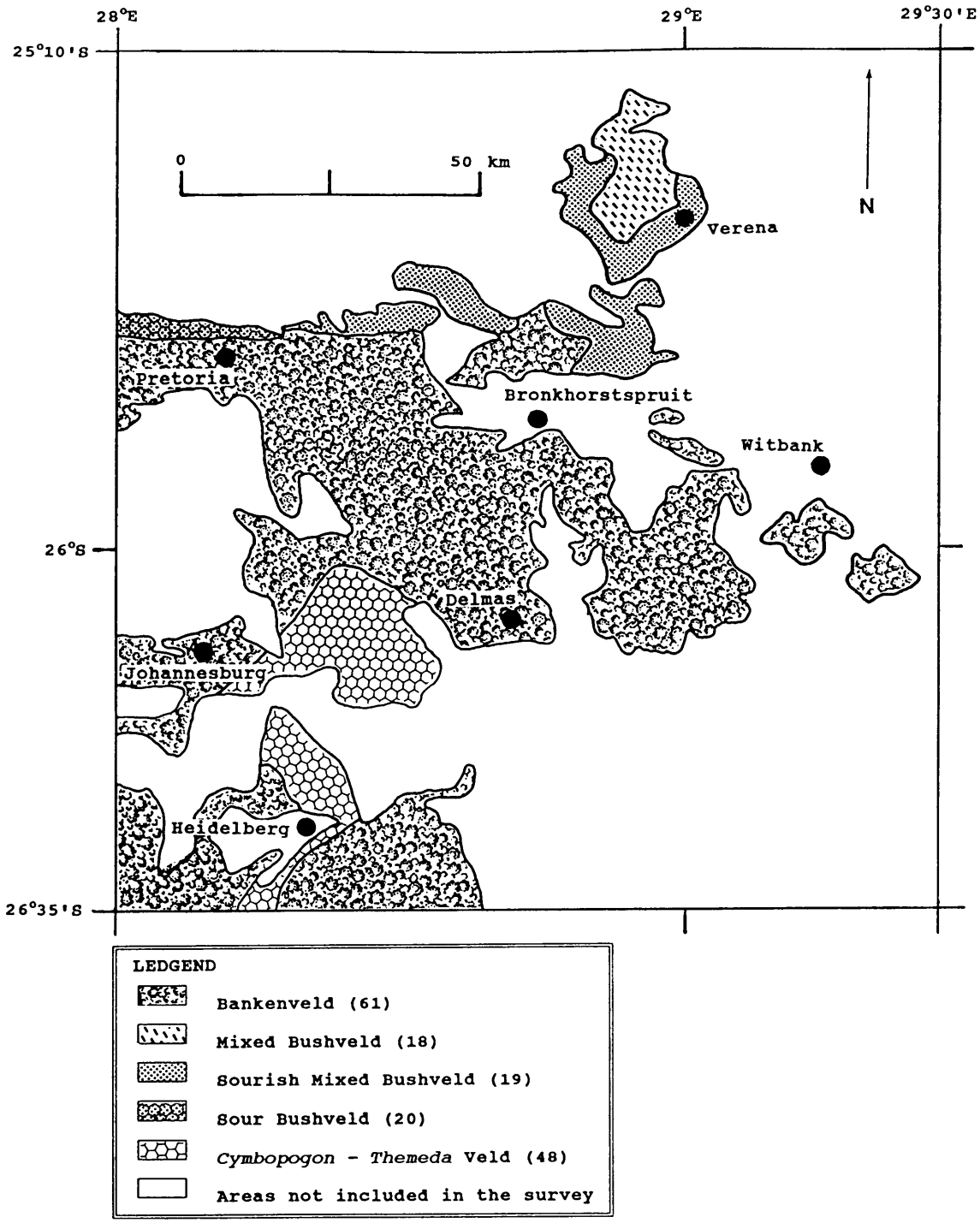

Figure 9. Veld types of Acocks within the Pretoria-Witbank-Heidelberg area (adapted from Acocks 1953, 1988).

vegetation is not denied, the results of this study indicate that the Woodland and Grassland vegetation units are associated with altitude and the corresponding climatic conditions. It is therefore suggested that altitude and the associated climatic conditions are primary environmental factors contributing to the mosaic distribution of woodland and grassland communities within Acocks' Bankenveld (see also Werger 1978; Bredenkamp & Van Vuuren 1987).

Acocks (1953, 1988) mapped the northern Variation of the *Cymbopogon - Themeda* Veld as an area between Johannesburg, Heidelberg and Delmas (Figure 9). However this study revealed that a large part between Johannesburg, Delmas and Bronkhorstspruit that was mapped as Bankenveld, actually represents *Cymbopogon -Themeda* Veld (Figure 10). The species that are typical of the Northern Variation of *Cymbopogon - Themeda* Veld are *Setaria sphacelata, Themeda triandra, Heteropogon contortus, Eragrostis capensis, E. racemosa, E. gummiflua, Elionurus muticus, Cymbopogon plurinodis, Brachiaria serrata, Cynodon dactylon, Helichrysum rugulosum, Aristida congesta* and *Eragrostis plana.* The most prominent and often diagnostic species encountered in the *Helichrysum rugulosum - Conyza podocephala* Grassland are the species in species Group M (Table 1). Coetzee *et al* (1993) mention the following species in a detailed classification and description of this grassland: *Themeda triandra, Setaria sphacelata, Heteropogon contortus, Eragrostis curvula, E. plana, E. gummiflua, Brachiaria serrata, Elionurus muticus, Eragrostis racemosa, Aristida congesta* and *Microchloa caffra.* These species compositions indicate that the *Helichrysum rugulosum -Conyza podocephala* Grassland is representative of the *Cymbopogon - Themeda* Veld. According to the distribution of the sample plots of the *Helichrysum rugulosum - Conyza podocephala* Grassland, the Northern Variation of the

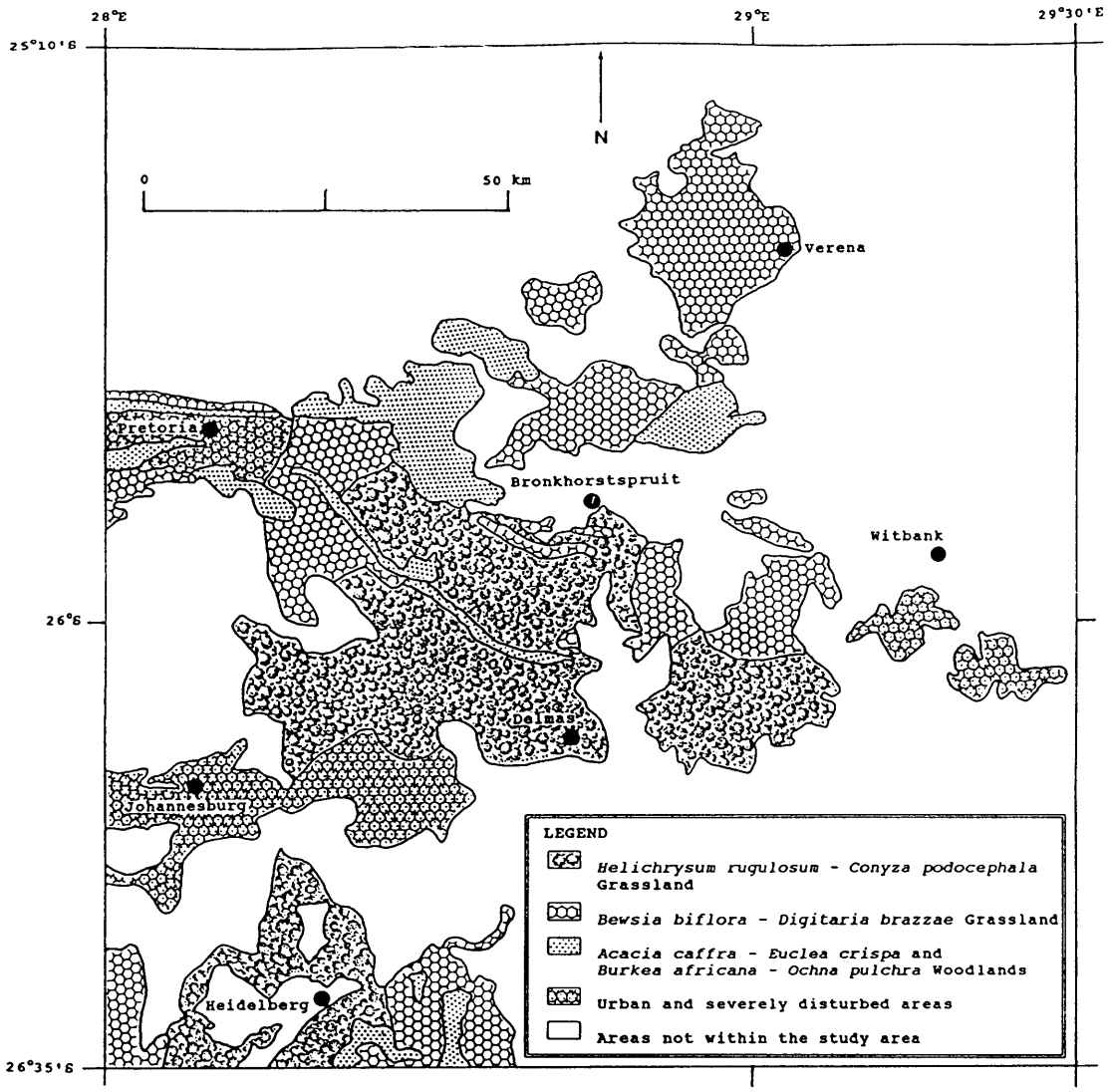

Figure 10. Vegetation map of the vegetation units within the Pretoria-Witbank-Heidelberg area compiled from this study.

Cymbopogon -Themeda Veld has a much wider distribution than was mapped by Acocks (1953, 1988) (Figure 10). The Bankenveld is restricted to shallow rocky soils while the *Cymbopogon - Themeda* Veld occurs predominantly on deeper soils of the plains.

The distribution of vegetation units on the ordination diagram (Figure 8) not only corresponds with the results of the classification (Table 1) but also with the actual geographical distribution of the vegetation units. The Sub-humid Warm Temperate Mountain Bushveld communities (Table 2) are found in the northernmost parts of the study area on the warmer north facing slopes, also associated with a lower altitude. Sub-humid Cool Temperate Mountain Bushveld is bordering the Sub-humid Warm Temperate Mountain Bushveld to the south and is associated with the cooler south facing slopes, also situated at a relatively low altitude. Bordering the Mountain Bushveld to the south, at higher altitudes, are the Moist Cool and Cold Temperate Grasslands with Wetlands and Seasonal wetlands occurring within the grasslands. The Moist Cool Temperate Grassland represent Bankenveld and the Moist Cold Temperate Grassland, the *Cymbopogon - Themeda* Veld. The Sub-humid Warm and Cool Temperate Mountain Bushveld as well as the northern parts of the Grasslands can be regarded as the transition between the Savanna and Grassland Biomes.

A comparison of the classifications of Werger (1978), Acocks (1953, 1988) and the vegetation units found in this study, is presented in Table 2.

In summary, Acocks' Bankenveld mapping unit is presently interpreted as a mosaic of grassland and bushveld communities, which include Bankenveld grassland of cool rocky

Table 2. Comparison of the eight plant communities with the classification of Werger (1978) and Acocks (1953, 1988) with associated climate and altitude.

Vegetation unit nr. (see text)	Acocks (1953, 1988)	Werger (1978)	Climate\ Altitude
2.1	Mixed Bushveld	Upland (Temperate) Sub-humid Mountain Bushveld	Sub-humid Warm Temperate (< 1 250 m)
2.2	Sour Bushveld Bankenveld	Upland (Temperate) Sub-humid Mountain Bushveld	Sub-humid Warm Temperate (1 250 - 1 450 m)
1	Sourish Mixed Bushveld Bankenveld	Upland (Temperate) Sub-humid Mountain Bushveld	Sub-humid Cool Temperate (1 250 - 1 450 m)
3.1	Bankenveld	Moist Cool Temperate Grassland	Moist Cool Temperate (> 1 450 m)
3.2	Bankenveld	Moist Cool Temperate Grassland	Moist Cool Temperate (> 1 450 m)
4	*Cymbopogon-Themeda* Veld	Moist Cold Temperate Grassland	Moist Cold Temperate (> 1 450 m)
5.1, 5.2		Azonal vegetation	Azonal

mountain or plateaux environments, *Cymbopogon - Themeda* Veld, Sour Bushveld and Sourish Mixed Bushveld. The latter two Bushveld communities may become dwarfed and poor in species composition as far as woody species are concerned, along a climatic / altitude gradient which eventually merge into typical Bankenveld rocky grassland.

Large parts of the study area are invaded by exotic invader species such as *Acacia mearnsii, Acacia dealbata, Acacia podalyriifolia, Sesbania punicea, Eucalyptus* spp., *Populus* spp. and *Melia azedarach.* Many of these areas represent riparian vegetation (*Hemarthria altissima - Paspalum dilatatum* Seasonal Wetland) with a high conservation status. In such areas the communities are usually replaced by these exotic species.

All vegetation units recognised in this study could be related to specific environmental conditions and are therefore ecologically distinguishable and interpretable. The classification is supported by the results of the ordination and the latter also provides an understanding of the vegetation gradients and associated habitat gradients between the vegetation units. Each of the eight vegetation units must be regarded as an unique ecological unit and these ecological boundaries should be taken into account during conservational and farming management.

Acknowledgements

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CHAPTER 5

The Sub-humid Warm Temperate Mountain Bushveld plant communities of the Pretoria-Witbank-Heidelberg area.

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Abstract

An analysis of the plant communities of the Sub-humid Warm Temperate Mountain Bushveld of the Pretoria-Witbank-Heidelberg area is presented. Relevés were compiled in 44 stratified random sample plots. A TWINSPAN classification, refined by Braun - Blanquet procedures, revealed six plant communities and four variations which can be regarded as distinct ecological units. A hierarchical classification, description and ecological interpretation of the six plant communities and variations are presented. Each of these plant communities may be regarded as an unique entity with it's own species composition, specific environmental relationships and inherent forage production. The identification, classification and description of these plant communities are not only important for vegetation management purposes but also as a scientific basis for the compilation of policies for the preservation of biotic diversity.

Uittreksel

'n Analise van die plantgemeenskappe van die Sub-humiede Warm Gematigde Berg Bosveld binne die Pretoria-Witbank-Heidelberg studiegebied, word aangebied. Relevés is in 44 gestratifiseerd ewekansige monsterpersele saamgestel. 'n TWINSPAN klassifikasie is op die floristiese data uitgevoer, waarna die tabel deur middel van Braun - Blanquet prosedures verder verfyn is. Ses plantgemeenskappe en vier variasies met elk 'n eie floristiese samestelling en produksie potensiaal is sodoende onderskei. Hierdie gemeenskappe toon elk verwantskappe met sekere omgewingsfaktore en kan dus as aparte ekologiese eenhede beskou word. 'n Hiërargiese klassifikasie, beskrywing en ekologiese interpretasie van die plantgemeenskappe en variasies word verskaf. Die identifisering, klassifisering en beskrywing van hierdie plantgemeenskappe is nie net belangrik vir veldbestuursdoeleindes nie, maar ook as wetenskaplike basis vir die opstel van 'n beleid vir die bewaring van biologiese diversiteit.

Keywords: Bankenveld, Braun - Blanquet, biotic diversity, Grassland Biome, synecology.

Introduction

Plant communities are conceived as vegetation units that are characterized by their floristic composition (Whittaker 1978). Each plant community may be regarded as an unique entity with its own species composition associated with a specific set of environmental factors and its own inherent forage production potential. The phenomenon that plant communities repeat themselves throughout a landscape as stands of the community where the specific set of environmental conditions occur underlines that plant communities are individual recognisable entities. Regardless of the importance to describe plant communities for agricultural planning and management purposes (Mentis & Huntley 1982; Scheepers 1986), the description of plant communities is essential to provide a scientific inventory for conservation and, in general the preservation of biotic diversity (Westhoff 1971). Trying to conserve biotic diversity is senseless and not possible if the entities that contribute to the diversity are not known. This investigation also forms part of the Grassland Biome project (Scheepers 1986), with the aim to establish a classification of the plant communities which should be taken into account in managing natural resources and the identification of priority areas for conservation. The study furthermore aims at providing data for the syntaxonomical synthesis of the Grassland Biome in South Africa (Du Preez & Bredenkamp 1991).

Coetzee *et al.* (1993b) recognised eight vegetation units in a general overview of the vegetation of the Pretoria-Witbank-Heidelberg area. From a phytosociological viewpoint, very little is known about the vegetation of the Sub-humid Warm Temperate Mountain Bushveld (Coetzee *et al.* 1993b) within this area and therefore this study aims

to identify, classify, describe and ecologically interpret the relevant plant communities.

Study area

The study area is situated on the interface of the Grassland and Savanna Biomes (Rutherford & Westfall 1986) between Pretoria, Witbank and Heidelberg. The Sub-humid Warm Temperate Mountain Bushveld occurs mainly on the warmer north facing slopes of the Ib land type (Land Type Survey Staff 1985, 1987) except for localized geological features of quartzite ridges north of Delmas within the Ba land type, east of Pretoria (Figure 1). It comprises less than 5% of the total study area (Coetzee *et al.* 1993b) and is situated between 1 000 and 1 550 m above sea level. The Ib land type consists predominantly of rocky quartzitic outcrops and ridges with the relatively low lying footslopes and undulating plains consisting of granite from the Bushveld Complex (Land Type Survey Staff 1984, 1987).

According to Werger (1978), the vegetation of the study area represents Upland (Temperate) Sub-humid Mountain Bushveld, and the warmer variations of this Bushveld are the *Landolphia capensis - Bequaertiodendron magalismontanum* Shrub Bushveld and *Faurea saligna-Burkea africana-Diplorhynchus condylocarpon* Mountain Bushveld. These warmer variations are mainly found on the warmer north facing slopes of the rocky outcrops and ridges and therefore it is called the Sub-humid Warm Temperate Mountain Bushveld in this paper (Coetzee *et al.* 1993b).

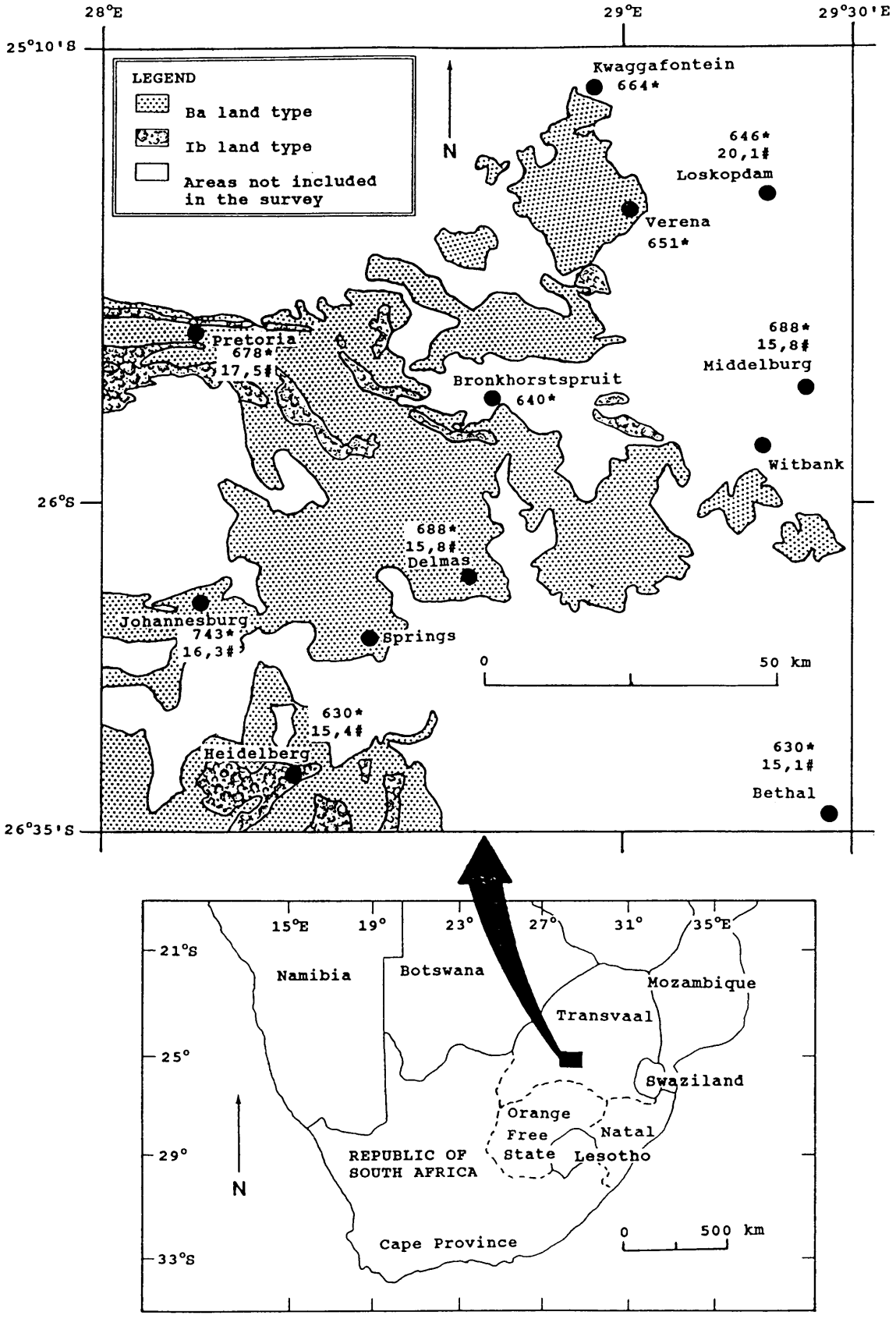


Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

The plant communities on quartzite of the Suikerbosrand area were described by Bredenkamp & Theron (1978) and therefore no sampling was done this area.

Acocks (1953, 1988) mapped the vegetation in the study area as Sourish Mixed Bushveld. A detailed description of the physical environment of the study area is presented by Coetzee *et al.* (1993b).

Methods

Relevés were compiled in 44 stratified random sample plots. Stratification was based on land type (Land Type Survey Staff 1985, 1987) and within land types on terrain units, namely 1 - crests, 2 - escarps and 3 - midslopes. Plot sizes varied from 200 m^2 in woody areas to 16 m^2 in grassland vegetation in accordance with Bredenkamp & Theron (1978). In each sample plot the cover-abundance of all species, using the Braun - Blanquet scale (Mueller-Dombois & Ellenberg 1974) was recorded. Taxon and author names conform to those of Gibbs Russell *et al.* (1985, 1987). The environmental information recorded, include land type, geology, terrain unit, aspect, slope, rockiness of the soil surface, soil type and depth, percentage clay, erosion, soil moistness and degree of utilization by herbivores.

Two-way indicator species analysis (TWINSPAN) (Hill 1979b) was applied to the floristic data set in order to derive a first approximation of the plant communities of the area. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989).

From the final phytosociological table, eight plant communities were identified (Table 1).

In order to determine possible vegetation gradients and the pattern of the plant communities on this gradient, the multivariate ordination technique, Detrended Correspondence Analysis (DECORANA) (Hill 1979b) was applied to the floristic data set.

Results

A diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the eight plant communities is given in Figure 2. Characteristic of the vegetation of the Warm Mountain Bushveld is the woody species present in each plant community. On the footslopes and undulating plains the woody species have an average height of five meters with a dense canopy cover. The hill tops, however, consists predominantly of stunted shrub-like (average height of 1,5 m) woody species with an open canopy cover. The most abundant woody species are *Burkea africana, Bequaertiodendron magalismontanum, Ochna pulchra, Mundulea sericea, Vangueria infausta, Diospyros lycioides* and *Rhus magalismontanum.* Graminoids with a high percentage constancy in most of the communities are *Themeda triandra, Eragrostis curvula* and *Setaria sphacelata* (Species Group R) (Table 1). These grass species have a characteristically wide ecological amplitude. Schematic illustrations of the plant communities along the terrain unit gradient is presented in Figures 3 and 4. The vegetation is classified into six distinct plant communities, two of which are represented

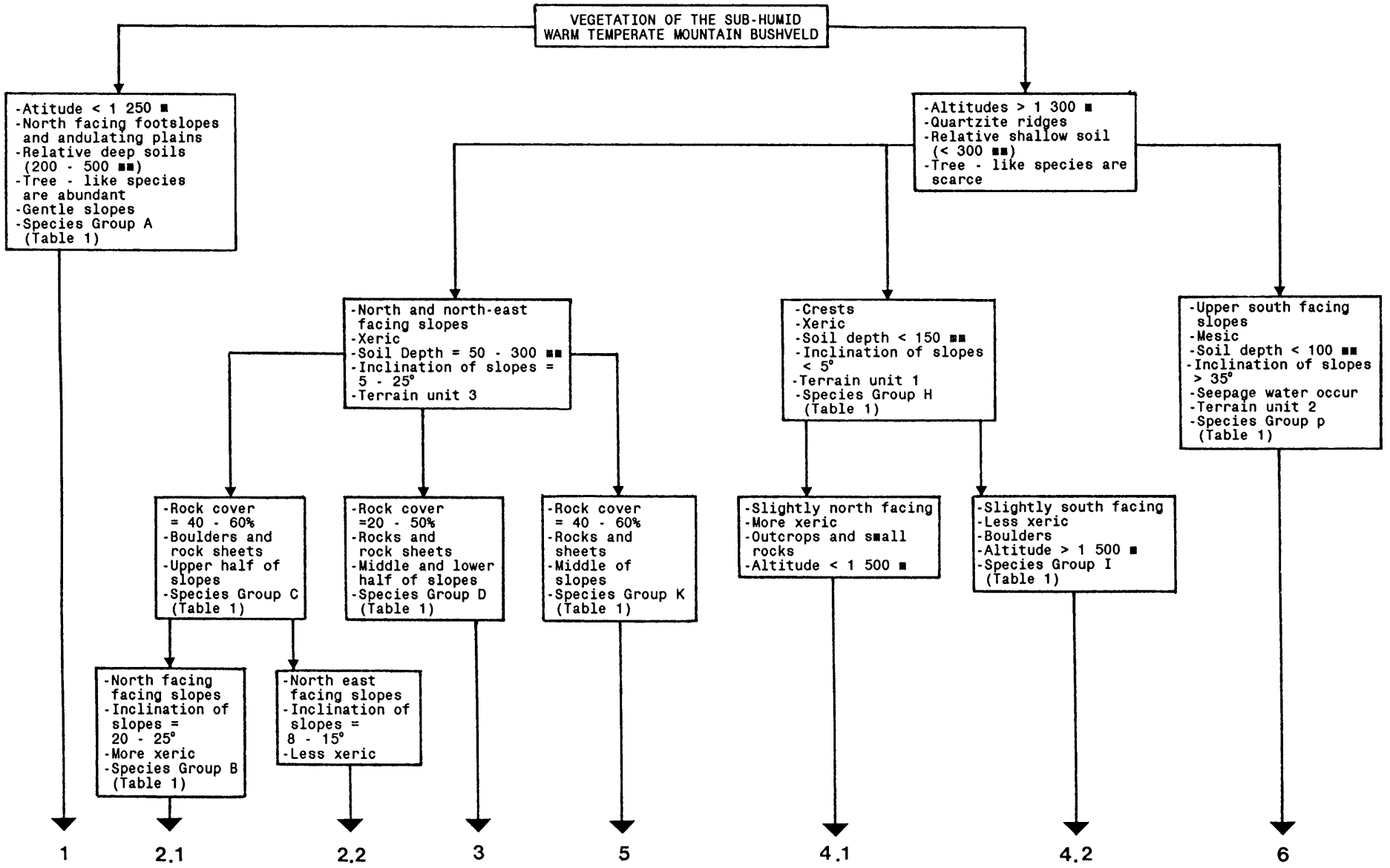


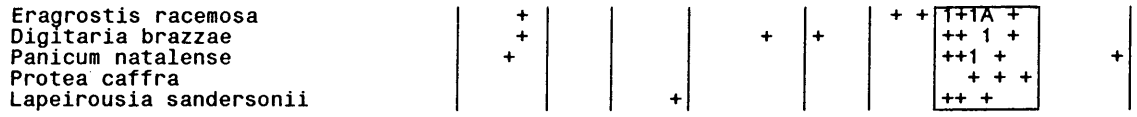
Figure 2. The hierarchial classification and associated environmental characteristics of the six plant communities. Community numbers correspond with descriptions in text.

Table 1. Phytsociological table the plant communities within the study area.

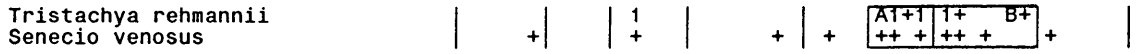
	222222	1111	11111	11101111	1111	1101	0001010	111110
	222225	1122	44724	01183360	3710	5515	7710883	022171
	362456	8907	63764	51012734	3979	4655	8942001	319686
Community numbers	**1**	**2.1**	**2.2**	**3**	**4.1**	**4.2**	**5**	**6**
Species Group A								
Faurea saligna	R1R1A+							
Terminalia sericea	A1++1							
Combretum apiculatum	1111+							
Rhus leptodictya	1 11 +			+				
Hyperthelia dissoluta	+ +B+							
Ozoroa paniculosa	++ + 1							
Dichrostachys cinerea	++++							
Trichoneura grandiglumis	++++				+			
Triumfetta sonderi	+++ +						1	
Aristida congesta	+++ +				+			+
Cymbopogon excavatus	+1 +				+			
Acacia caffra	++1		1					
Eragrostis gummiflua	++ +					+		
Indigofera daleoides	++ +		+	+		+		
Rhus zeyheri	++ +		+	+				
Felicia muricata	+++				+			
Lippia javanica	+++							
Peltophorum africanum	+ +							
Pogonarthria squarrosa	++							+
Lannea edulis	+ +							
Helichrysum cephaloideum	+ +							
Species Group B								
Koeleria capensis		+A1A		1				+
Brachylaena rotundata		+++1	+					
Aristida diffusa		++1	+	+ +				
Kyllinga alba		++ +						+
Setaria lindenbergiana		11						
Brachiaria nigropedata		+ +			+			
Pouzolzia mixta		++						
Ficus abutilifolia		+ +						
Tephrosia longipes		++						
Species Group C								
Dovyalis zeyheri		+++1	+++1		+			
Croton gratissimus		+333	A1		+			
Elephantorrhiza burkei		++	+ + +	+				
Psydrax livida		+	+ +					
Species Group D								
Helichrysum kraussii				++ + +	+			
Ziziphus mucronata	+1			A + +			+	
Aristida junciformis				1 ++		+		
Aloe davyana	+			+++	+			
Species Group E								
Strychnos pungens		1 11	++ +	+11 +++			+	
Combretum molle		1A11	111 +	A1+				
Canthium gilfillanii		1	1++ +	+++	+		+	+ +
Kalanchoe thyrsiflora		+++	+ +	++	+		+	+
Species Group F								
Burkea africana	++1A1+	1 11	1 1 1	ABB 1+ 1	1		11 1A	
Lannea discolor	1 +1+	1111	1	1AA11 1				
Digitaria eriantha	1111 +	A1+	+	A11 + 1				
Species Group G								
Rhynchosia nitens	+	+++	+ +	+ + +	++	+	+	
Euphorbia schinzii		++++	+	+ ++	+ ++			
Species Group H								
Sporobolus pectinatus			++		++++	++1+		+
Chaetacanthus setiger			++ +	+	+++	++ +	+	+ +
Species Group I								
Monocymbium ceresiiforme	+					11 +		
Phymaspermum athanasioides						1++		
Cassia comosa	+		+		+	+ +		

Species Group J

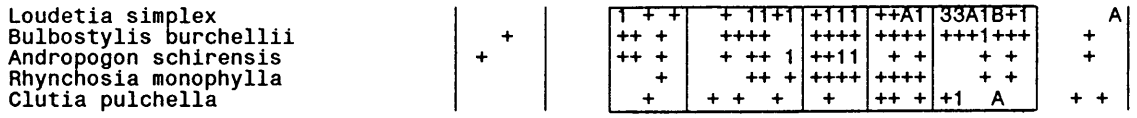
Species Group K



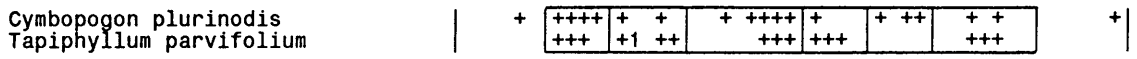
Species Group L



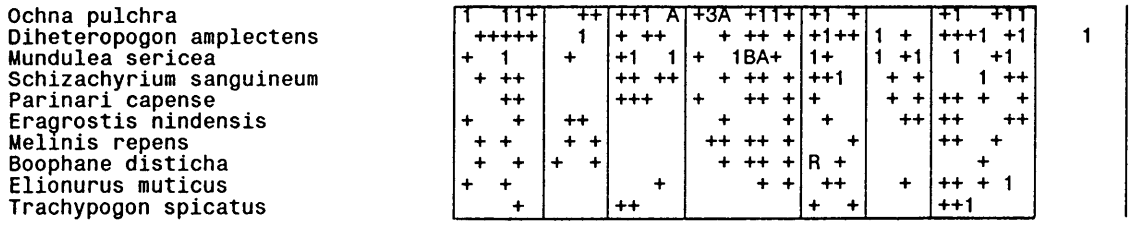
Species Group M



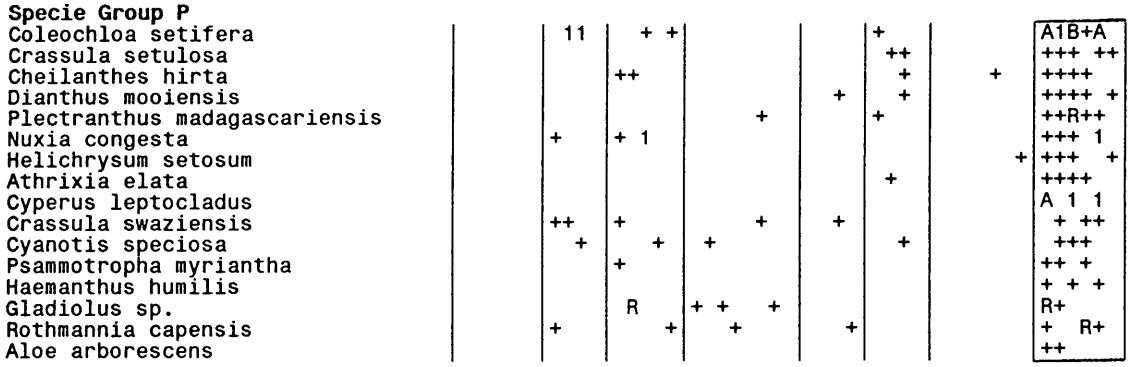
Species Group N



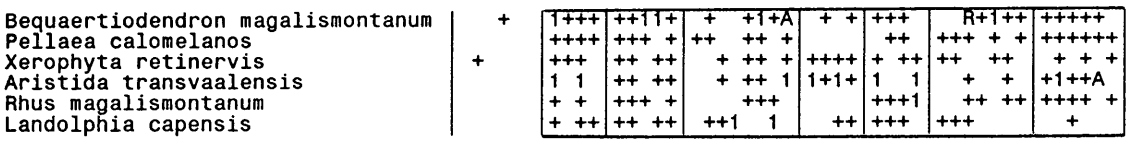
Species Group O



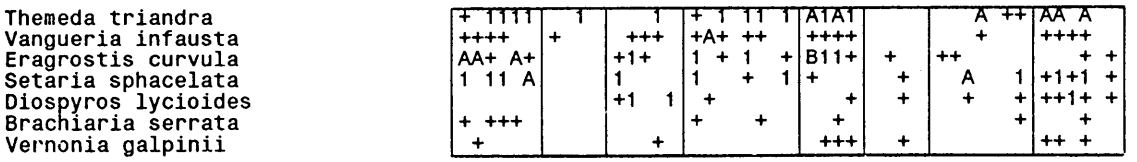
Specie Group P



Species Group Q



Species Group R



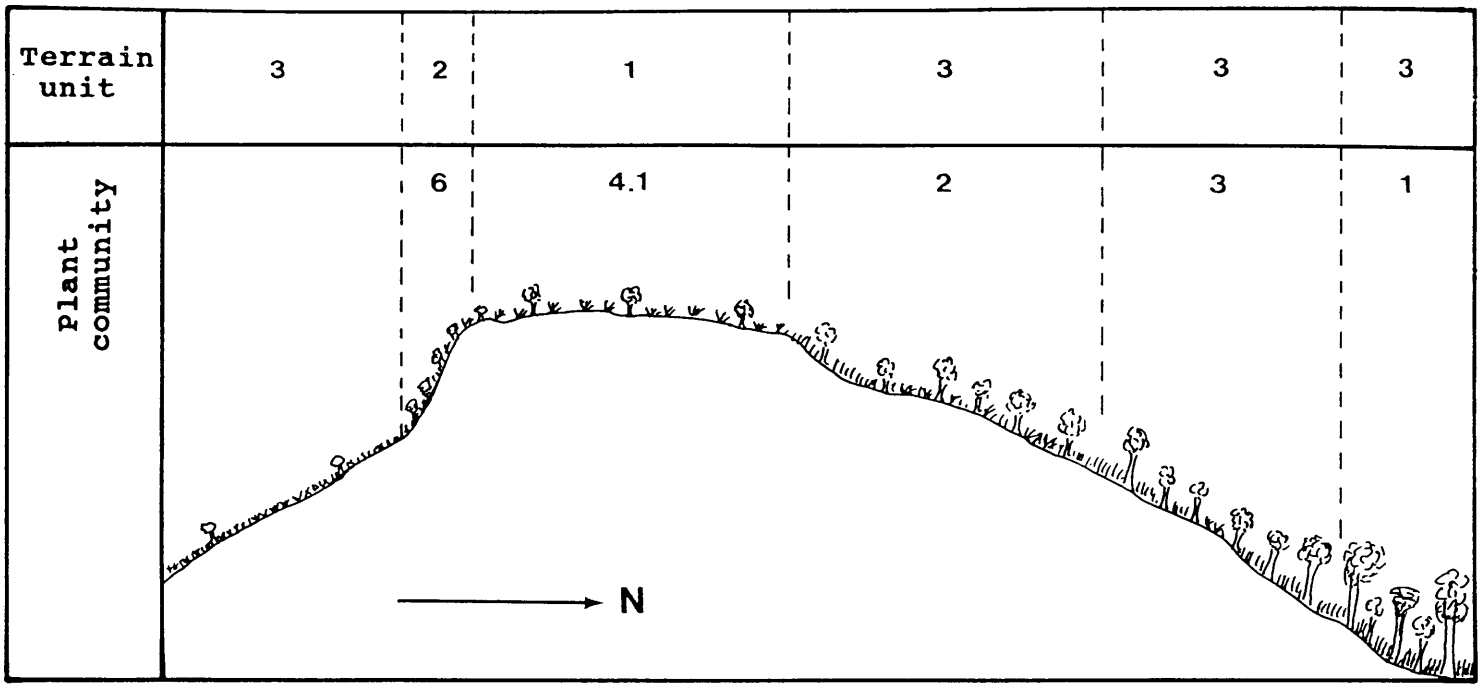


Figure 3. A schematic illustration of the distribution of the plant communities along the terrain from gradient above 1 450 m above sea level.

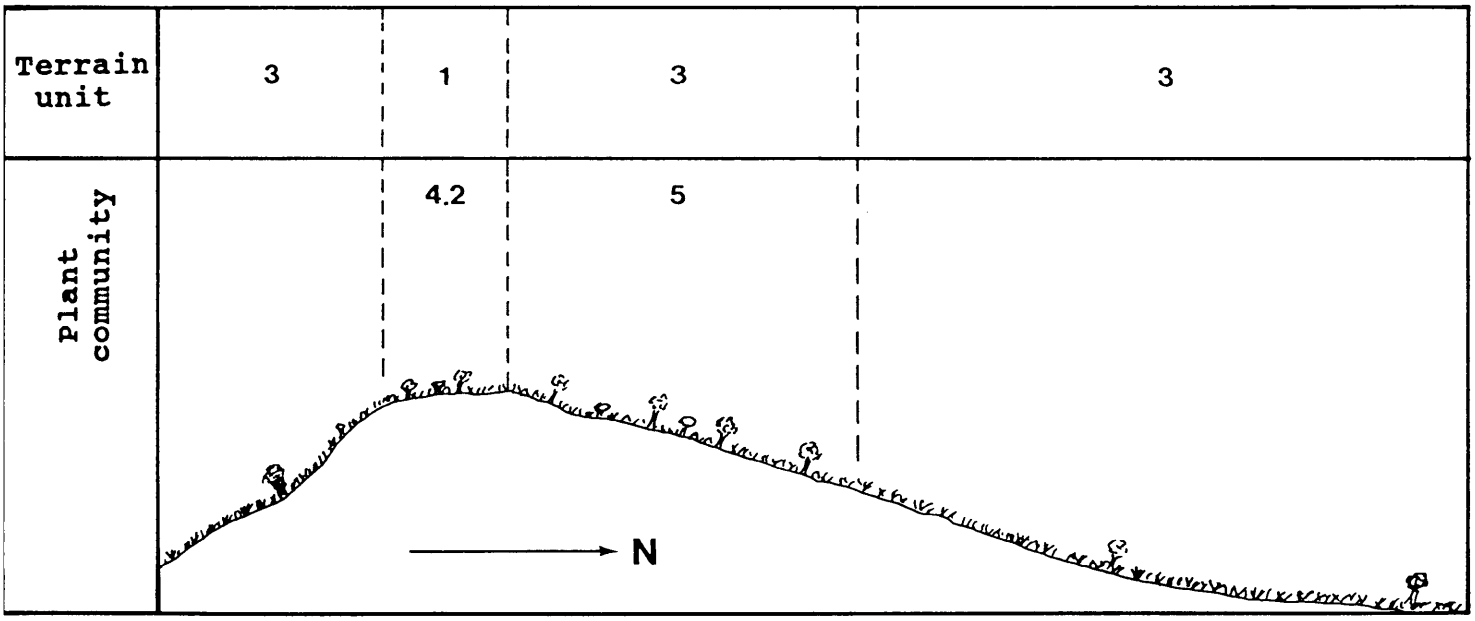


Figure 4. A schematic illustration of the distribution of the plant communities along the terrain unit gradient below 1 450 m above sea level.

by two variations each (Table 1). The hierarchical classification is as follows:

1. The *Faurea saligna - Terminalia sericea* Woodland
2. The *Dovyalis zeyheri - Croton gratissimus* Closed Shrubland
   2.1. The *Dovyalis zeyheri - Koeleria capensis* Variation
   2.2. The *Dovyalis zeyheri - Elephantorrhiza burkei* Variation
3. The *Helichrysum kraussii - Ziziphus mucronata* Closed Shrubland
4. The *Sporobolus pectinatus - Chaetacanthus setiger* Sparse Shrubland
   4.1. The *Sporobolus pectinatus - Euphorbia schinzii* Variation
   4.2. The *Sporobolus pectinatus - Phymaspermum athanasioides* Variation
5. The *Digitaria brazzae - Panicum natalense* Sparse Shrubland
6. The *Coleochloa setifera - Cheilanthes hirta* Sparse Shrubland

Plant community descriptions

1. The *Faurea saligna - Terminalia sericea* Woodland.

The *Faurea saligna - Terminalia sericea* Woodland is restricted to the northernmost parts of the study area at relatively low altitudes of < 1 250 m. It occurs on gentle (< 5°) north facing, not rocky, foot slopes and undulating low lying plains (terrain unit 3). The most common soil types are the Clovelly, Glenrosa and Hutton soil forms with a depth of 200 - 500 mm, with a low percentage of surface rocks (0 - 10%).

An average of 33 species per sample plot was recorded. Characteristic of this plant community is the woody tree species with an average height of about five meters. Towards the transitional areas to the grassland occurring at higher altitudes (relevés 225, 226), the trees become more widely spaced, smaller and the number of woody species and their abundances decrease. The following species are absent or decrease in abundance: *Rhus leptodictya, Combretum apiculatum, Ozoroa paniculosa, Peltophorum africanum* and *Dichrostachys cinerea*. Grass species such as *Monocymbium ceresiiforme, Eragrostis racemosa, Trachypogon spicatus* and *Digitaria brazzae,* typical for the grassland communities (Coetzee *et al.* 1993a) become more abundant at the higher altitudes. This area may be regarded as the transition between the Grassland and Savanna Biomes.

The most conspicuous and diagnostic woody species are *Faurea saligna, Terminalia sericea, Combretum apiculatum, Rhus leptodictya, Ozoroa paniculosa, Dichrostachys cinerea, Acacia caffra* and *Peltophorum africanum.* Diagnostic grass species are *Hyperthelia dissoluta, Trichoneura grandiglumis, Aristida congesta, Cymbopogon excavatus, Eragrostis gummiflua* and *Pogonarthria squarrosa* (Species Group A) (Table 1). The absence of species from Species Group Q (Table 1), associated with extremely rocky mountain areas, can also be regarded as characteristic. This plant community shows floristic relationships with the Mixed Bushveld and/or Sourish Mixed Bushveld of Acocks (1953, 1988) and more specifically with the *Faurea saligna - Burkea africana - Diplorhynchus condylocarpon* Mountain Bushveld of Werger (1978).

2. The *Dovyalis zeyheri - Croton gratissimus* Closed Shrubland.

This plant community is restricted to the upper part of the north- and north east facing slopes (terrain unit 3) with gradients varying from 8° to 25°. Large quartzite boulders and rocky sheets occur within this community. The surface stone and rock cover exceeds 40%. and the large boulders provide a sheltered and moist environment (Stuart-Hill 1984). The soils are 50 - 300 mm deep and represents the Mispah and Glenrosa soil forms.

All diagnostic species are woody and prominent namely *Dovyalis zeyheri, Croton gratissimus, Elephantorrhiza burkei* and *Psydrax livida* (Species Group C, Table 1), indicating the rocky nature of the habitat. Other prominent woody species are *Combretum molle* and *Strychnos pungens* with *Ficus ingens, F. abutilifolia, Landolphia capensis, Rhus magalismontanum* and *Bequaertiodendron magalismontanum* growing in the crevices between the boulders. This community is divided into two variations:

2.1 The *Dovyalis zeyheri - Koeleria capensis* Variation.

This variation is more xeric consisting of rocky sheets with steep (20° - 25°) slopes and a rock cover of more than 50%.

An average of 34 species per sample plot was recorded. The following species, typical of rocky mountain environments are diagnostic: the tree *Brachylaena rotundata*, the shrubby *Pouzolzia mixta,* the graminoids *Aristida diffusa, Koeleria capensis, Setaria*

lindenbergiana and *Brachiaria nigropedata,* the semi-woody forb *Tephrosia longipes* and the sedge *Kyllinga alba* (Species Group B, Table 1). Although *Aristida diffusa* may be an indicator of disturbed and overgrazed areas (Van Oudtshoorn 1991), it is not the case in this variation. *Aristida diffusa* is here rather an indicator of the harsh xeric environment. It was shown that species that act as Increaser IIc (pioneer species) (Trollope *et al.* 1990) in favourable climatic regions, may act as Decreasers or Increaser I species in drier or under less favourable conditions (Van Rooyen *et al.* 1991)

2.2. The *Dovyalis zeyheri - Elephantorrhiza burkei* Variation

This variation is restricted to the less steep (8° - 15°) and more moist north-east facing slopes with a rock cover of 40 - 60%. Large boulders occur in this community resulting in microhabitats that provide a somewhat more moist environment (Stuart-Hill 1984) than surrounding areas.

An average of 38 species per sample plot was recorded. No diagnostic species are found in this variation and therefore it is differentiated by the absence of Species Group B (Table 1) and by the presence of Species Groups H, J and M.

3. The *Helichrysum kraussii - Ziziphus mucronata* Closed Shrubland

This community occurs mostly on the lower and middle slopes (terrain unit 3) of the hills and ridges and also within drainage ways or depressions of north facing slopes. The gradient varies from 10° to 20° and with a rock cover of 20 - 50%, but with much smaller

rocks (not boulders) and only a few rock sheets. The soils are shallow (50 - 200 mm deep) and represents the Mispah and Glenrosa soil forms.

An average of 31 species per sample plot was recorded. The most conspicuous woody species are *Strychnos pungens, Combretum molle, Ochna pulchra* and *Bequaertiodendron magalismontanum.* The diagnostic species for this plant community are *Helichrysum kraussii, Ziziphus mucronata, Aristida junciformis* and *Aloe davyana* (Species Group D, Table 1).

4. The *Sporobolus pectinatus - Chaetacanthus setiger* Open Shrubland

This plant community is restricted to the crests (Terrain unit 1) of the quartzitic rocky outcrops. Soils are generally very shallow (< 100 mm deep) and is classified as the Mispah soil form. The surface rock cover varies from 40 to 60%, mainly in the form of sheet outcrops.

The woody species are stunted shrubs of *Vangueria infausta* and *Bequaertiodendron magalismontanum* with an average height of < 1,5 m and is widely spaced from each other, resulting in an open shrubland. Diagnostic species are the short rhizomatous grass *Sporobolus pectinatus* indicative of shallow rocky sheets and the forb *Chaetacanthus setiger.* The most conspicuous herbaceous species are the graminoids *Loudetia simplex* and *Andropogon schinzii.* Two variations were recognised within this plant community:

4.1. The *Sporobolus pectinatus - Euphorbia schinzii* Variation

This variation is differentiated by the absence of Species Group I (Table 1). It is north facing with a slope of less than 2° and is relatively dry at altitudes predominantly < 1 450 m. Many outcrops and rock sheets are found in this variation. An average of 31 species per sample plot was recorded.

4.2. The *Sporobolus pectinatus - Phymaspermum athanasioides* Variation

This variation is restricted to more or less south facing slopes and therefore cooler and moister than variation 4.1. Characteristic of this variation is large boulders that cover more than 60% of the soil surface. It occurs mostly at relatively higher altitudes (predominantly > 1 450 m).

An average of 35 species per sample plot was recorded. The diagnostic species are *Monocymbium ceresiiforme, Phymaspermum athanasioides* and *Cassia comosa* (Species Group I, Table 1), all indicative of cooler conditions at the higher altitudes. Common species that can be regarded as differential species because of there absence in this variation, are *Tapiphyllum parvifolium, Ochna pulchra, Boophane disticha, Vangueria infausta, Themeda triandra* and *Eragrostis curvula.*

5. The *Digitaria brazzae - Panicum natalense* Open Shrubland

This community is encountered on gentle (5°-8°) middle north and east facing slopes with

shallow soil (< 100 mm deep). Rock sheets are frequently found and the average rock cover is 40 - 60%. Most of the sample plots occur above 1 450 m above sea level.

An average of 31 species per sample plot was recorded. No species attain dominance but the most abundant species are *Loudetia simplex, Eragrostis racemosa, Bulbostylis burchellii* and *Pellaea calomelanos*. The following stunted shrubs occur infrequently and are sparsely distributed: *Bequaertiodendron magalismontanum, Rhus magalismontanum, Landolphia capensis, Mundulea sericea, Protea caffra* and *Ochna pulchra*. Diagnostic species are the graminoids *Eragrostis racemosa, Digitaria brazzae* and *Panicum natalense,* the small tree (2-4 m) *Protea caffra* and the geophyte *Lapeirousia sandersonii* (Species Group K, Table 1). This plant community is floristically related to the *Sporobolus pectinatus - Phymaspermum athanasioides* Variation (4.2) through Species Group L (Table 1).

In this study it was found that *Protea caffra* occurs on the north facing slopes only at altitudes above 1 450 m where it is cooler. In contrast, Coetzee *et al.* (1993a) found that on the generally cooler south facing slopes, *Protea caffra* may also occur at lower altitudes. This phenomenon that *Protea caffra* occurs on north facing slopes only at relatively high altitudes which provides cooler conditions, is also described by Theron (1975).

The protected plant *Lapeirousia sandersonii* (Ordinance 12 1983), is a diagnostic species in this plant community.

6. The *Coleochloa setifera - Cheilanthes hirta* Open shrubland

This unique plant community is found only on the upper steep (< 35°, terrain unit 2) south facing slopes of the rocky outcrops and ridges. This plant community is characterized by drainage lines containing seepage water and many rock sheets and ridges.

These environmental conditions provide a moist environment with diagnostic hydrophillic species (Species Group P, Table 1) such as *Coleochloa setifera, Psammotropha myriantha* and *Haemanthus humilis*. Other diagnostic species are the xeric *Cheilanthes hirta, Crassula setulosa, Plectranthus madagascariensis, Nuxia congesta, Helichrysum setosum, Athrixia elata, Crassula swaziensis*, and *Aloe arborescens,* occurring on the dry rocky patches. The most conspicuous species are *Coleochloa setifera, Cheilanthes hirta, Nuxia congesta* and *Plectranthus madagascariensis.* The restricted occurrence of this community and diagnostic protected species (Ordinance 12 1983) such as *Cheilanthes hirta, Haemanthus humilis* and *Gladiolus* spp. give this plant community a high conservational priority. An average of 34 species per sample plot was recorded.

Ordination

The distribution of relevés along the first and second axes of the ordination is presented in Figure 5. A distinct discontinuity in the distribution of the respective plant communities can be observed. The syntaxa are generally restricted to specific areas in the scatter diagram. The vegetation gradient on the first axis is associated with a soil

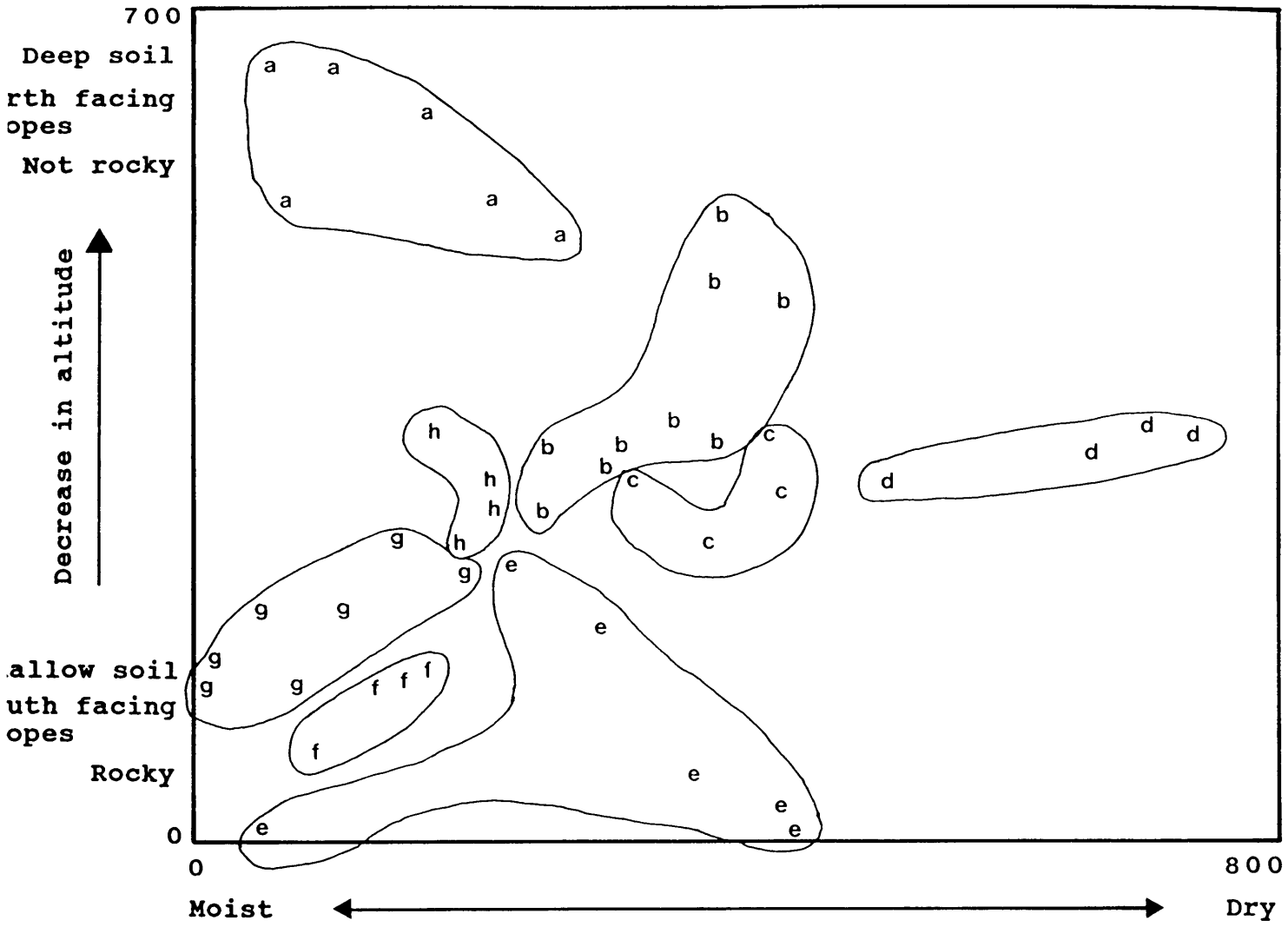


Figure 5. A DCA ordination diagram of the vegetation of the Sub-humid Warm Temperate Mountain Bushveld communities of the study area. a = The *Faurea saligna - Terminalia sericea* Woodland; b = The *Helichrysum kraussii -Ziziphus mucronata* Closed shrubland; c = The *Dovyalis zeyheri - Elephantorrhiza burkei* Variation; d = The *Dovyalis zeyheri - Koeleria capensis* Variation; e = The *Coleochloa setifera - Cheilanthes hirta* Sparse shrubland; f = The *Sporobolus pectinatus - Phymaspermum athanasioides* Variation; g = The *Digitaria brazzae - Panicum natalense* Sparse shrubland; h = The *sporobolus pectinatus - Euphorbia schinzii* Variation.

moisture gradient. The second axis denotes a soil depth, as well as an altitudinal gradient with lower altitudes and deep soils at the top to higher altitudes and shallow soils at the bottom of the diagram. The second axis is also associated with the percentage of surface rock cover and aspect. Two distinct groups of communities were distinguished: the drier communities with relatively deep soil and steep north facing slopes (communities 1, 2, and 3) and the more moist, gentle north facing and steep south facing communities with relatively shallow soils (communities 4, 5 and 6).

Communities 1, 2 and 3 are also floristically related through Species Group F (Table 1), which suggests that these communities may be grouped into a higher syntaxon.

Concluding remarks

The plant communities that were recognised in the Sub-humid Warm Temperate Mountain Bushveld, show floristical and ecological relationships with similar communities that have been described by various authors.

In the Roodeplaatdam Nature Reserve (Van Rooyen 1984) a community similar to the *Faurea saligna - Terminalia sericea* Woodland occurs. The floristical relationship is due to diagnostic species such as *Faurea saligna, Combretum apiculatum, Acacia caffra, Hyperthelia dissoluta* and *Lippia javanica.* The *Dovyalis zeyheri - Croton Gratissimus* Closed Woodland and *Helichrysum kraussii - Ziziphus mucronata* Closed Shrubland are floristical related to communities described by Du Plessis (1972) on the farm Doornkop in the district Middelburg by the following species: *Elephantorrhiza burkei, Aristida*

junciformis, Combretum molle, Canthium gilfillanii, and *Croton gratissimus*. Similar vegetation as the *Sporobolus pectinatus - Chaetacanthus setiger* Sparse Shrubland is also found on the farm Doornkop (Du Plessis 1972). The floristical relationship is through the mutual occurrence of the species *Sporobolus pectinatus, Tristachya rehmannii, Lopholaena coriifolia, Landolphia capensis, Loudetia simplex, Rhynchosia monophylla* and *Andropogon schirensis.* Similar vegetation also occurs on the quartzite in the Suikerbosrand Nature Reserve (Bredenkamp & Theron 1978), the Jack Scott Nature Reserve (Coetzee 1974) and the Loskopdam Nature Reserve (Theron 1973), but the specific plant communities seem to differ, as the diagnostic species for the plant communities are different. Specific floristic relationships among the various plant communities will only be detected in a phytosociological synthesis of the vegetation types.

The classification obtained by TWINSPAN (Hill 1979b) and refined by Braun - Blanquet procedures resulted in vegetation units that can be related to the environmental factors observed, and can therefore be considered as ecologically interpretable communities for the area concerned. The classification is supported by the results of the floristic ordination. The description of these plant communities contributes to the scanty knowledge of the syntaxonomy and synecology of the Mountain Bushveld of the Pretoria-Witbank-Heidelberg area. The results can be employed to advance the preservation of biological diversity and conservational management.

The following protected species in Transvaal, according to Ordinance 12 (1983), were encountered: *Aloe peglerae, A. pretoriensis, Gladiolus* spp., *Pellaea calomelanos,*

Cheilanthes viridis, Cheilanthes hirta, Cussonia paniculata, Lapeirousia sandersonii, Scadoxus puniceus, Protea caffra and *Haemanthus humilis.* The restricted occurrence, relative high biodiversity within a small area and the number of protected species, give the Sub-humid Warm Temperate Mountain Bushveld a high conservation priority. Until now there has been little disturbance by human activities in this area, but these areas are increasingly in demand for urban development.

Acknowledgements

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CHAPTER 6

The plant communities of the Sub-humid Cool Temperate Mountain Bushveld of the Pretoria-Witbank-Heidelberg area, South Africa.

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Abstract

An analysis of the plant communities of the Sub-humid Cool Temperate Mountain Bushveld of the Pretoria-Witbank-Heidelberg area within the Grassland Biome of South Africa is presented. Relevés were compiled in 33 stratified random sample plots. A TWINSPAN classification, refined by Braun - Blanquet procedures, revealed five plant communities and seven variations which can be regarded as distinct ecological systems. Each of these plant communities may be regarded as an unique entity with it's own species composition, specific environmental conditions and inherent forage production. The identification, hierarchical classification, description and ecological interpretation of these plant communities are not only essential for vegetation management but may also serve as a basis for strategic planning of conservation areas and the preservation of biotic diversity.

Introduction

The importance of determining the location and extent of the vegetation types within the Grassland Biome has been repeatedly emphasised (Mentis & Huntley 1982; Scheepers 1986). The fact that Acocks' (1953, 1988) broad description of South African vegetation types is one of the most cited vegetation classifications, indicates the importance and need for vegetation classifications. However, little advance has been made towards a more detailed floristic classification of the vegetation of the grassland within the central, eastern and southern Transvaal. In view of the degradation of the vegetation in the densely populated, urbanized and industrialised study area, it is imperative that land-use planning as well as management and conservation strategies be based on sound ecological principles. As part of a phytosociological research programme on the synthesis of the vegetation of the Grassland Biome in South Africa (Scheepers 1986; Coetzee *et al.* 1993), the Sub-humid Cool Temperate Mountain Bushveld within the Pretoria-Witbank-Heidelberg area was identified by Coetzee *et al.* (1993) in an overview of the vegetation within the study area. The aim of this study is to identify, classify and ecologically interpret the different plant communities within the Sub-humid Cool Temperate Mountain Bushveld.

Study area

The study area is situated in the Pretoria-Witbank-Heidelberg area within the Grassland Biome of South Africa (Rutherford & Westfall 1986) (Figure 1). The Sub-humid Cool Temperate Mountain Bushveld is mainly found on south facing slopes on quartzite reefs

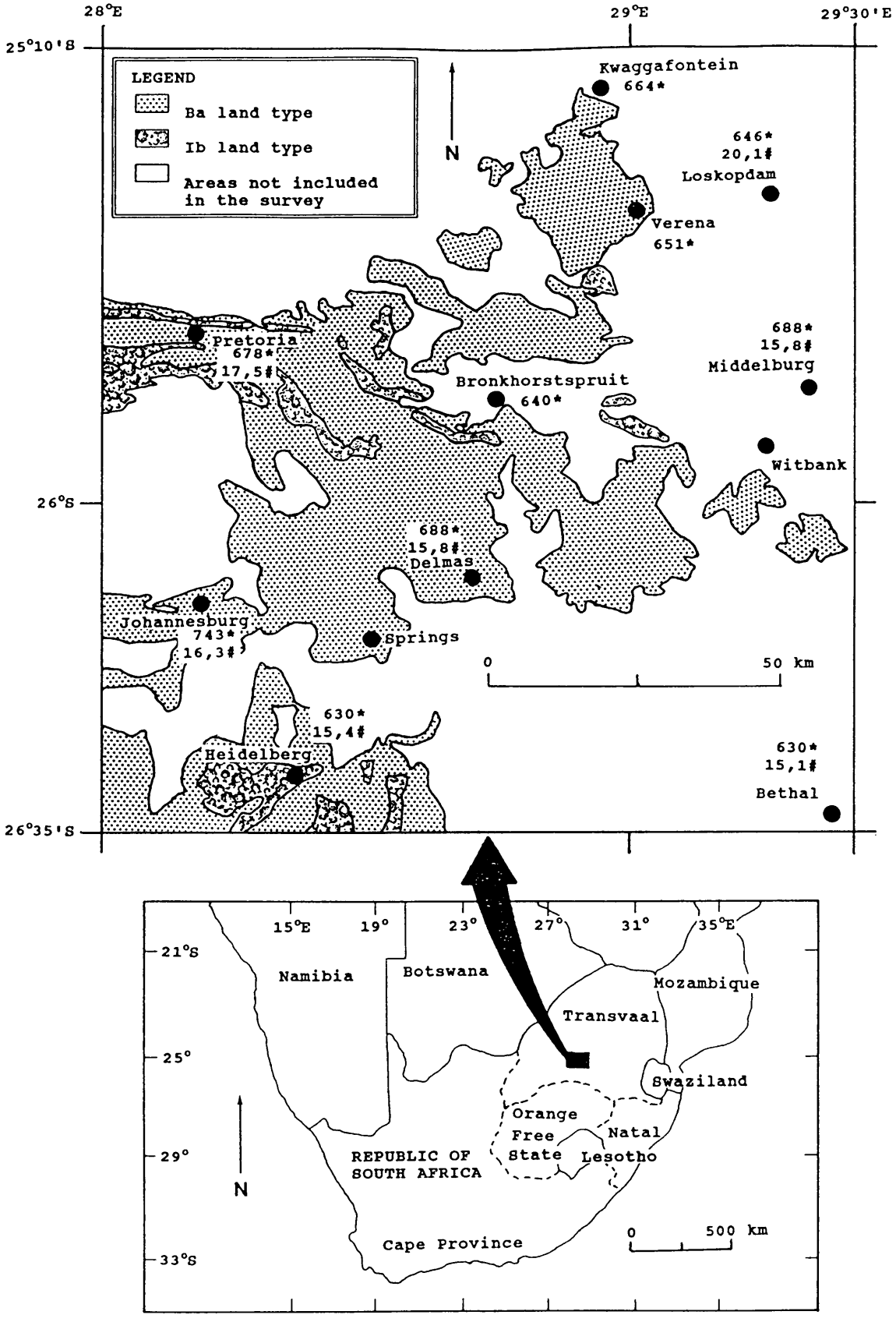


Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

within the Ib land type and on diabase on the flat plains at an altitude of less than 1 450 m within the Ba land type. Acocks (1953, 1988) classified the vegetation of the study area as Mixed Bushveld and/or Sour Bushveld. According to Werger (1978), the vegetation concerned is described as the Upland (Temperate) Sub-humid Mountain Bushveld. The variations associated with cooler conditions within this Bushveld are the *Protea* - dominated Bushveld and the *Eustachys paspaloides* - *Acacia caffra* Mountain Bushveld (Werger 1978). A detailed description of the physical environment of the study area is presented by Coetzee *et al.* (1993).

Methods

Relevés were compiled in 33 stratified random sample plots. Stratification was based on land type (Land Type Survey Staff 1985, 1987) and terrain units within land types, namely 1 - crests, 2 - escarps and 3 - midslopes. Plot sizes were fixed on 200 m^2 in accordance with Bredenkamp & Theron (1978). In each sample plot the floristic composition was recorded and a cover-abundance value, according to the Braun - Blanquet scale (Mueller-Dombois & Ellenberg 1974), was allocated to each species. Taxon and author names conform to those of Gibbs Russell *et al.* (1985, 1987). The environmental information recorded include geology, land type, terrain unit, aspect, slope, rockiness of the soil surface, soil type and depth, percentage clay, erosion, soil moistness and degree of utilization by herbivores.

Two-way indicator species analysis (TWINSPAN) (Hill 1979b) was applied to the floristic data set in order to derive a first approximation of the plant communities of the

area. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). From the final phytosociological table, five plant communities and seven variations were identified (Table 1).

In order to determine vegetation gradients, the multivariate ordination technique, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set.

Results and discussion

The following plant communities and variations were recognised from the phytosociological table (Table 1):

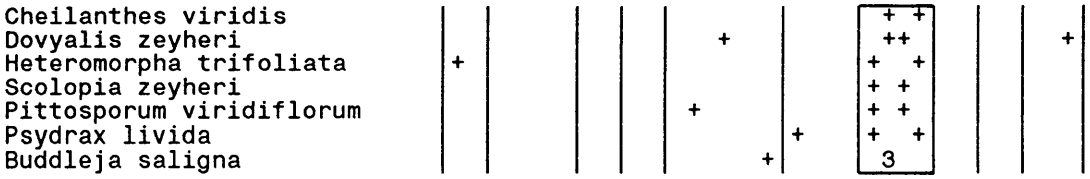
1. *Aristida transvaalensis - Diospyros lycioides* Closed Woodland
2. *Protea caffra - Athrixia elata* Open Woodland
3. *Acacia karroo - Lippia javanica* Closed Woodland
   - 3.1 The *Acacia karroo - Maytenus polyacantha* Variation
   - 3.2 The *Acacia karroo - Adenia digitata* Variation
   - 3.3 The *Acacia karroo - Teucrium trifidum* Variation
4. The *Setaria lindenbergiana - Ehretia rigida* Bush-clumps
   - 4.1 The *Setaria lindenbergiana - Commelina africana* Variation
   - 4.2 The *Setaria lindenbergiana - Cheilanthes viridis* Variation
   - 4.3 The *Setaria lindenbergiana - Panicum maximum* Variation

Table 1. Phytosociological table of the Sub-humid Cool Temperate Mountain Bushveld.

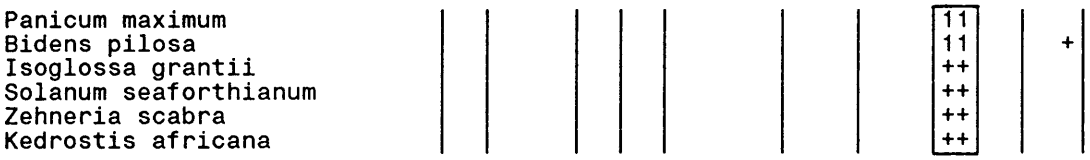
	11 99 45	11111 41310 84637	22 11 89	00 22 67	0122000 7566585 7376721	1111 2634 8645	1111 6061 7882	11 23 50	11 88 12	110 224 345
Community number	1	2	3.1	3.2	3.3	4.1	4.2	4.3	4.4	5
Species Group A										
Aristida transvaalensis	AA									
Clutia pulchella	++	+				+				
Bulbostylis burchellii	++									
Rhus magalismontana	++									+
Cheilanthes hirta	++						+			
Species Group B										
Protea caffra		B1BA3								
Athrixia elata		+++++			+					
Hypoxis rigidula		+++++		+	+					+
Diheteropogon amplectens		+++++		+	+					+
Tristachya biseriata		11 11		+	+					
Vernonia natalensis		++++								
Panicum natalense		++ ++								
Digitaria brazzae		1 + +								
Cymbopogon excavatus		++ +			+					+
Trachypogon spicatus		+++		+			+			
Digitaria diagonalis		1 +		+						
Hypericum aethiopicum		+ +								
Sphenostylis angustifolia		+ +								
Pearsonia sessilifolia		+ +								
Andropogon schirensis		+ +			+					
Eragrostis nindensis		+ +		+						
Xerophyta retinervis		+ +								+
Species Group C										
Acacia karroo			1	1A	13AA313	1				
Lippia javanica			++	++	1+++ ++					
Vernonia oligocephala			+	++	+++++					
Species Group D										
Maytenus polyacantha			11		+		+			
Felicia filifolia			+A							
Rhus rigida	+		++							
Carissa bispinosa			++							
Species Group E										
Hyparrhenia hirta			++	A1	+					
Eragrostis gummiflua				11						
Eragrostis superba		+		1+	1					+
Melinis nerviglume				1+						
Heteropogon contortus				++						
Geigeria burkei				++						
Striga elegans				++						
Adenia digitata				++						
Vernonia galpinii		+		++						
Eragrostis racemosa			+	++	+					++
Species Group F										
Teucrium trifidum					++++ ++					
Aloe transvaalensis					++++			+		
Conyza podocephala				+	++ +					
Species Group G										
Themeda triandra		31333	+1	3A	+ +B 1					11
Elionurus muticus		+ +	++	1A	+ +++ +					++
Species Group H										
Setaria lindenbergiana						+AA1	A11A	AA		
Ehretia rigida			+		+ +	1	++1	1		
Zanthoxylum capense			1	+	+	++	++ +			

Species Group I

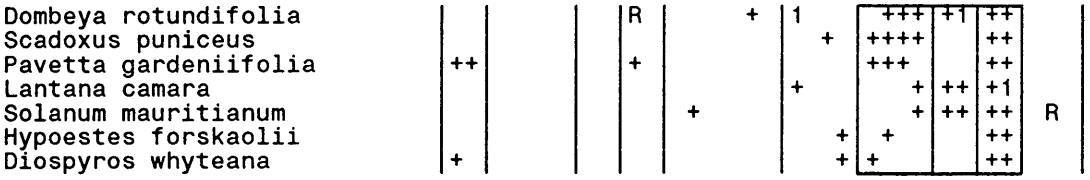
Species Group J



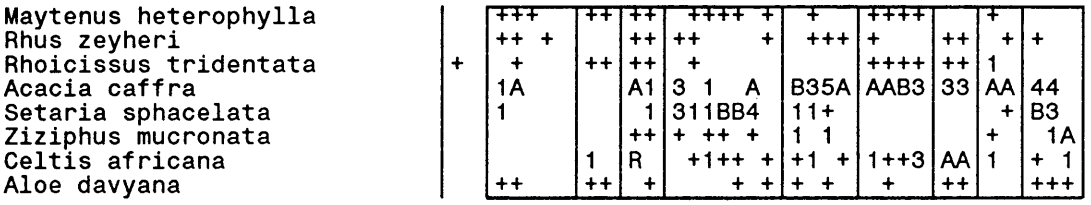
Species Group K



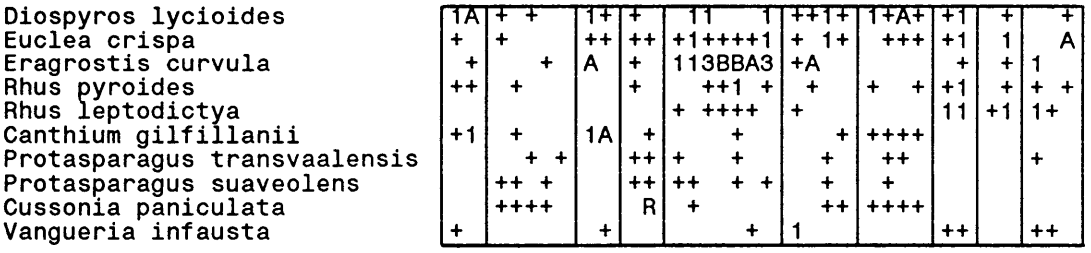
Species Group L



Species Group M



Species Group N



4.4 The *Setaria lindenbergiana - Hypoestes forskaolii* Variation

5. The *Acacia caffra - Setaria sphacelata* Closed Woodland

A diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the plant communities are given in Figure 2. The vegetation varies from open woodland to bush clumps in more protected environments. Most of the plant communities encountered are situated on the south facing slopes of rocky outcrops, except for two communities which are found on east facing slopes and one community is situated on the north and south facing slopes of localized hillocks. Characteristic of the vegetation of the Sub-humid Cool Temperate Mountain Bushveld is the woody species present in each plant community. The most abundant woody species with a high constancy are *Diospyros lycioides, Rhus pyroides* and *Euclea crispa.* Graminoids that occur frequently are *Setaria sphacelata* and *Eragrostis curvula.* A schematic illustration of the distribution of plant communities along the terrain unit gradient is presented in Figure 3.

Description of plant communities

1. *Aristida transvaalensis - Diospyros lycioides* Closed Woodland.

This is a localized plant community found on escarpments within the Ba land type, south-east of Heidelberg at an altitude of 1 600 - 1 650 m. The escarpments are situated on quartzite with interbedded shale and conglomerate. This community occurs on east facing slopes with an inclination from 25° to 35° and is situated on terrain unit 2. Rocks

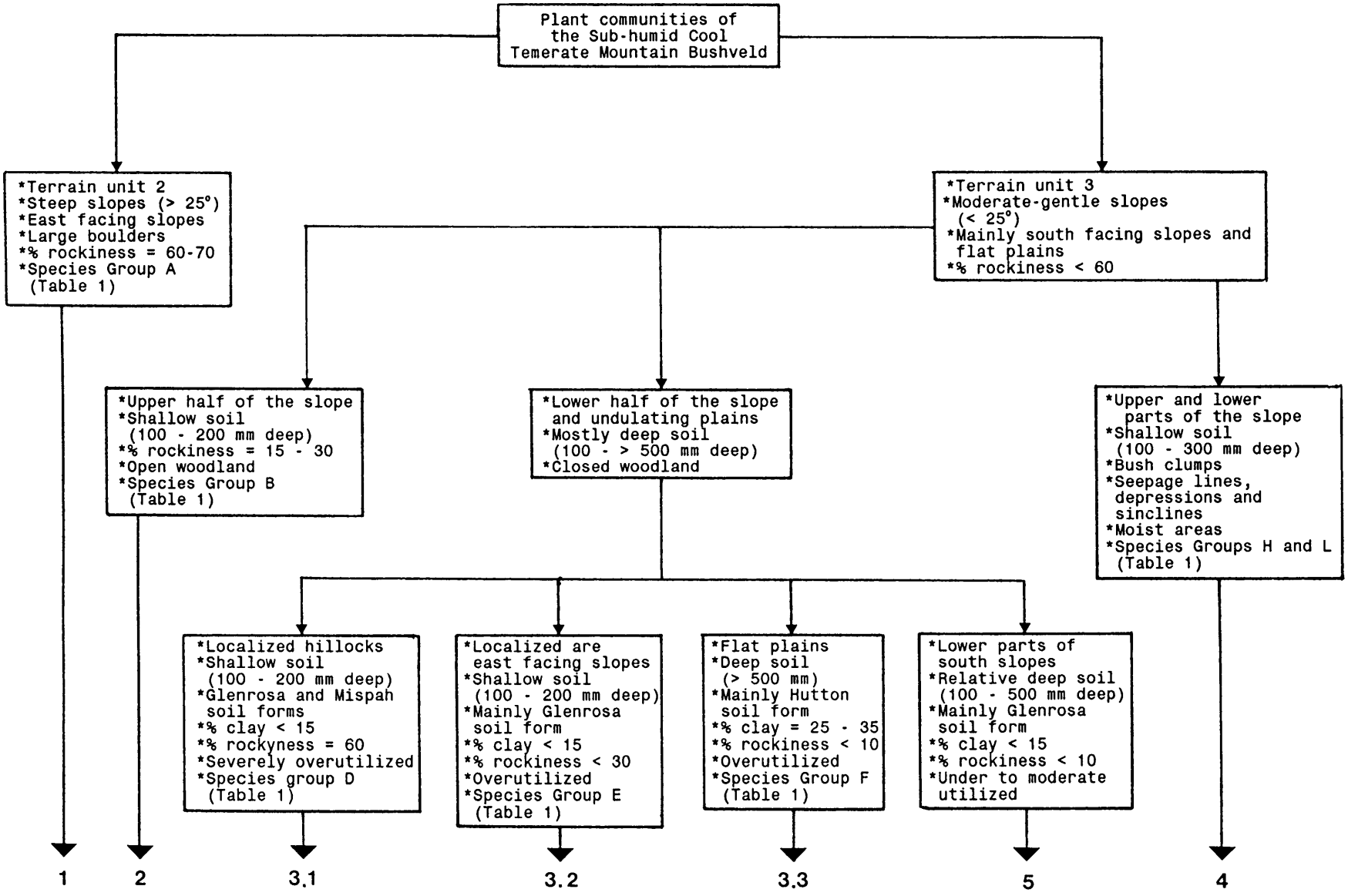


Figure 2. The hierarchical classification and associated environmental characteristics of the plant communities. Community numbers correspond with descriptions in text.

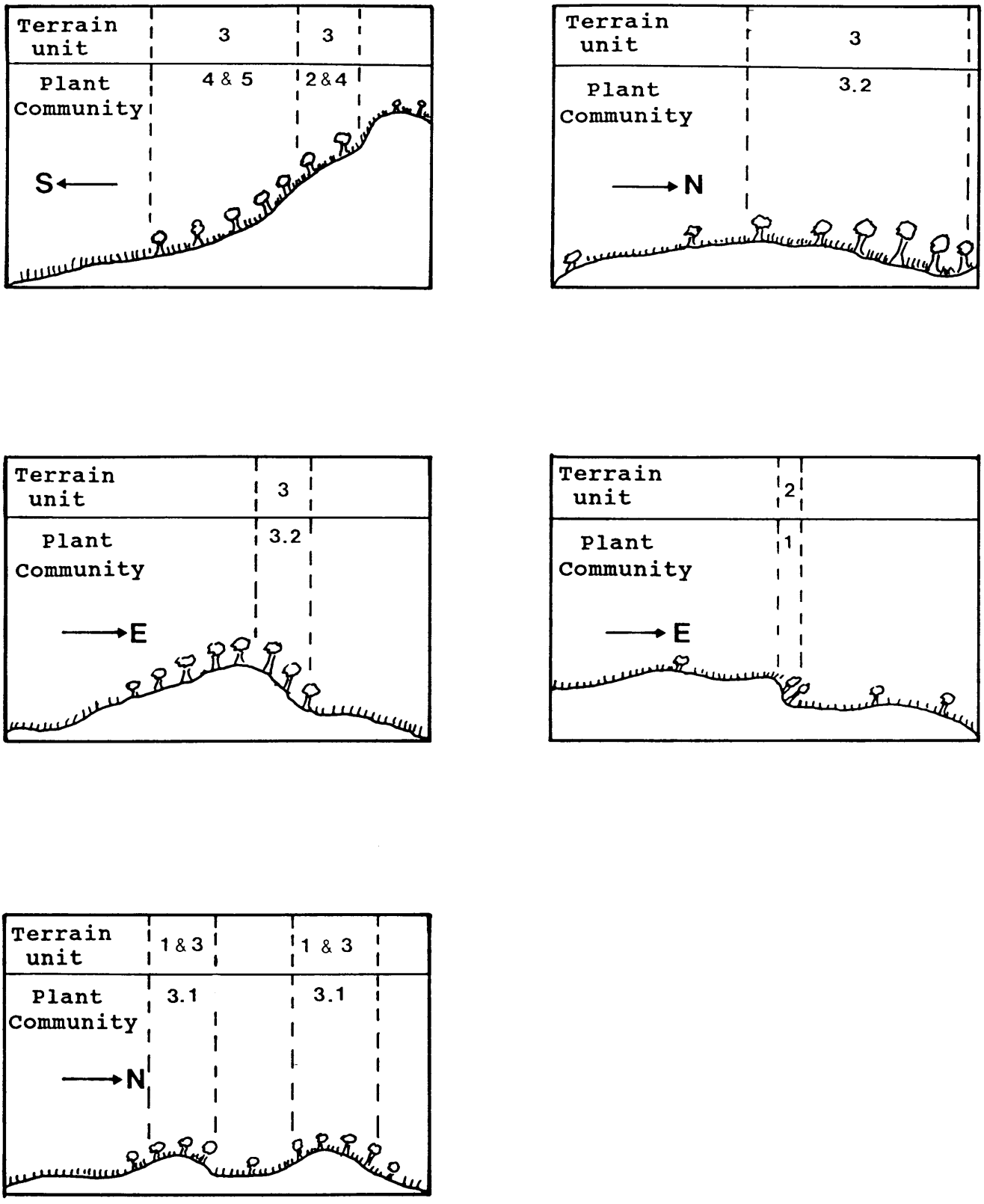


Figure 3. A schematic illustration of the distribution of the plant communities along terrain unit gradients. Addapted from Land Type Survey Staff (1985, 1987).

are large boulders and rock sheets, covering 60 to 70% of the soil surface. The soil is shallow (< 100 mm deep) with a clay content of less than 15% and is classified as Glenrosa (orthic A horizon on a lithocutanic B horizon) and/or Mispah (orthic A horizon on rocks) soil forms.

The most prominent woody species are the deciduous shrub *Diospyros lycioides,* and the much-branched shrub or small tree *Rhus pyroides*. The diagnostic, perennial, densely tufted grass *Aristida transvaalensis* is associated with rocky ridges and is often found to be wedged in rock fissures. Diagnostic species (Species Group A, Table 1) are the small shrub *Clutia pulchella,* the xerophytic perennial sedge *Bulbostylis burchellii*, the dwarf, evergreen shrublet *Rhus magalismontana* and the small xerophytic fern *Cheilanthes hirta.* Other abundant woody species are the shrubs or small trees *Pavetta gardeniifolia* and *Canthium gilfillanii.* An average of 21 species per sample plot was encountered in this community. Similar vegetation was described by Bredenkamp & Theron (1978), the specific plant communities may differ slightly in species composition.

2. *Protea caffra - Athrixia elata* Open Woodland.

This open woodland is found on the upper south facing slopes (altitude = 1 400 - 1 500 m) on quartzite ridges within the Ib land type with an inclination varying from 15° to 25°. Rocky outcrops and sheets occur only occasionally. The rockiness vary from 15 to 30% and consists of small to medium size rocks (100 - 500 mm diameter). The soil is shallow (50 - 200 mm deep) representing the Glenrosa and Mispah soil forms.

This plant community consists of nearly pure stands of the evergreen tree *Protea caffra.* Other woody species that occur only occasionally are *Maytenus heterophylla, Rhus zeyheri, Acacia caffra, Diospyros lycioides* and *Cussonia paniculata.* Besides *Protea caffra*, the most abundant diagnostic species are the much-branched perennial shrublet *Athrixia elata,* the perennial geophyte *Hypoxis rigidula,* the forb *Vernonia natalensis,* and the tufted, perennial graminoids *Diheteropogon amplectens, Panicum natalense, Digitaria brazzae* and *Tristachya biseriata* (Species Group B, Table 1). An average of 24 species per sample plot was encountered. The following communities, described by various authors, show similarities in species composition with this community: The *Protea caffra - Tristachya biseriata* Woodland (Theron 1973); the *Diheteropogon amplectens - Andropogon schirensis - Bulbostylis burchellii - Protea caffra* Variation (Du Plessis 1972); the *Protea caffra-Bulbostylis schoenoides - Rhynchosia totta* Savannas (Coetzee 1974); the *Tristachya biseriata - Protea caffra* Woodland (Coetzee 1975) and the *Rhus pyroides - Protea caffra* Savanna (Bredenkamp & Theron 1980).

3. *Acacia karroo - Lippia javanica* Closed Woodland.

This plant community is situated on severely overgrazed areas on the undulating and flat plains of the Ba land type at an altitude of 1 350 to 1 450 m. Various geological formations are present in this area but shale, hornfels and chert from the Silverton Formation of the Pretoria Group and diabase from the Waterberg Group are the most common (Coetzee *et al.* 1993).

This community is characterized by a dense woody layer of the microphalous thorny

trees *Acacia karroo* and *A. caffra,* which often form dense bush-clumps. In these bush-clumps species such as the much-branched evergreen shrub or small tree *Euclea crispa,* the deciduous trees *Celtis africana, Ziziphus mucronata, Rhus leptodictya* and *R. pyroides* and the erect woody shrublet *Protasparagus suaveolens* occur abundantly. Conspicuous grass species are *Setaria sphacelata, Eragrostis curvula* and to a lesser extent *Themeda triandra* and *Elionurus muticus.* The diagnostic species (Species Group C, Table 1) of this community are *Acacia karroo,* the erect much-branched shrublet *Lippia javanica* and the forb *Vernonia oligocephala.* Louw (1951), Werger (1978), Bredenkamp *et al.* (1989), Bredenkamp & Bezuidenhout (1990) and Bezuidenhout & Bredenkamp (1990) reported that *Acacia karroo* communities are associated with areas of moderately deep soils, with nutrient and clay accumulation. These conditions bring forth a palatable vegetation that is preferred and therefore heavily utilized by cattle and game. *Acacia karroo* communities are therefore often severely overutilized, resulting in bush thickening. This community corresponds to the following communities described by various authors: the Thornveld as briefly described by Louw (1951); the *Acacia karroo - Setaria sphacelata* Woodland (Theron 1973); the *Acacia karroo - Teucrium trifidum* Savanna community (Bredenkamp & Theron 1978); the *Acacia karroo* Closed Woodland (Van Rooyen 1984); the *Acacia karroo* Woodland (Bredenkamp *et al.* 1989); the *Grewia flava - Acacia karroo* Woodland (Bredenkamp & Bezuidenhout 1990); the *Rhus pyroides - Acacia karroo* Woodland (Bezuidenhout & Bredenkamp 1990); Acacion karroo (Bezuidenhout & Bredenkamp 1991) and the *Acacia karroo - Protasparagus laricinus* Thornveld (Kooij *et al.* 1991). Du Preez & Bredenkamp (1991) made a summary of *Acacia karroo* communities described from the Orange Free State. A syntaxonomical review of *Acacia karroo* communities in South Africa is necessary.

3.1 The *Acacia karroo - Maytenus polyacantha* Variation

This Variation is found on localized hillocks west of Heidelberg, on basaltic lava, agglomerate and tuff from the Klipriviersberg Group. The soil is relatively shallow (100 - 200 mm deep) representing the Glenrosa and Mispah soil forms. Surface rock cover is 60% consisting of large boulders and rock sheets. Characteristic of this Variation is that it is more degraded than variations 3.2 and 3.3.

The grass layer is severely degraded and only *Hyparrhenia hirta, Themeda triandra, Elionurus muticus* and *Eragrostis curvula* occurs with a cover abundance of less than 15% each. The diagnostic species (Species Group D, Table 1) are the dense and much branched, thorny evergreen shrublet *Maytenus polyacantha,* the perennial shrublet *Felicia filifolia*, the shrubs *Rhus rigida* and *Carissa bispinosa.* An average of 26 species per sample plot was encountered in this Variation.

3.2 The *Acacia karroo - Adenia digitata* Variation

This Variation occurs on east facing slopes at a localized area south east of Pretoria. The geology consists of shale and diabase and the inclination of the slopes is about 8°. The soil is shallow (100 - 200 mm deep) and is of the Glenrosa soil form. The rock cover is less than 30%, consisting of rock sheets and rocky outcrops.

Diagnostic species of this Variation (Species Group E, Table 1) are the graminoids *Eragrostis gummiflua, E. superba, Melinis nerviglume, Heteropogon contortus* and the forbs

Geigeria burkei and *Vernonia galpinii,* the parasitic *Striga elegans* and the herbaceous climber *Adenia digitata.* This variation has an average of 53 species per sample plot. The relatively high amount of species per sample plot may be due to the great variation of microhabitats that occur in these areas as a result of rock sheets and rocky outcrops that occur in places.

3.3 The *Acacia karroo - Teucrium trifidum* Variation

This Variation is situated on flat plains underlain by shale, diabase and sandstone from the Wilge River Formation of the Waterberg Group, north of Pretoria. The soil is deep (> 500 mm), mainly of the Hutton (orthic A horizon on a red apodal (structureless) B horizon) and Clovelly (orthic A horizon on yellow apodal(structureless) B horizon) soil forms. The clay content in the soil varies from 25 to 35%. Surface rocks were only encountered in two sample plots and the rock cover does not exceed 10%.

Diagnostic species (Species Group F, Table 1) are the erect herbaceous perennial shrublet *Teucrium trifidum,* the leaf succulent *Aloe transvaalensis* and the perennial herb *Conyza podocephala.* An average of 29 species per sample plot was encountered in this variation.

4. The *Setaria lindenbergiana - Ehretia rigida* Bush-clumps

This plant community is situated on the south facing slopes of quartzite ridges and hills within the Ib land type. These bush-clumps are found on localized moist areas such as

seepage lines, depressions, inclines and areas between or beneath rock sheets and boulders and is therefore less exposed than other communities. The rock cover varies from 20 to 30% and the soil is of the Mispah and Glenrosa soil forms, with a depth of 100 - 300 mm. Various degrees of erosion occur, especially within the seepage lines, resulting in the exposure of boulders and rocks.

Characteristic of this plant community is forest-like clusters of large trees (>10 m high) such as *Dombeya rotundifolia, Acacia caffra, Celtis africana* and *Rhus leptodictya*, resulting in a closed canopy cover. Species occurring in the sub-layer are the following shrubs (< 5 m tall): *Pavetta gardeniifolia, Diospyros whyteana, Maytenus heterophylla, Ehretia rigida, Zanthoxylum capense, Diospyros lycioides* and *Euclea crispa.* The herbaceous layer consists of the perennial rhizomatous graminoid *Setaria lindenbergiana*, the deciduous climber or sprawling shrub *Rhoicissus tridentata,* the exotic soft wooded weedy shrub *Solanum mauritianum,* the leaf succulent *Aloe davyana,* the bulbous geophyte *Scadoxus puniceus,* the forb *Hypoestes forskaolii* and the exotic weed *Lantana camara.* The diagnostic species (Species Group H, Table 1) are *Setaria lindenbergiana, Ehretia rigida* and *Zanthoxylum capense.* Similar communities were described by Bredenkamp & Theron (1980) as the *Euclea crispa -Maytenus polyacantha - Canthium gilfillanii* Bush and Savanna Communities from the Suikerbosrand Nature Reserve and by Coetzee (1975) as the *Setaria lindenbergiana - Acacia caffra* Woodland in the Rustenburg Nature Reserve.

The following four variations are recognised within this community:

4.1 The *Setaria lindenbergiana - Commelina africana* Variation which is characterized by Species Group I (Table 1) with *Digitaria eriantha* as a diagnostic graminoid, *Commelina africana* as a diagnostic forb and *Rothmannia capensis* as a diagnostic tree species. An average of 25 species per sample plot was encountered in this Variation.

4.2. The *Setaria lindenbergiana - Cheilanthes viridis* Variation which is, except for the xerophytic fern *Cheilanthes viridis*, characterized by woody species such as *Dovyalis zeyheri, Heteromorpha trifoliata, Scolopia zeyheri, Pittosporum viridiflorum, Psydrax livida* and *Buddleja saligna* (Species Group J, Table 1). Due to the presence of these diagnostic woody species it seems that this Variation is in a later successional state of development than the *Setaria lindenbergiana - Panicum maximum* Variation. An average of 27 species per sample plot was encountered in this Variation.

4.3. The *Setaria lindenbergiana - Panicum maximum* Variation is mainly characterized by pioneer grass and forb species, indicating that this Variation may be in an early successional stage. The diagnostic species are the graminoid *Panicum maximum*, the forbs *Bidens pilosa, Isoglossa grantii, Solanum seaforthianum* and *Zehneria scabra* and the herbaceous climber *Kedrostis africana* (Species Group K, Table 1). A average of 29 species per sample plot was encountered in this Variation.

4.4. The *Setaria lindenbergiana - Hypoestes forskaolii* Variation is characterized by the absence of Species Group H (Table 1). Although the diagnostic species for this

community are absent in variation 4.4, the communal species in Species Group L (Table 1), indicate that variation 4.4 is floristically related to variations 4.1, 4.2 and 4.3. This community was found to be severely overgrazed, with exotic weedy invader species such as *Lantana camara* and *Solanum mauritianum* prominently present. An average of 22 species per sample plot was encountered in this community.

No distinct environmental factors can be associated with variations 4.1, 4.2 and 4.3. However the floristic differences within these bush clumps seem to indicate different stages of development and are associated with the size of the clump. The floristic differences of Variation 4.4 however, is due to overgrazing.

5. The *Acacia caffra - Setaria sphacelata* Closed Woodland

This plant community is restricted to the lower parts (Figure 3) of the south facing slopes with an inclination less than 9°, on quartzite ridges and hills north of Pretoria. The soil is relative deep (100 - 500 mm deep) and represents the Glenrosa soil form with a clay content of less than 15%. Surface rocks are rare (< 10%) and no outcrops or rock sheets are found in this community.

This plant community is characterized by the absence of Species Group L (Table 1). The most conspicuous woody species are the trees (> 10 m high) *Acacia caffra, Ziziphus mucronata, Rhus leptodictya* and *Celtis africana.* The graminoids *Themeda triandra, Elionurus muticus* and *Setaria sphacelata* and the leaf succulent *Aloe davyana* are abundantly present. An average of 21 species per sample plot was encountered. Similar

plant communities were described as the *Acacia caffra - Teucrium capense* Savanna in the Jack Scott Nature Reserve (Coetzee 1974); the *Acacia caffra - Setaria sphacelata* Closed woodland in the Roodeplaatdam Nature Reserve (Van Rooyen 1984); the *Kalanchoe paniculata - Acacia caffra* Variation in the Rustenberg Nature Reserve (Coetzee 1975) and the *Acacia caffra - Teucrium trifidum* Savanna (Bredenkamp & Theron 1980) in the Suikerbosrand Nature Reserve.

Ordination

The distribution of relevés along the first and second axes of the ordination is given in Figure 4. Clear environmental gradients along these axes are illustrated found on the scatter diagram. Plant communities situated to the left of the diagram are mostly bush clumps, associated with moist habitats, while open woodland communities, associated with drier habitats are situated to the right. Communities on rocky habitats and shallow soils are situated to the top of the diagram and those of less rocky habitats and deeper soils to the bottom.

Concluding remarks

The classification obtained by TWINSPAN and refined by Braun - Blanquet procedures resulted in vegetation units that can be related to the environmental factors observed, and should therefore be considered as ecologically sound plant communities of the area concerned. The classification is supported by the results of the ordination and the latter also provides an understanding of the vegetation gradients and the associated habitat

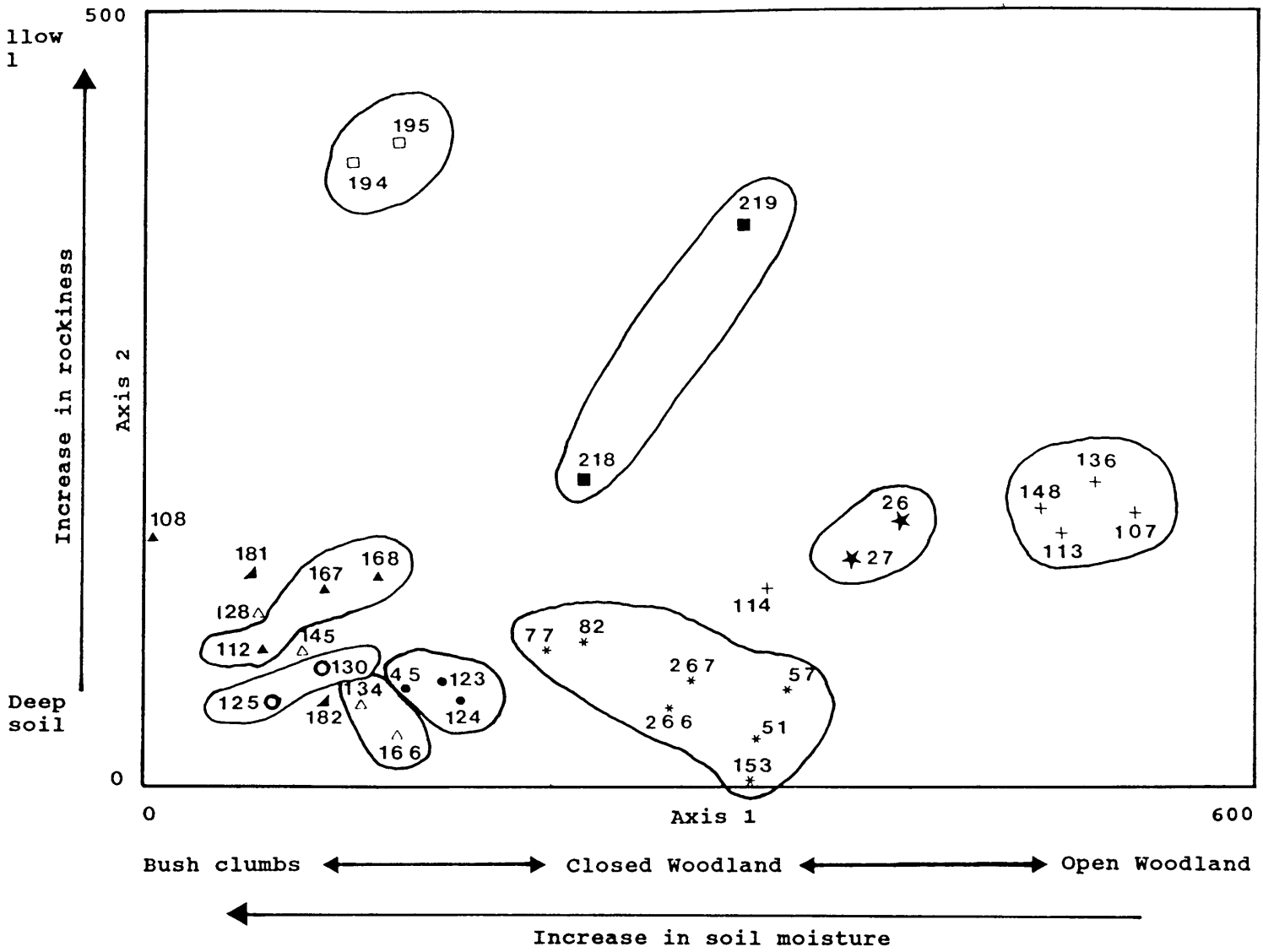


Figure 4. A DCA ordination diagram of the relevés representing the Sub-humid Cool Temperate Mountain Bushveld. □= the *Aristida transvaalensis - Diospyros lycioides* Closed Woodland; + = the *Protea caffra - Athrixia elata* Open Woodland; ■= the *Acacia karroo - Maytenus polyacantha* Variation; ★ = the *Acacia karroo - Adenia digitata* Variation; * = the *Acacia karroo - Teucrium trifidum* Variation; △ = the *Setaria lindenbergiana - Commelina africana* Variation; ▲ = the *Setaria lindenbergiana - Cheilanthes viridis* Variation; ○ = the *Setaria lindenbergiana - Panicum maximum* Variation; ◢ = the *Setaria lindenbergiana - Hypoestes forskaolii* Variation; ● = the *Acacia caffra - Setaria sphacelata* Closed woodland.

gradients within the association.

The classification contributes to the present scanty knowledge of the synecology and syntaxonomy of the Pretoria-Witbank-Heidelberg area and especially of the transitional area between the Grassland and Savanna Biomes.

Due to the present scanty synecological and syntaxonomical knowledge within the central-southern Transvaal grasslands, no attempt was made to formally fix names or ranks to syntaxa. Although formal syntaxonomical classifications were conducted in grasslands in the south-eastern Orange Free State and western Transvaal, these differ substantially from the synecology of the grasslands of the Pretoria-Witbank-Heidelberg area. However a formal syntaxonomical synthesis of the central, eastern and southern parts of the Transvaal should be done as soon as sufficient data are available.

As indicated in the descriptions of various plant communities similar vegetation types have been described by various authors, but floristic differences do occur among the communities. In many of these cases a syntaxonomical synthesis could clarify the syntaxonomic status of the communities described by various authors.

Acknowledgements

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CHAPTER 7

The phytosociology of the Grasslands of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area, South Africa.

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Abstract

An analysis of the plant communities of the Grasslands of the Pretoria-Witbank-Heidelberg area is presented. Relevés were compiled in 148 stratified random sample plots. A TWINSPAN classification, refined by Braun - Blanquet procedures, revealed fourteen plant communities and a hierarchical classification, description and ecological interpretation of each of these plant communities are presented. Each of these plant communities may be regarded as an unique entity with it's own species composition, specific environmental relationships and inherent forage production potential. The identification, classification and description of these plant communities are not only important for management purposes but also for the preservation of biotic diversity.

Introduction

Natural vegetation, being a composite result of several factors such as climate, soil and topography, serves as one of the clear indicators for the determination of agricultural regions and hence to a better understanding of problems of pasture management and soil conservation. Therefore, the basis for scientific veld management is the plant community. Each plant community has its own species composition with an own inherent production potential. Each plant community will react differently to certain management practices for example grazing pressure and burning. Pentz (1983) produced evidence to show that, in a country such as South Africa, any farming system not in accord with the natural vegetation must be regarded as artificial and a threat to the permanent occupation of the land. The necessity to identify and describe plant communities, not only for agricultural purposes but also in conservational management, is further well documented by Mentis & Huntley (1982) and Scheepers (1986). In order to provide an ecologically sound identification, description and interpretation of the grassland plant communities in the Pretoria-Witbank-Heidelberg area, an extensive survey, using the Zurich-Montpellier approach, was undertaken. In an overview of the vegetation of this area, Coetzee *et al.* (1993) recognised two distinct, though related major Grassland communities in the area concerned namely the *Bewsia biflora - Digitaria brazzae* Grassland, of rocky areas, representing Bankenveld of Acocks (1953, 1988) and Moist Cool Temperate Grassland of Werger (1978), and the *Helichrysum rugulosum - Conyza podocephala* Grassland, representing *Cymbopogon - Themeda* Veld of Acocks (1953, 1988) and Moist Cold Temperate Grassland of Werger (1978). Very little is known about the phytosociology of the grasslands of the Pretoria-Witbank-Heidelberg

area and therefore this report aims to identify, describe and interpret ecologically the different plant communities of the Grassland in this area.

Study area

The study area is situated within the Grassland Biome of South Africa (Rutherford & Westfall 1986), in the Pretoria-Witbank-Heidelberg area (Figure 1). Characteristic of this area is the undulating landscape with flat plains and with localized quartzite reefs. The quartzite reefs are mainly restricted to the Ib land type, characterized by rocky areas with miscellaneous soils. In contrast, the undulating and flat plains are found on the Ba land type, characterized by distrophic and mesotrophic red soils occurring on various geological formations (Land Type Survey Staff 1985, 1987). Most parts of the study area are situated at altitudes above 1 450 m, while restricted localized areas may be situated from 1 400 to 1 450 m above sea level. Due to the deep red soils, much of the Ba land type is utilised for intensive crop production. Thus, together with the increasing mining activities, rural and urban development, encroachment of foreign plant species and veld mismanagement, little of the natural vegetation is remaining and the plant communities represented in these remnants are poorly conserved. A detailed description of the physical environment of the study area is presented by Coetzee *et al.* (1993).

Methods

Relevés were compiled in 148 stratified random sample plots in vegetation taken to be in fair condition. Stratification was based on land type (Land Type Survey Staff 1985,

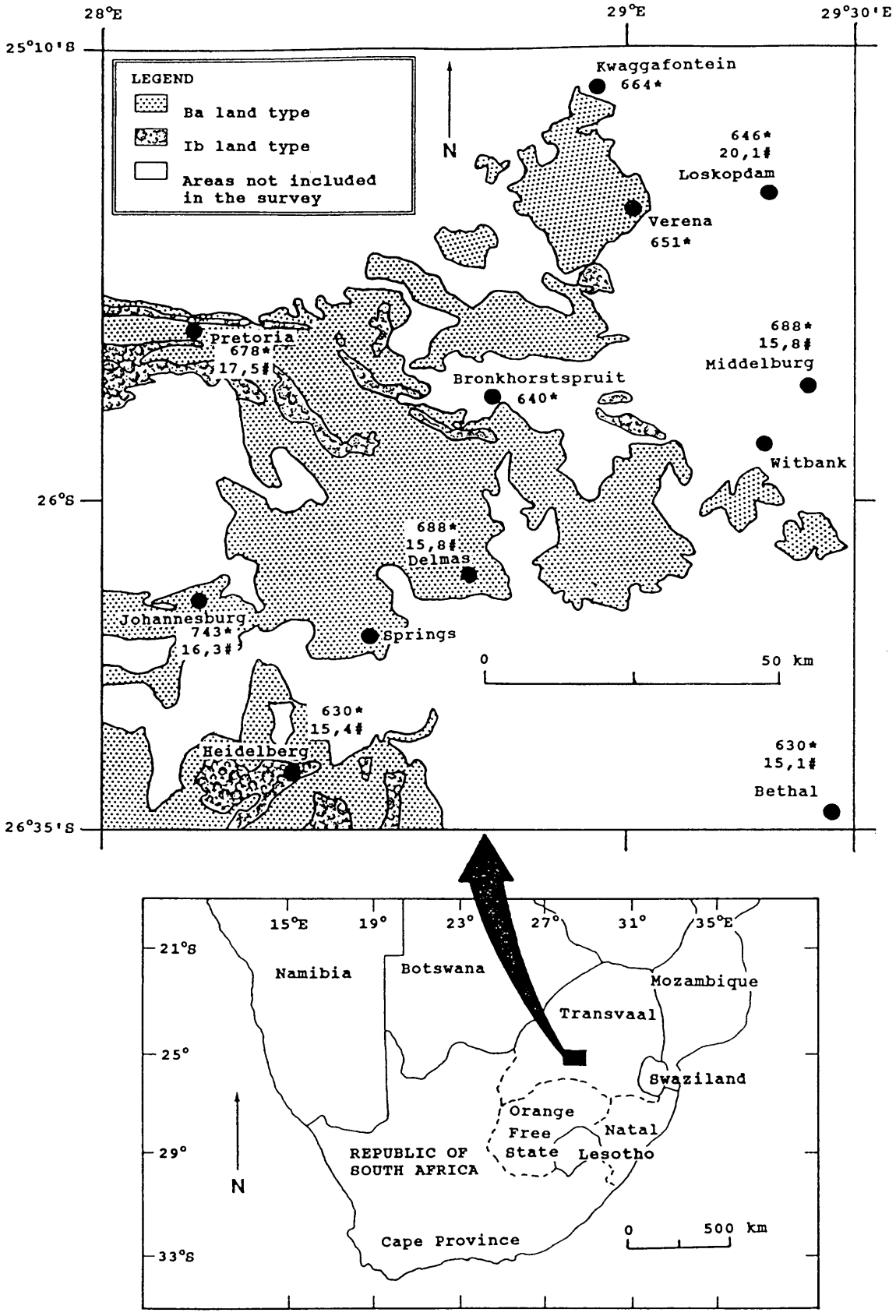


Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

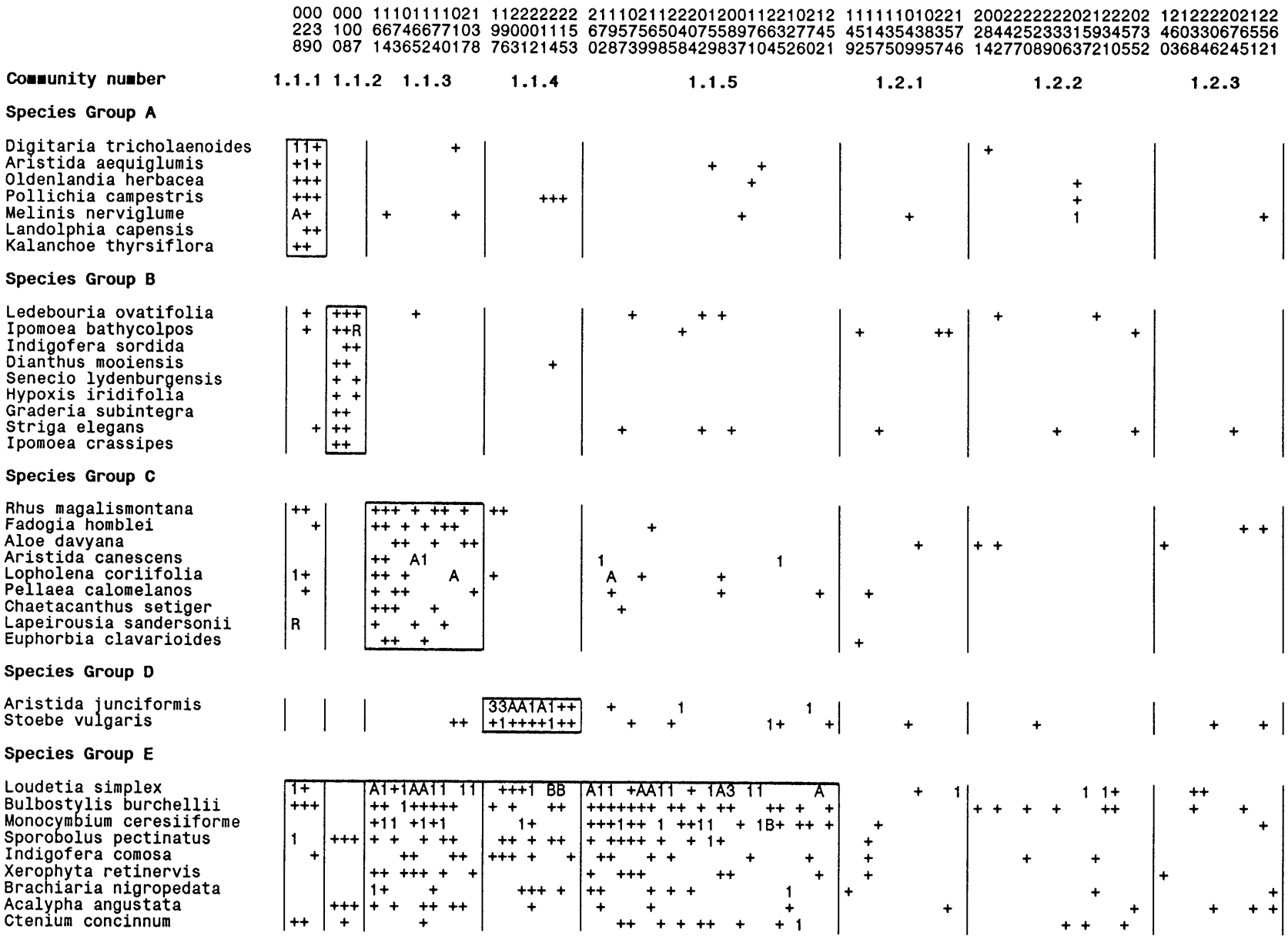
1987) and within land types on terrain units, namely 1 - crests, 2 - escarps and 3 - midslopes. Plot sizes varied from 200 m^2 in woody areas to 16 m^2 in grassland vegetation, in accordance with Bredenkamp & Theron (1978). In each sample plot the floristic composition, using the Braun - Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974) was recorded. Taxon and author names conform to those of Gibbs Russell *et al.* (1985, 1987). The environmental information that was recorded included land type, geology, terrain unit, aspect, slope, rockiness of the soil surface, soil type and depth, percentage clay, erosion, soil moistness and degree of utilization by herbivores.

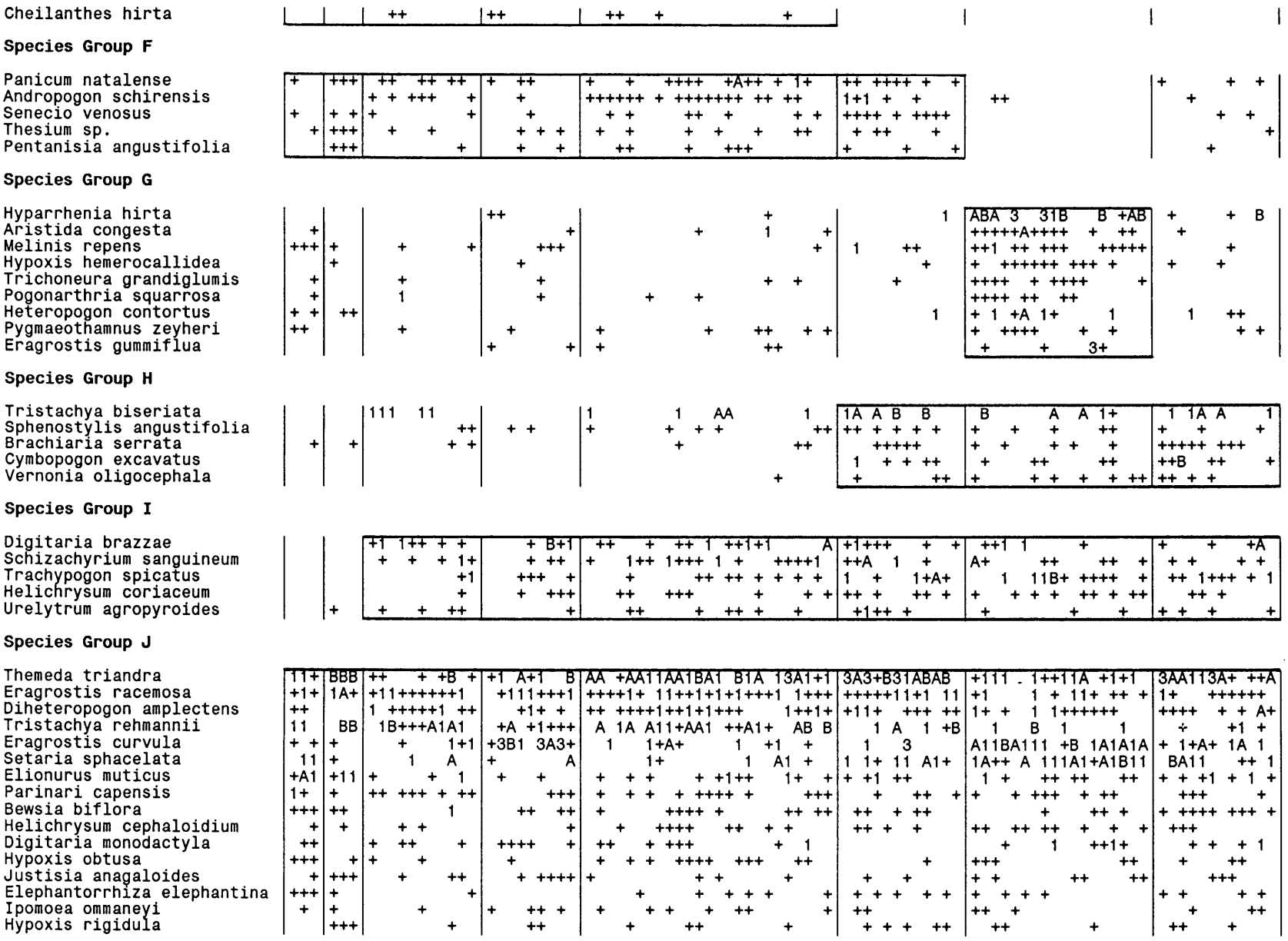
Two-way indicator species analysis (TWINSPAN) (Hill 1979) was applied to the floristic data set in order to derive a first approximation of the plant communities of the area. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). From the final phytosociological table, fourteen plant communities were identified (Table 1 & 2).

Results

According to the classification program TWINSPAN (Hill 1979), two distinct vegetation units occur in the study area (Coetzee *et al.* 1993) (Tables 1 & 2). The first unit is found on shallow rocky soils, mainly found on the quartzite ridges within the Ib and Ba land types. The plant communities of this unit are given in Table 1. According to Coetzee *et al.* (1993), this vegetation represents the *Bewsia biflora - Digitaria brazzae* Grassland, with the following diagnostic species: *Tristachya rehmannii, Panicum natalense, Digitaria*

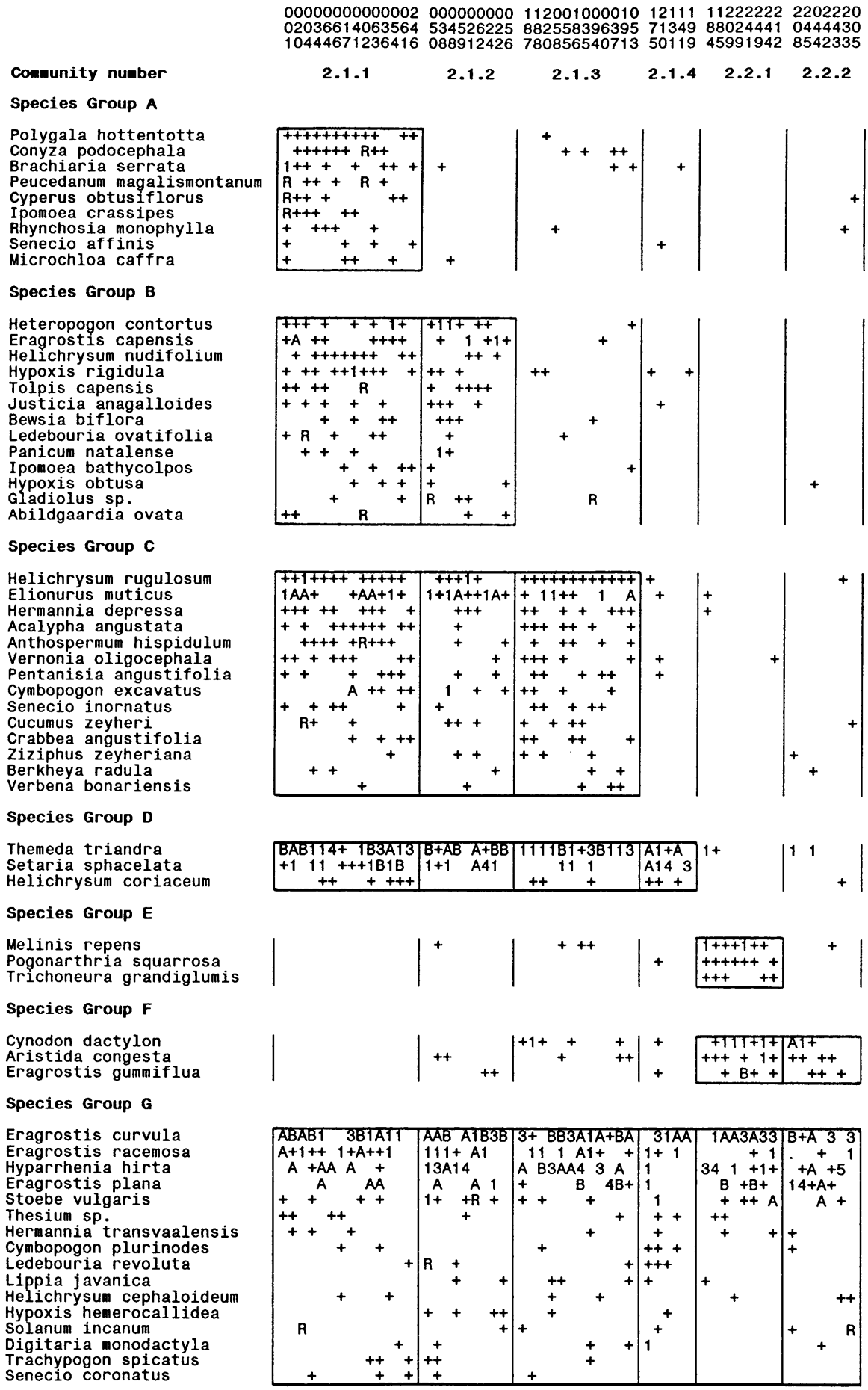
Table 1. Phytosociological table of the *Bewsia biflora - Digitaria brazzae* Grassland.





Rhynchosia monophylla	+	+	++ ++ +		+ + + +	+	+ +	+ +
Eragrostis nindensis	+		+ 1 +		+	1	11 ++ + +	++
Pearsonia sessilifolia		+			+ + + + +	+ +	+ + +	+ + +
Senecio coronatus	+	R	+		+ +	+ ++	+	+ +
Vernonia natalensis		+		+	+ + +	+	+	+ + + +
Dicoma anomala	+			+ ++	++	++ +	+	
Eriosema burkei				+ +	++ +		+ + + +	+
Boophane disticha		+			+	+	+ + R	+ + R
Burkea africana					1 1 1	1 1	1 1	A
Cleome maculata	+		+ + +	+	+		+	+
Cassia comosa					+ + +	++	+ +	+
Helichrysum dasymalum			+ +	+	+ + +	+		+
Eragrostis plana	14	+			A	A	+ 3	
Ledebouria revoluta			+ +	+ +		+	+	+
Cymbopogon plurinoides	+	+			+ +	+	+	+
Indigofera daleoides			+		+ + +		+	+ +
Protasparagus suaveolens	++		+		+	+		

Table 2. Phytosociological table of the *Helichrysum rugulosum - Conyza podocephala* Grassland.



brazzae, Bewsia biflora and *Monocymbium ceresiiforme.* Werger (1978) described this type of grassland as the Moist Cool Temperate Grassland. The second vegetation unit, the *Helichrysum rugulosum - Conyza podocephala* Grassland (Coetzee *et al.* 1993), is mainly restricted to moister, deeper soils than those of the *Bewsia biflora - Digitaria brazzae* Grassland and is mostly found on the undulating and flat plains within the Ba land type. The plant communities of this vegetation unit is presented in Table 2. Werger (1978) described this vegetation unit as the Moist Cold Temperate Grassland. Diagnostic species are *Cynodon dactylon, Eragrostis capensis, Helichrysum rugulosum, Anthospermum hispidulum, Hermannia depressa* and *Conyza podocephala* (Coetzee *et al.* 1993). Species that occur abundantly in both vegetation units are *Eragrostis curvula* and *Eragrostis racemosa* while *Themeda triandra* and *Setaria sphacelata* occur constantly in the less disturbed communities. A schematic diagram of the habitat interpretation of each vegetation unit is presented in Figures 2 and 3.

The *Bewsia biflora - Digitaria brazzae* Grassland (Table 1) is divided into eight distinct plant communities (Table 1), while the *Helichrysum rugulosum - Conyza podocephala* Grassland (Table 2) is divided into six distinct plant communities:

1. The *Bewsia biflora - Digitaria brazzae* Grassland
   1.1. *Bewsia biflora - Monocymbium ceresiiforme* Grassland
      1.1.1. *Eragrostis racemosa - Digitaria tricholaenoides* Grassland
      1.1.2. *Themeda triandra - Ledebouria ovatifolia* Grassland
      1.1.3. *Loudetia simplex - Rhus magalismontana* Grassland
      1.1.4. *Aristida junciformis - Stoebe vulgaris* Grassland

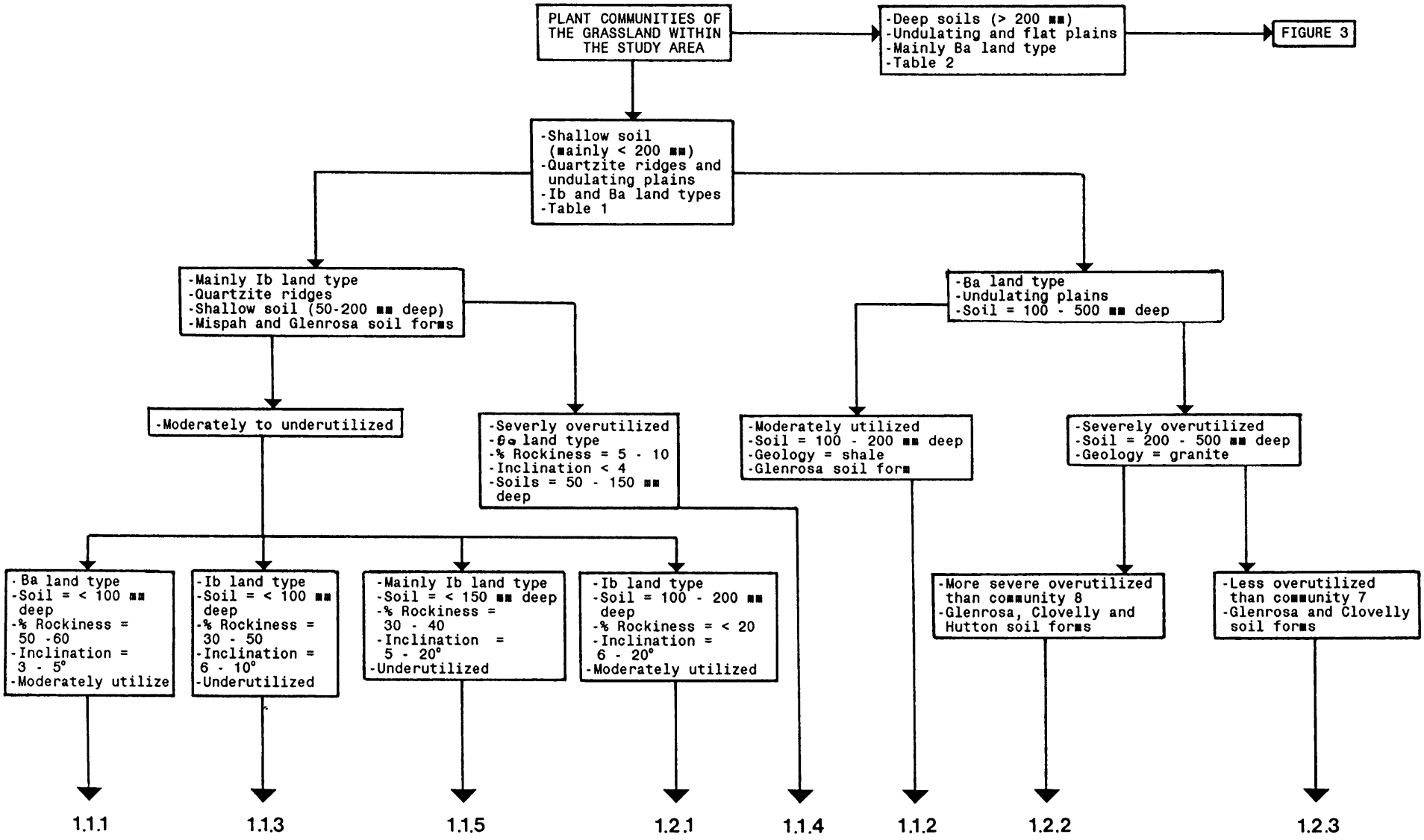


Figure 2. The hierarchical classification and associated environmental characteristics of the *Bewsia biflora* - *Digitaria brazzae* Grassland (Table 1). Community numbers correspond with descriptions in text.

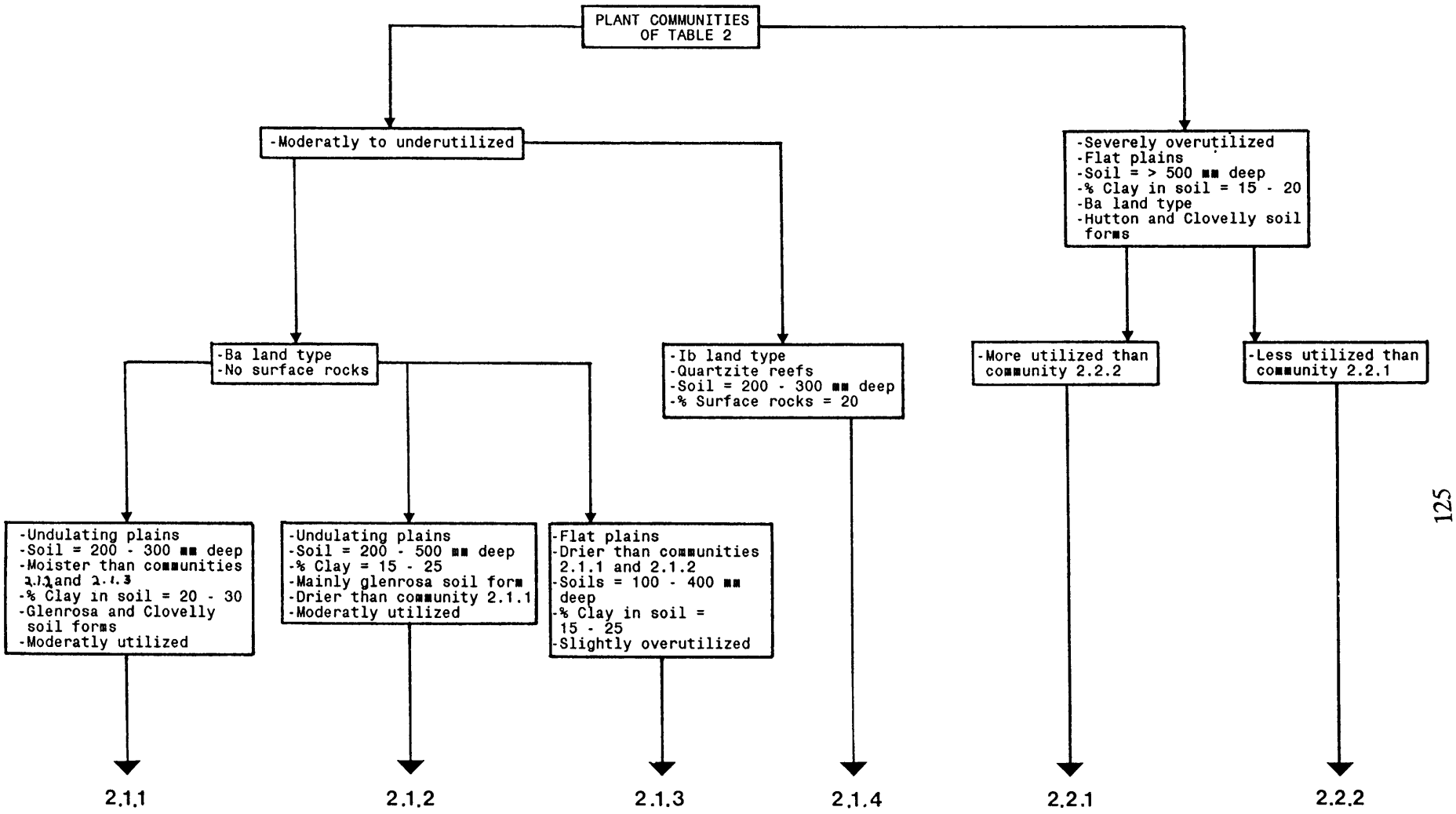


Figure 3. The hierarchical classification and associated environmental characteristics of the *Helichrysum rugulosum* - *Conyza podocephala* Grassland (Table 2). Community numbers correspond with descriptions in text.

1.1.5. *Loudetia simplex - Monocymbium ceresiiforme* Grassland

1.2. *Bewsia biflora - Tristachya biseriata* Grassland

1.2.1. *Themeda triandra - Tristachya biseriata* Grassland

1.2.2. *Hyparrhenia hirta - Aristida congesta* Grassland

1.2.3. *Trachypogon spicatus - Bewsia biflora* Grassland

2. The *Helichrysum rugulosum - Conyza podocephala* Grassland

2.1. *Themeda triandra - Setaria sphacelata* Grassland

2.1.1. *Themeda triandra - Brachiaria serrata* Grassland

2.1.2. *Themeda triandra - Heteropogon contortus* Grassland

2.1.3. *Themeda triandra - Hyparrhenia hirta* Grassland

2.1.4. *Themeda triandra - Ledebouria revoluta* Grassland

2.2. *Eragrostis gummiflua - Cynodon dactylon* Grassland

2.2.1. *Eragrostis gummiflua - Pogonarthria squarrosa* Grassland

2.2.2. *Eragrostis gummiflua - Aristida congesta* Grassland

1. *Bewsia biflora - Digitaria brazzae* Grassland (Coetzee *et al.* 1993).

The plant communities within this grassland are presented in Table 1.

1.1. *Bewsia biflora - Monocymbium ceresiiforme* Grassland.

This major plant community occurs on the rocky and stony slopes above an altitude of 1 450 m with a mean percentage rockiness of 30% and an inclination of 8-20°. The soils are shallow (mean depth is 100 mm) with Mispah and Glenrosa soil forms. Rocky

outcrops are conspicuous in this area. The higher percentage rockiness and outcrops in this Major plant community provides a micro-habitat that prevents excessive evaporation of water. Thus this vegetation unit is more moist than those which have a lesser percentage of rockiness.

Diagnostic species are the graminoids *Loudetia simplex, Sporobolus pectinatus, Monocymbium ceresiiforme, Brachiaria nigropedata* and *Ctenium concinnum*, the xerophytic sedge *Bulbostylis burchellii,* the xerophytic fern *Cheilanthes hirta* and the forbs *Indigofera comosa, Xerophyta retinervis* and *Acalypha angustata* (Species Group E, Table 1). The most conspicuous species are *Loudetia simplex, Monocymbium ceresiiforme* and *Themeda triandra.* Five plant communities were recognised in this major plant community.

1.1.1. *Eragrostis racemosa - Digitaria tricholaenoides* Grassland.

This plant community is restricted to the Witpoort area, north-east of Delmas, within the Ba land type (Figure 1). This grassland occurs on a localized geological feature of quartzitic reefs, with minor hornfels from the Magaliesberg Formation within the Pretoria Group. This community is situated from 1 450 to 1 500 m above sea level. The soils are shallow (>100 mm) with the Mispah (orthic A Horizon on rocks) and Glenrosa (orthic A horizon on a lithocutanic B horizon) soil forms predominant. The clay content of the soil is < 15%. Many rock sheets and rocky outcrops are found, with rocks covering 50 -60% of the soil surface. This community is not restricted to a specific aspect, and occurs on both north and south facing slopes with an inclination of 3-5°, and

also on the crests.

The only woody species found in this community are the small (0,5 - 1,5 m) evergreen semi-succulent shrub *Lopholaena coriifolia,* the scandent evergreen diagnostic *Landolphia capensis* and the evergreen dwarf shrub *Rhus magalismontana.* The most abundant perennial grass species are the densely tufted *Elionurus muticus*, *Eragrostis racemosa* and *Themeda triandra* and the rhizomatous, tufted *Bewsia biflora.* A conspicuous xerophytic sedge is the thread-like *Bulbostylis burchellii.* The following perennial graminoids are diagnostic (Species Group A, Table 1) for this community: the rhizomatous and tufted *Digitaria tricholaenoides,* the stout rhizomatous and densely tufted *Aristida aequiglumis* and the tufted *Melinis nerviglume.* The diagnostic forbs are the very slender *Oldenlandia herbacea* and the perennial, low-growing shrublet *Pollichia campestris.* An average of 49 species per sample plot was recorded. Most of these species are restricted to rocky areas.

1.1.2. *Themeda triandra - Ledebouria ovatifolia* Grassland.

This community was sampled on a localized area north-east of Delmas (Figure 1) on the farm Groenfontein on diamictite and shale of the Dwyka Formation from the Karoo Sequence. This community is situated on the east and west facing slopes with an inclination of 3° and at an altitude of 1 550 m. The soil contains more or less 15% clay and represents the Glenrosa soil form. Surface rock varies from 0 - 10%. This community is moderately utilized by livestock with little erosion present.

The most abundant graminoid species with a canopy cover of 12 - 25% are *Themeda triandra, Tristachya rehmannii* and the wiry, perennial and densely tufted *Eragrostis curvula*. Grass species with a smaller canopy cover, but still abundantly present are *Elionurus muticus, Panicum natalense* and the rhizomatous *Sporobolus pectinatus.* No woody species occur in this community. All diagnostic species (Species Group B, Table 1) are forbs, including the geophyte *Ledebouria ovatifolia,* the scandent creeper *Ipomoea bathycolpos,* the shrublet *Indigofera sordida* and *Dianthus mooiensis.* An average of 41 species per sample plot was recorded.

1.1.3. *Loudetia simplex - Rhus magalismontana* Grassland.

This community is found on quartzite and minor hornfels ridges representing the Ib land type on the Magaliesberg Formation from the Pretoria Group, situated 1 500 - 1 580 m above sea level. These areas lie north and north-west of the Bronkhorstspruit Dam with a few sample plots south-west of Pretoria. The community is situated mainly on the north facing slopes with an inclination of 6 to 10°, and also on the crests of the ridges. The soil is shallow, from the Glenrosa soil form, with 30 - 50% surface rocks. The percentage clay of the soil is < 15%. Most of the sample plots are undisturbed or underutilized by livestock, probably as a result of the unpalatable (sour) nature of the vegetation.

Conspicuous species are the dwarf shrub *Rhus magalismontana,* the tufted grasses *Loudetia simplex* and *Tristachya rehmannii* which are indicators of sour veld (Van Wyk & Malan 1988), the loosely tufted perennial grass *Monocymbium ceresiiforme* and also

Eragrostis racemosa. The diagnostic woody species are the shrublets *Fadogia homblei*, *Lopholaena coriifolia* and *Rhus magalismontana*. The only diagnostic graminoid is the slender tufted perennial *Aristida canescens* subsp. *canescens*. Although *Aristida canescens* subsp. *canescens* is often an indicator of eroded and disturbed soil (Van Oudtshoorn 1991), it is not the case in this community, but rather of the natural harsh, rocky environmental conditions. Only one sample plot was recorded that was slightly disturbed and eroded. Diagnostic succulent species are leaf succulent *Aloe davyana* and semi-succulent *Euphorbia clavarioides* with *Pellaea calomelanos* as diagnostic xerophytic fern and *Chaetacanthus setiger* and *Lapeirousia sandersonii* as diagnostic forbs. An average of 27 species per sample plot was recorded.

1.1.4. *Aristida junciformis - Stoebe vulgaris* Grassland.

This community is restricted to rocky outcrops consisting of partly ferruginous shale, quartzite and banded ironstone of the Hospital Hill Formation of the West Rand Group and ferruginous shale of the Timeball Hill Formation of the Pretoria Group around Heidelberg (Figure 1). This community is not restricted to a specific aspect, but more than 50% of the sample plots were situated on north facing slopes. The inclination is not more than 4°. A few rock sheets and outcrops (5 - 10% surface rocks) are prominent. The soils are shallow (50 -150 mm deep) representing the Mispah and Glenrosa soil forms. The clay content in the soil is < 15%. This community is severely overgrazed as indicated by the presence of *Aristida junciformis* subsp. *junciformis* (Gibbs Russell *et al.* 1991) and *Stoebe vulgaris* (van Wyk & Malan 1988) both diagnostic species (Species Group D, Table 1). Species that can be regarded as relatively abundant are

Loudetia simplex, Sporobolus pectinatus, Bulbostylis burchellii and *Indigofera comosa.* An average of 22 species per sample plot was recorded.

1.1.5. *Loudetia simplex - Monocymbium ceresiiforme* Grassland

This community is found on rocky outcrops consisting of quartzite and minor hornfels from the Magaliesberg Formation of the Pretoria Group and shale, sandstone, conglomerate and volcanic rocks from the Loskop Formation of the Bushveld Complex south of Verena (Figure 1). This community is situated mainly in the Ib land type on altitudes varying from 1 500 to 1 690 m above sea level. The soil is shallow (<150 mm deep) representing the Glenrosa and Mispah soil forms. The clay content in the soil is more or less 15%. The surface rock cover varies from 30 - 40%. This community is not restricted to a specific aspect but occurs mainly on the south and east facing slopes and crests. The inclination varies mainly from 5 - 20° but extreme cases were recorded of up to 30°. Most of the sample plots were underutilized by livestock.

No diagnostic species is found and this community is characterized by the presence of Species Group E (Table 1) and the absence of Species Groups C and D (Table 1). There are no specific dominant species to be found, the most abundant species are however *Ctenium concinnum, Loudetia simplex, Monocymbium ceresiiforme, Panicum natalense, Andropogon schirensis, Sporobolus pectinatus* and *Bulbostylis burchellii*, all indicators of rocky habitats. This area was mapped by Acocks (1953, 1988) as Mixed Bushveld and\or Sourish Mixed Bushveld, but this vegetation clearly represents typical Bankenveld grassland (Coetzee *et al.* 1993). An average of 23 species per sample plot was recorded.

1.2. *Bewsia biflora - Tristachya biseriata* Grassland.

This vegetation unit can be found on somewhat less stony undulating plains with a mean percentage rockiness on the soil surface of 5 - 10%, an inclination of 2-6° and with drier and deeper soils (mean depth is 200 mm), than the *Bewsia biflora - Monocymbium ceresiiforme* Grassland.

Diagnostic Species are the graminoids *Tristachya biseriata, Brachiaria serrata* and *Cymbopogon excavatus* and the forbs *Sphenostylis angustifolia* and *Vernonia oligocephala.* (Species Group H, Table 1). Conspicuous species are *Eragrostis curvula, Setaria sphacelata, Elionurus muticus* and *Tristachya biseriata.*

1.2.1. *Themeda triandra - Tristachya biseriata* Grassland.

The hills and ridges that consist of quartzite (Magaliesberg Formation), andesite (Hekpoort Formation) and dolomite (Malmani Subgroup), all of the Pretoria Group, represent the largest area of this community. Although this community occurs mainly on the Ib land type (Figure 1), a few sample plots are also situated in the Ba land type. This community is only found on south facing slopes on the hills and ridges. The inclination does not exceed 6° on the hills but may be as steep as 20° on the quartzite ridges. The altitude varies from 1 450 to 1 550 m. The soil is shallow (100 - 200 mm), contains more or less 15% clay and represents the Glenrosa and Mispah soil forms. Rocky outcrops and rock sheets do not occur frequently and the surface rock cover does not exceed 20%. Most of the sample plots are moderately utilized to overutilized by

livestock.

This grassland is characterized by the presence of Species Group F (Table 1) and the absence of Species Group E (Tabel 1). The presence of Species Group H (Table 1) indicate an environment that is less rocky with slightly deeper soils and a more undulating landscape. The most abundant graminoid species are the rhizomatous and densely tufted perennial *Panicum natalense* that is an indicator of sour veld (Van Wyk & Malan 1988; Van Oudtshoorn 1991), *Themeda triandra,* the perennial rhizomatous *Diheteropogon amplectens, Eragrostis racemosa* and the fairly robust, rhizomatous and tufted perennial *Setaria sphacelata.* An average of 25 species per sample plot was recorded.

1.2.2. *Hyparrhenia hirta - Aristida congesta* Grassland.

This grassland is mainly found on grey to pink coarse-grained granite from the Lebowa Granite Suite of the Bushveld Complex west and south-west of Verena (Figure 1). This community is situated at 1 400 to 1 500 m above sea level on the Ba land type. The landscape consists of slightly undulating plains with slopes of not more than 6°. The aspect is of no importance in this community. The soils are relatively deep (200 - 500 mm) representing the Glenrosa, Clovelly (orthic A horizon on yellow apodal (structureless) B horizon) and Hutton (orthic A horizon on a red apodal (structureless) B horizon) soil forms. The clay content in the soil varies from 15 to 20%. In most of the sample plots no surface rocks were encountered. This community is severely overgrazed, with moderate to severely eroded areas. Termite mounds occur abundantly

in some areas. As is the case with community 1.1.5, the *Loudetia simplex - Monocymbium ceresiiforme* Grassland, this community also represents Bankenveld grassland rather than Mixed or Sourish Mixed Bushveld as mapped by Acocks (1953, 1988).

The vegetation is mostly dominated by the tall rhizomatous and wiry perennial grass *Hyparrhenia hirta* while the tufted perennials *Heteropogon contortus, Eragrostis curvula,* and *Setaria sphacelata* are also abundantly present. The diagnostic graminoids are *Hyparrhenia hirta,* the annual pioneers *Aristida congesta,* and *Trichoneura grandiglumis,* and the perennial pioneers *Pogonarthria squarrosa, Eragrostis gummiflua* and *Heteropogon contortus.* The two diagnostic non-grassy species are the geophyte *Hypoxis hemerocallidea* and the erect, sparsely branched geoxylophyte *Pygmaeothamnus zeyheri.* An average of 23 species per sample plot was recorded.

1.2.3. *Trachypogon spicatus - Bewsia biflora* Grassland

This community is closely related, environmentally and floristically (Species Group J Table 1), to the *Hyparrhenia hirta - Aristida congesta* Grassland (community 1.2.2). The differences between these two communities are that here the slopes are more gentle (maximum inclination is 4°) and the vegetation is less severely overgrazed, resulting in the absence of Species Group G (Table 1). The vegetation is dominated by *Themeda triandra*, with *Eragrostis curvula* and *Tristachya biseriata* also prominent. An average of 20 species per sample plot was recorded.

2. *Helichrysum rugulosum - Conyza podocephala* Grassland (Coetzee *et al.* 1993).

The plant communities of this grassland are presented in Table 2.

2.1. *Themeda triandra - Setaria sphacelata* Grassland.

This grassland represents less disturbed or lightly to moderately grazed areas which are characterized by prominence of *Themeda triandra* and *Setaria sphacelata* (Species Group D, Table 2).

2.1.1. *Themeda triandra - Brachiaria serrata* Grassland.

This community is found on carbonaceous shale from the Silverton Formation of the Pretoria Group and on diabase of the Waterberg Group. The landscape consists of very gentle undulating plains with flat areas. The inclination does not exceed 4° and the aspect is of no importance. The soils are relatively deep (200 - 300 mm) mainly representing the Glenrosa and Clovelly soil forms. The clay content of the soil varies from 20 - 30%. Most of the sample plots in this community occur in depressions that are moister than the habitat of the other communities in Table 2. This community is moderately utilized by livestock with only a few sample plots that are overgrazed.

This community can easily be distinguished by the following diagnostic species: the slender forbs *Polygala hottentotta* and *Peucedanum magalismontanum*, the perennial sedge *Cyperus obtusiflorus* subsp. *obtusiflorus* and the perennial short graminoid *Microchloa*

caffra (Species Group A, Table 2). Many of the diagnostic species are indicators of slightly moist conditions (Van Wyk & Malan 1988). Abundant species, with a total canopy cover of 5 - 25%, are the graminoides *Themeda triandra, Setaria sphacelata, Eragrostis curvula* and *Eragrostis racemosa.* An average of 35 species per sample plot was recorded.

2.1.2. *Themeda triandra - Heteropogon contortus* Grassland.

This community is mainly situated on shale from the Silverton Formation of the Pretoria Group. The landscape is similar as in community 2.1.1 except for a few sample plots with a more steep inclination (6°). The soil depth varies from 200 - 500 mm with a clay content of 15 - 25%. The soil is representative of the Glenrosa soil form. The vegetation in the sample plots is lightly or moderately utilized. The main difference between this community and community 2.1.1 is that the habitat of this community is drier, resulting in the absence of species from Species Group A. The most abundant species are the grass species *Elionurus muticus, Themeda triandra, Setaria sphacelata, Eragrostis curvula, E. racemosa* and also *Hyparrhenia hirta* in some places. No diagnostic species were identified but the community can be recognised by the presence of Species Group B and the absence of Species Group A (Table 2). An average of 25 species per sample plot was recorded.

2.1.3. *Themeda triandra - Hyparrhenia hirta* Grassland.

This community is found on various geological formations namely shale and hornfels

from the Silverton Formation of the Pretoria Group, diabase from the Waterberg Group, dolomite and chert from the Chuniespoort Group, all between Pretoria and Delmas and also on basaltic lava, agglomerate and tuff from the Klipriviersberg Group around Heidelberg (Figure 1). This community occurs on flat plains and its habitat is drier than that of communities 2.1.1 and 2.1.2. The soil in most of the sample plots contains 15 - 25% clay, although the clay content may be sometimes as high as 35%. The soil is mainly of the Glenrosa and Hutton forms and the soil depth varies from 100 to 400 mm. This community shows signs of overutilization as indicated by the presence of the pioneer graminoids *Cynodon dactylon* and *Aristida congesta* (Species Group F).

This grassland is characterized by the presence of Species Group C and the absence of Species Group B (Table 2). Although the grass species *Eragrostis curvula* and *Themeda triandra* are the most prominent species, tallgrowing *Hyparrhenia hirta* is locally the most conspicuous especially in overgrazed areas. Other species constantly present in this community are the grasses *Elionurus muticus* and *Eragrostis curvula* and the forbs *Helichrysum rugulosum, Hermannia depressa, Acalypha angustata* and *Senecio inornatus.* An average of 20 species per sample plot was recorded.

2.1.4. *Themeda triandra - Ledebouria revoluta* Grassland

This grassland is restricted to the south facing slopes (4 - 8°) and crests of quartzite ridges with relatively deep soils (200 - 300 mm), within the Ib land type. The soil is well drained and drier than that of communities 2.1.1, 2.1.2 and 2.1.3 with a clay content of less than 15%. Surface rocks are rare (20 %). All the sample plots in this community

were undisturbed and underutilized.

This community is characterized by the presence of Species Group D and the absence of Species Group C (Table 2). The most conspicuous and dominant grass species are *Themeda triandra, Setaria sphacelata* and *Eragrostis curvula.* Species with a relatively high presence but of no diagnostic value, are the graminoid *Cymbopogon plurinodis* and the geophyte *Ledebouria revoluta* (Species Group G, Table 2). Species that can be regarded as locally common are *Hyparrhenia hirta, Eragrostis plana* and *Stoebe vulgaris* (Species Group G, Table 2). An average of only 15 species per sample plot was recorded. This relatively low species richness is typical of areas where the vegetation is dominated by the tall growing *Hyparrhenia hirta* which overshadow and exclude many other species.

2.2. *Eragrostis gummiflua - Cynodon dactylon* Grassland.

This grassland represents overgrazed and trampled areas which is characterized by Species Group F (Table 2) and where *Themeda triandra* and *Setaria sphacelata* are almost entirely absent.

2.2.1. *Eragrostis gummiflua - Pogonarthria squarrosa* Grassland.

This degraded community is situated on shale and Tillite from the Dwyka Formation of the Karoo sequence and basaltic lava, agglomerate and tuff from the Klipriviersberg Formation. These flat plains consist mainly of the deep (> 500 mm) Hutton and Clovelly soil forms with a clay content of 15 - 20%. This grassland is severely overgrazed

and disturbed and many areas were cultivated resulting in pioneer vegetation.

The most conspicuous grass species are *Eragrostis curvula, Hyparrhenia hirta* and the perennial densely tufted *Eragrostis plana* (Species Group G, Table 2). The diagnostic species are the tufted, pioneer or sub-climax annual *Melinis repens* and *Trichoneura grandiglumis* and the tufted, pioneer perennial *Pogonarthria squarrosa*. The disturbed nature of this vegetation is further emphasized by the constant occurrence of the pioneer grasses *Cynodon dactylon, Aristida congesta* and *Eragrostis gummiflua* (Species Group F, Table 2). An average of only 11 species per sample plot was recorded.

2.2.2. *Eragrostis gummiflua - Aristida congesta* Grassland

The geographical distribution and environmental conditions of this community are similar to those of community 2.2.1 indicating that these communities may be regarded related floristically and ecologically but due to different degrees of overgrazing, they are in different stages of degradation. This community is characterized by the presence of Species Group F and the absence of Species Group E (Table 2) resulting in a poorer species composition and entirely dominated by pioneer species such as *Cynodon dactylon, Aristida congesta, Aristida gummiflua, Eragrostis curvula* and *Hyparrhenia hirta*, indicating that this community is even more degraded than community 2.2.1. An average of 12 species per sample plot was recorded.

Concluding remarks

All plant communities are clearly related to specific environmental conditions and are therefore ecologically recognisable and interpretable. The delineation of the plant communities and associated habitats of the grassland of the Pretoria-Witbank-Heidelberg area should be used as the basis for future management and conservation of these areas.

Large parts of the study area that was mapped by Acocks (1953, 1988) as Bankenveld, should be regarded according to Coetzee *et al.* (1993), as part of the Northern Variation of the *Cymbopogon - Themeda* Veld. These areas are classified within the *Helichrysum rugulosum - Conyza podocephala* which is according to the species composition, similar to the Northern Variation of the *Cymbopogon - Themeda* Veld. The Bankenveld on the contrary is similar to the *Bewsia biflora - Digitaria brazzae* Grassland (Coetzee *et al.* 1993). These findings are supported by the phytosociological tables (Tables 1 & 2) of the two vegetation units. Species that are typical of the *Cymbopogon - Themeda* Veld (Acocks 1953. 1988) are *Setaria sphacelata, Themeda triandra, Heteropogon contortus, Helichrysum rugulosum, Cynodon Dactylon, Brachiaria serrata, Eragrostis plana, Cymbopogon plurinodis* and *Eragrostis* spp. and that of the Bankenveld, *Trachypogon spicatus, Digitaria tricholaenoides, Tristachya leucothrix, Loudetia simplex, Tristachya rehmannii, Monocymbium ceresiiforme, Urelytrum agropyroides, Diheteropogon amplectens, Digitaria monodactyla* and *Parinari capensis.* Some species with a wide ecological amplitude for example *Setaria sphacelata, Themeda triandra* and *Eragrostis racemosa*, occur in both vegetation units (Tables 1 and 2) but are often more conspicuous in the one unit than in the other.

According to Coetzee *et al.* (1993) the part of the Ba land type that is situated in the Mixed Bushveld and\or Sourish Mixed Bushveld map units of Acocks (1953, 1988), to the north and south-west of Verena, should be regarded as Bankenveld, according to the species compositions. The plant communities found in those areas are classified within the *Loudetia simplex - Monocymbium ceresiiforme* and the *Hyparrhenia hirta - Aristida congesta* Grasslands which are both classified within the *Bewsia biflora - Digitaria brazzae* Grassland (Coetzee *et al.* 1993), typical of Bankenveld vegetation.

Although various grassland communities have been described by various authors (eg. Bredenkamp & Theron, 1980; Kooij *et al.*, 1990; Bezuidenhout & Bredenkamp, 1991) and floristic and ecological similarities with some of the plant communities described in this report may occur, a syntaxonomic comparison of the grassland communities is not desirable at the present, because of the lack of phytosociological data in large parts of eastern and southern Transvaal. However a syntaxonomic synthesis should be done when sufficient data are collected from these areas of the South African Grassland Biome.

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CHAPTER 8

Phytosociology of the Wetlands of the Ba and Ib land types in the Pretoria-Witbank-Heidelberg area of the Transvaal, South Africa.

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Abstract

An analysis of the plant communities of the wetlands of the Pretoria-Witbank-Heidelberg area of the Transvaal province, South Africa is presented. Relevés were compiled in 40 stratified random sample plots. A TWINSPAN classification, refined by Braun - Blanquet procedures, revealed seven distinct plant communities. A description and ecological interpretation of the plant communities are presented.

Uittreksel

'n Analise van die plantgemeenskappe van die vleilande van die Pretoria-Witbank-Heidelberg gebied in die Transvaal, Suid-Afrika, word aangebied. Relevés is in 40 gestratifiseerde ewekansig gekose monsterpersele saamgestel. 'n TWINSPAN-klassifikasie, verfyn deur Braun - Blanquet-prosedures, toon sewe duidelik onderskeibare plantgemeenskappe. 'n Beskrywing en ekologiese interpretasie van hierdie plantgemeenskappe word aangebied.

Key words: Braun - Blanquet, classification, syntaxonomy, wetlands.

Introduction

The initial utilization management of South Africa's water resources was based primarily on meeting bulk user demands, mainly agricultural, with scant consideration towards water quality or ecological implications. However, due to more intensive agricultural, mining and industrial development and the resulting ecological problems, an increasing awareness has forced water resource management to recognize the importance of these aspects (Walmsley 1988).

No approach enhancing the scientific and technological expertise necessary to address problems regarding water quality and related ecological problems can be realised on an ad hoc basis. According to Begg (1986) a wetland is an area where excess of water is the dominating factor determining the nature of soil development and types of plant and animal communities living at the soil interface. It spans a continuum of environments where terrestrial and aquatic systems intergrade. Wetlands are therefore a water-dominating area with impeded drainage where soils are saturated with water (at least periodically) and where there is a characteristic flora and fauna. In this paper, the term wetland refers to an area that is permanent saturated with water and seasonally wetland refers to an area that is seasonally or periodically saturated with water.

Ecological management of any area should be based on sound scientific information on the natural resources present in the area. The necessity to classify, describe and interpret the different plant communities as a natural resource, is well documented by Mentis & Huntley (1982) and Scheepers (1986). Coetzee *et al.* (1993) recognised eight

major vegetation units in a general overview of the vegetation of the Pretoria-Witbank-Heidelberg area, one representing the *Hemarthria altissima - Paspalum dilatatum* Wetland. From a phytosociological viewpoint, very little is known about the vegetation of the wetlands (*Hemarthria altissima - Paspalum dilatatum* Wetland (Coetzee *et al.* 1993) of this area and therefore this study aims to identify, classify, describe and interpret ecologically the wetland plant communities of this area.

Study area

The Pretoria-Witbank-Heidelberg area is situated in the Ba and Ib land types between 25°10' and 26°35' S and 28°00' and 29°30' E within the Grassland Biome of South Africa (Rutherford & Westfall 1986) (Figure 1). In this area Wetlands are mostly represented by streams, rivers, pans and swamps (vlei) mainly found in bottomland situations (terrain unit 5) but also by floodplains adjacent to streams and rivers (terrain unit 4).
The wetlands of the study area are situated in the Bankenveld, *Cymbopogon - Themeda* Veld, Sourish Mixed Bushveld and Mixed Bushveld (Acocks 1953, 1988). Werger (1978) however, classified the wetlands as "Flood plain and dambo grasslands" under the heading Azonal vegetation. A detailed description of the physical environment of the study area is presented by Coetzee *et al.* (1993).

Methods

Relevés were compiled in 40 stratified random sample plots. Stratification was based on land type (Land Type Survey Staff 1985, 1987) and within land types on terrain units,

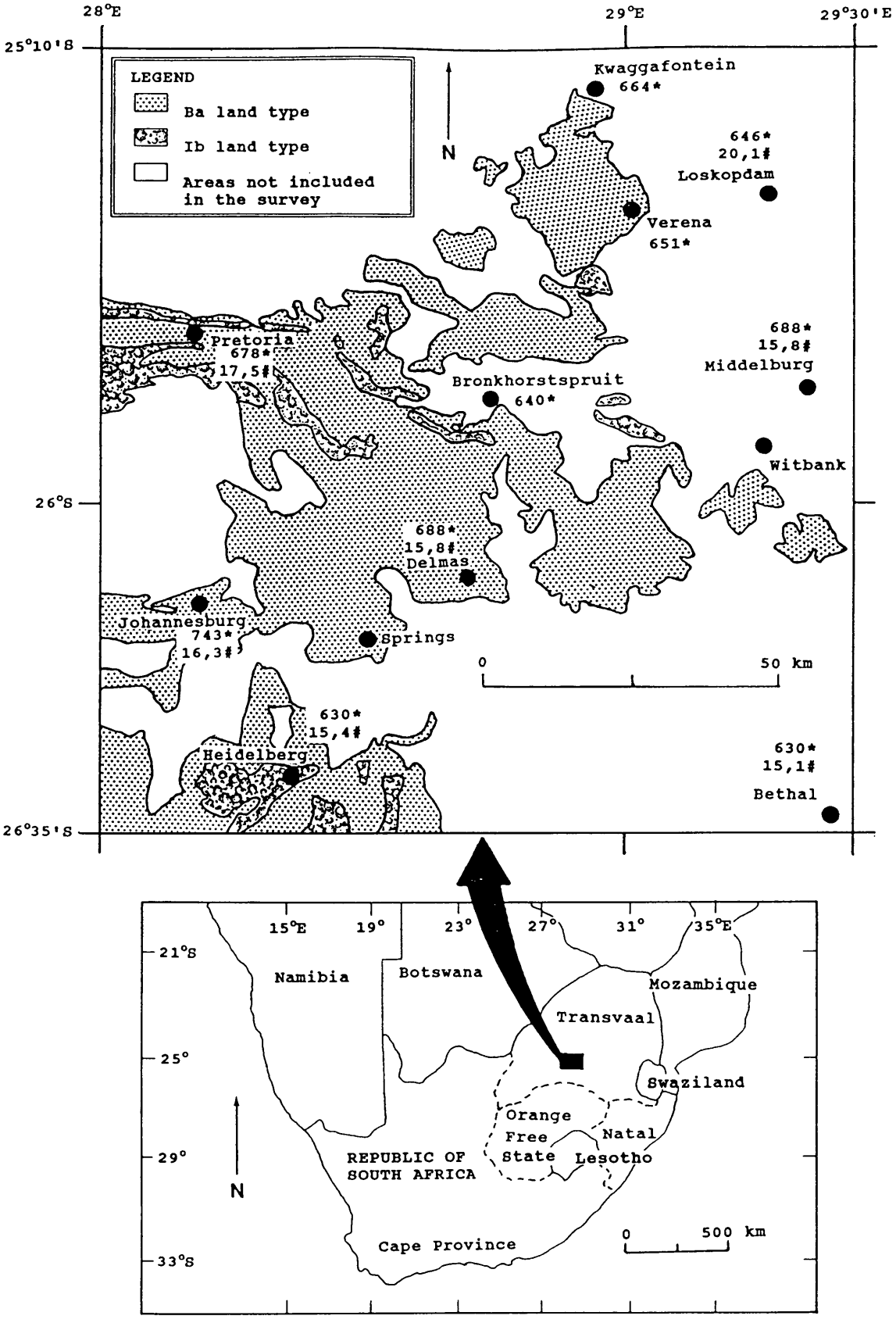

Figure 1. The Ba and Ib land types whithin the Pretoria-Witbank-Heidelberg area (adapted from Land Type Survey Staff 1985, 1987) and mean annual rainfall (*) and temperatures (#) for several weather stations (Weather Bureau 1986).

(terrain unit 4 = footslopes and terrain unit 5 = floodplains). Plot sizes were fixed at 100 m^2 (Scheepers 1976). In each sample plot the floristic composition was recorded and a cover-abundance value, according to the Braun - Blanquet scale (Mueller-Dombois & Ellenberg 1974), was allocated to each species. Taxon and author names conform to those of Gibbs Russell *et al.* (1985, 1987).

The environmental information recorded include geology, land type, terrain unit, aspect, slope, soil type and depth, percentage clay, erosion, soil moistness and degree of utilization by herbivores.

Two-way indicator species analysis (TWINSPAN) (Hill 1979b) was applied to the floristic data set in order to derive a first approximation of the plant communities of the area. Refinement of this classification was done by the application of Braun - Blanquet procedures (Behr & Bredenkamp 1988; Bredenkamp *et al.* 1989). From the final phytosociological table, seven plant communities, which can be classified under three major communities, were identified (Table 1).

In order to determine vegetation gradients, the multivariate ordination technique, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set.

Table 1. Phytosociological table of the Wetlands in the study area.

	0000000	1122000000	0000000	02120	0011	00	22000
	9494998	9911919268	6703706	01046	9908	88	66314
	9750687	0336190356	8099139	67157	2309	89	98283
Community number	**1.1**	**1.2**	**2.1**	**2.2**	**2.3**	**2.4**	**3**
Species Group A							
Pennisetum sphacelatum	BAB 111	A +					
Senecio inornatus	+++++ +	++					
Arundinella nepalensis	11 A +			+			+
Species Group B							
Setaria sphacelata		+1A1 A	+		1		
Setaria nigrirostris	1 +	+11 +	1 +				++
Cynodon dactylon	+	+ 1 +		1			
Conyza podocephala	+	+ ++					
Species Group C							
Themeda triandra	A +A	++A1+3BAAB	1 B				1A
Berkheya radula	++ ++	+1+++++++	+				+ +
Species Group D							
Fimbristylis complanata			1++ 1A+				
Centella asiatica	+ +		+ +1+1				
Agrostis eriantha	+		+1 ++				
Chironia palustris			++ +				+
Fuirena pubescens			1+				
Andropogon eucomus			+ 1				
Juncus oxycarpus			++				
Cycnium tubulosum		+R	R R				
Species Group E							
Eragrostis plana	1 B	33333A3B43	34A34 5	++44B		+	+ 1
Species Group F							
Phragmites australis		1	3		5443		1
Typha capensis					53A3		
Cyperus longus	A			+	1 +A		+
Species Group G							
Eragrostis planiculmis	3					++	
Eragrostis micrantha	A	+				++	
Eleocharis palustris			+			++	
Cyperus marginatus		1 +			B	4	
Potamogeton thunbergii						4	
Species Group H							
Leersia hexandra	A	A	++ +	1 B	AAA	BB	
Species Group I							
Sium repandum	1 +		1		+		+++++
Hyparrhenia hirta		3 1		+			+11B
Diospyros lycioides							+++ A
Polygonum salicifolium			+	+	1	A	++++
Verbena bonariensis		+ +	+				+++ +
Gomphostigma virgatum							+++ +
Miscanthus junceus							1+ 1
Salix mucronata							+ 3
Cyperus latifolius							AA
Protasparagus laricinus							++
Asclepias fruticosa							+ +
Species Group J							
Paspalum dilatatum	11 1	++	BBB1 11	1A		AA	+ 1 +
Hemarthria altissima	3 1	+	+ B 1		+	1+	
Mariscus congestus	+3	+ +	A	+	A	+	+
Eragrostis curvula	1	+ A +		+A			+
Kyllinga erecta	+	1+	+1	B+			

Results

The following communities were identified in the study area:

1. *Themeda triandra-Berkheya radula* Wetland
   1.1. *Themeda triandra - Pennisetum sphacelatum* Seasonal Wetland
   1.2. *Themeda triandra - Setaria sphacelata* Seasonal Wetland
2. *Leersia hexandra - Paspalum dilatatum* Stagnant and slow flowing streams
   2.1. *Leersia hexandra - Fimbristylis complanata* Seasonal Wetland
   2.2. *Leersia hexandra - Eragrostis plana* Wetland
   2.3. *Leersia hexandra - Phragmites australis* Wetland
   2.4. *Leersia hexandra - Eragrostis planiculmis* Seasonal Wetland
3. *Sium repandum - Diospyros lycioides* Wetland

A diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the recognised plant communities is given in Figure 2 and a schematic illustration of the plant communities along the terrain unit gradient is presented in Figure 3.

1. The *Themeda triandra - Berkheya radula* Wetland.

This major community is situated on seasonally waterlogged floodplains along rivers and streams. The vegetation was usually overgrazed as the grazing of moist environments is more palatable than those of adjacent drier areas (Tainton 1981). Therefore, if these

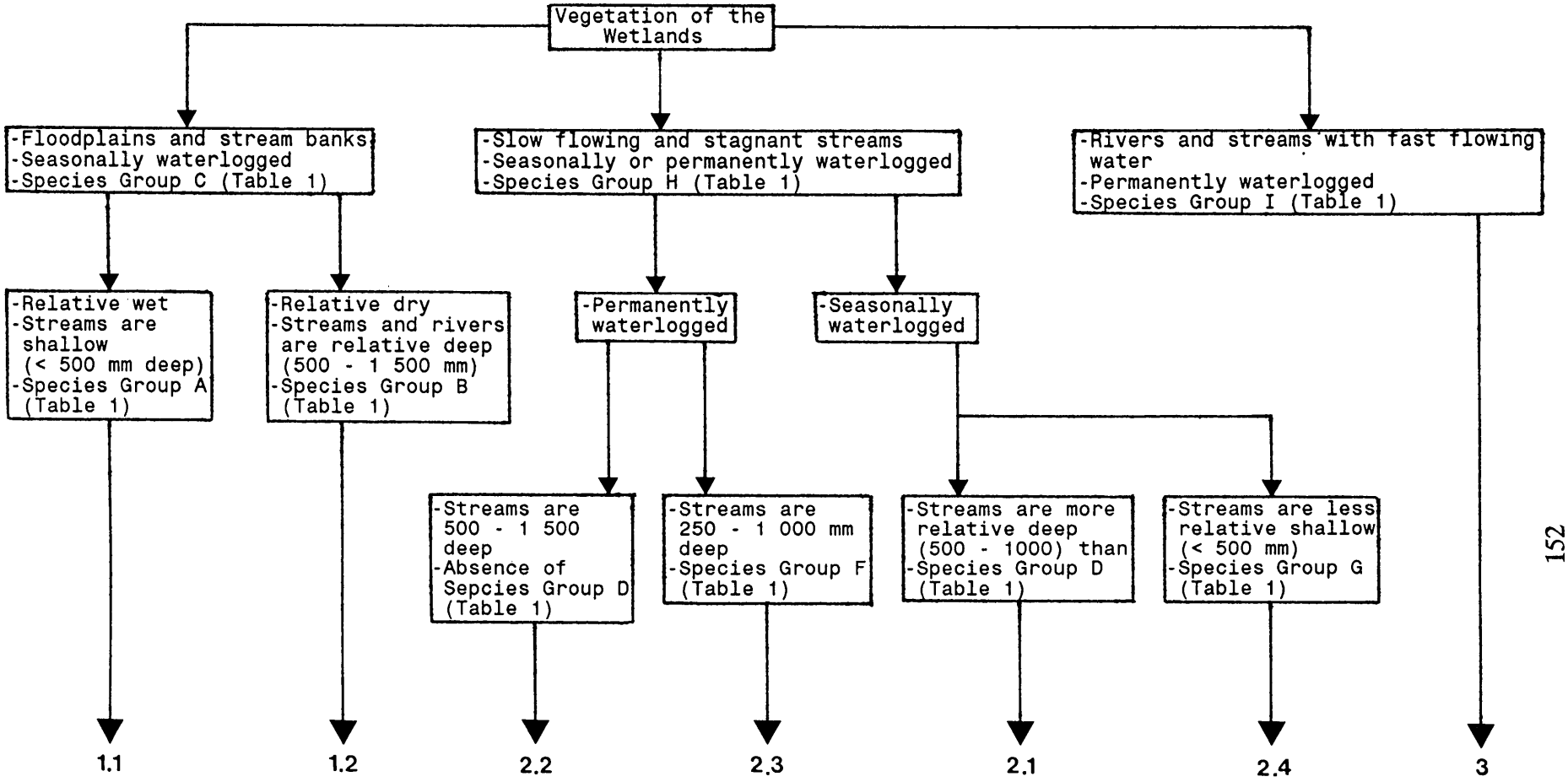

Figure 2. The hierarchical classification and habitat interpretation of the Wetlands and in the study area. Community numbers correspond to plant community descriptions in text.

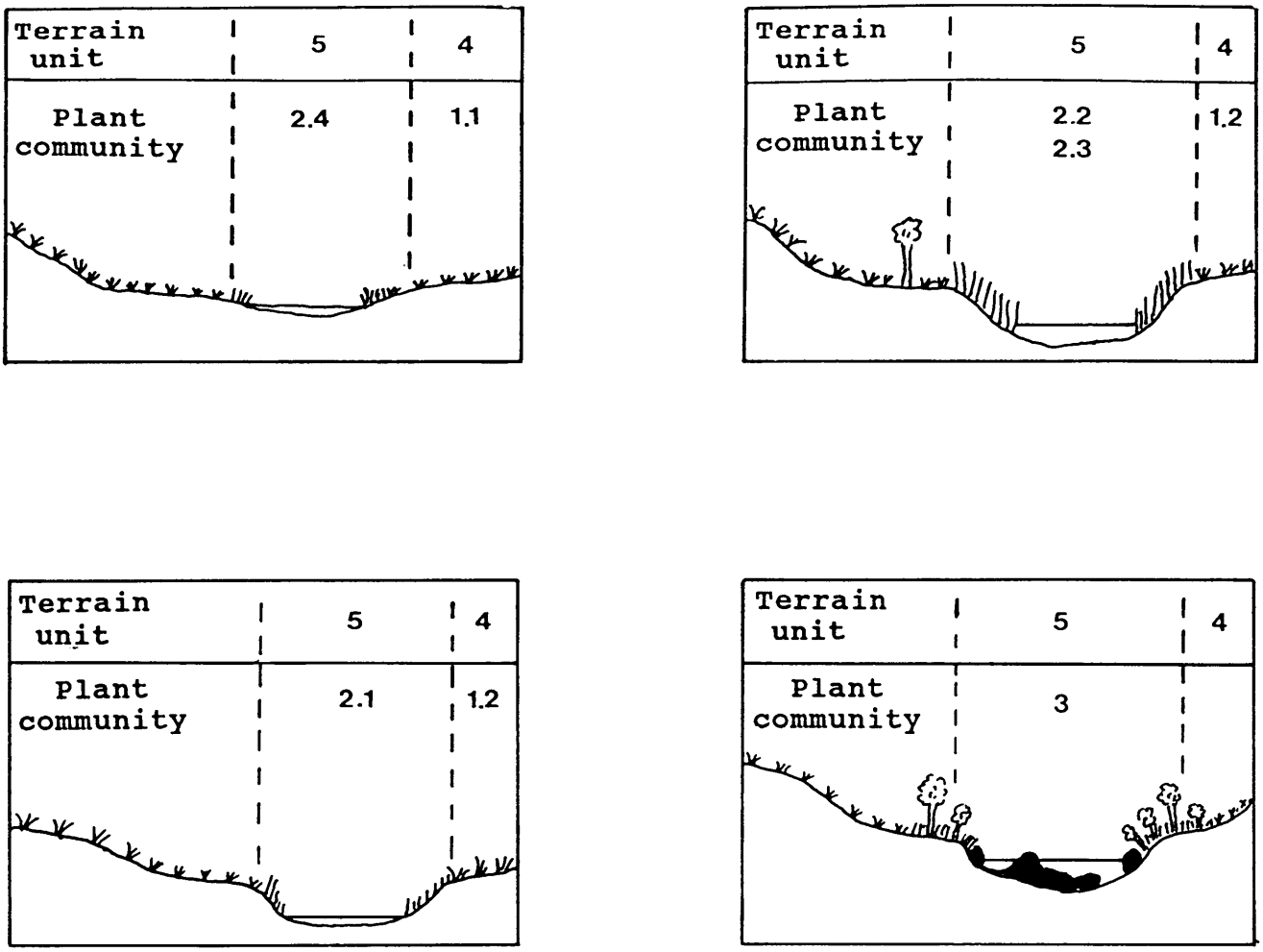

Figure 3. A schematic illustration of the distribution of the plant communities along the terrain unit gradient.

areas are not fenced from the adjacent grassland, selection for this habitat occurs which usually leads to overutilization. This major community was identified as the *Hemarthria altissima - Setaria nigrirostris* Seasonal Wetland by Coetzee *et al.* (1993), but this detailed phytosociological study indicates that both *Hemarthria altissima* and *Setaria nigrirostris* have limited constancy and could not be regarded as diagnostic for this wetland.

The diagnostic and most conspicuous species in this major community are *Themeda triandra* and the robust perennial herb *Berkheya radula* (Species Group C, Table 1). This major community is represented by two distinct plant communities:

1.1. The *Themeda triandra - Pennisetum sphacelatum* Seasonal Wetland.

This community is found on stream banks and floodplains of less incised streams (< 500 mm deep) with a shallow watertable, resulting in a moister environment than more incised streams. Most of the streams in this community are only seasonally waterlogged. The predominant soil types are of the Rensburg and Willowbrook forms. The presence of a G-horizon in the soil profile at depths greater than 500 mm indicates a horizon that is saturated with water for long periods, although the A-horizon is only periodically flooded with water. This community is found mainly on shale of the Silverton Formation of the Pretoria Group, diabase from the Waterberg Group and alluvial deposits.

The most conspicuous species are the widely distributed *Themeda triandra* and the forb *Berkheya radula.* Diagnostic species are the perennial tufted grass *Pennisetum sphacelatum,* the erect perennial forb *Senecio inornatus* and the tufted grass *Arundinella*

nepalensis (Species Group A, Table 1). An average of 13 species per sample plot was recorded.

1.2. The *Themeda triandra - Setaria sphacelata* Seasonal Wetland.

This community is found on river and stream floodplains and banks that are seasonally waterlogged, although the streams may have water permanently. The streams are deeply incised (500 - 1 500 mm), with a deeper watertable than streams that are less incised. The floodplains are therefore relatively drier than those of community 1.1. The Rensburg, Arcadia, Tukulu and Katspruit soil forms are predominant in this community. These soil forms indicate the presence of a permanently water saturated deeper horizon. This community is found on various geological formations.

The most abundant species are *Themeda triandra, Berkheya radula* and the densely tufted locally dominant grass *Eragrostis plana.* Diagnostic species are the tufted robust grass *Setaria sphacelata,* the rhizomatous grass *Setaria nigrirostris,* the creeping pioneer grass *Cynodon dactylon* and the forb *Conyza podocephala* (Species Group B, Table 1). *Cynodon dactylon* and *Conyza podocephala* are indicators of disturbed conditions. An average of 15 species per sample plot was recorded.

2. The *Leersia hexandra - Paspalum dilatatum* Stagnant and slow flowing streams.

Although Coetzee *et al.* (1993) recognised the *Hemarthria altissima - Phragmites australis* Wetland as a vegetation unit, this study reveals that this wetland is part of the widely

distributed *Leersia hexandra - Paspalum dilatatum* Wetland.

This wetland is restricted to terrain unit 5 and can be found in permanent and seasonal streams, pans and marshes. This major community occurs on pans and streams that are permanently or seasonally waterlogged. The streams are slow flowing with no rapids, or stilstanding, resulting in swampy or marshy conditions. The only diagnostic species for this major community is the rhizomatous graminoid *Leersia hexandra* (Species Group H, Table 1). The tufted perennial grass *Paspalum dilatatum* is, locally very abundant, but in most areas *Eragrostis plana* is the dominant grass species. Four distinct communities are recognised:

2.1. The *Leersia hexandra - Fimbristylis complanata* Seasonal Wetland.

This seasonal wetland is found in deeply incised seasonally waterlogged (500 - 1000 mm deep) streams. During the rainy season surface water is visible. Soil types commonly found are of the Rensburg, Kroonstad and Tukulu forms. This community is mostly undisturbed or locally moderately utilized.

The most conspicuous species are the grass *Eragrostis plana* on the drier areas and the perennial tufted and rhizomatous *Agrostis eriantha.* The small sedge *Fimbristylis complanata* and *Paspalum dilatatum* are common in the waterlogged areas. Diagnostic species are the sedges *Fimbristylis complanata, Fuirena pubescens* and *Juncus oxycarpus*, the erect perennial hemi-parasitic forb, *Cycnium tubulosum*, the erect bushy forb *Chironia palustris,* the perennial densely tufted graminoids *Andropogon eucomis* and

Agrostis eriantha and the prostrate forb *Centella asiatica* (Species Group D, Table 1). An average of 17 species per sample plot was recorded.

2.2. The *Leersia hexandra - Eragrostis plana* Wetland.

This wetland is found in pans and streams that are permanently waterlogged with stagnant water. The permanently waterlogged streams result in the development of vlei or marshy areas densely covered by one or two hygrophilous species. The depth of the streams varies from 500 mm to 1 500 mm. The local drier areas on the banks are inhabited by *Eragrostis plana,* and these areas are usually overgrazed. The predominant soil type in this community is the wet vertic Rensburg form.

An average of nine species per sample plot was encountered, indicating a low species diversity. This community is characterized by the absence of Species Group D (Table 1). One or two sedge species with a high cover-abundance occur in all sample plots, resulting in a low constancy of diagnostic species (Table 1) and with only *Eragrostis plana* as a companion species with a high constancy. An average of 11 species per sample plot was recorded.

2.3. The *Leersia hexandra - Phragmites australis* Wetland.

This wetland is found within permanently stagnant or slow flowing water. The riverbeds are shallow (250 - 1 000 mm deep) and the predominant soil type is of the Rensburg form. No distinct physical environmental differences between this community and the

Leersia hexandra - Eragrostis plana Wetland could be detected. These two communities occur next to each other in a mosaic pattern along the same streams.

An average of seven species per sample plot was recorded, indicating a low species diversity. The most conspicuous and also diagnostic species are the tall perennial reed *Phragmites australis* and the erect aquatic herb *Typha capensis*. These two species occur in nearly pure stands with the diagnostic sedge *Cyperus longus* inbetween (Species Group F, Table1). The only other non-diagnostic species with a high abundance and constancy is the creeping graminoid *Leersia hexandra*. This community typically represents the *Hemarthria altissima - Paspalum dilatatum* Wetland, recognised by (Coetzee *et al.* 1993).

2.4. The *Leersia hexandra - Eragrostis planiculmis* Seasonal Wetland.

Characteristic of this community is the very shallow riverbeds (< 500 mm deep) of the streams with slow flowing or stagnant water. The streams are seasonally waterlogged and the main soil type is of the vertic Rensburg form.

The most conspicuous species are *Leersia hexandra,* the perennial rhizomatous and stoloniferous graminoid *Hemarthria altissima* and *Paspalum dilatatum.* The diagnostic species are the perennial erect tufted *Eragrostis planiculmis,* the erect tufted *Eragrostis micrantha,* the aquatic herb with floating leaves *Potamogeton thunbergii* and the sedges *Eleocharis palustris* and *Cyperus marginatus* (Species Group G, Table 1). An average of 9 species per sample plot was recorded.

3. The *Sium repandum - Diospyros lycioides* Wetland.

This community is restricted to larger streams with permanent flowing water. The streambeds are 500 - 1 500 mm deep with rocks and rock sheets, especially in ravines in the quartzite ridges. The soil types are mainly of the Rensburg and Dundee forms. The vegetation in most of the sample plots was overgrazed or disturbed by livestock. This community is partly situated in running water and partly on drier river banks, depending of the hight of the water level in the streams.

An average of 20 species per sample plot was recorded in this community. The most conspicuous diagnostic species are the perennial tufted *Hyparrhenia hirta,* the deciduous shrub *Diospyros lycioides* and the tall growing robust perennial graminoid *Miscanthus junceus*. The diagnostic species are the erect perennial herb *Sium repandum,* the slender erect decumbent annual forb *Polygonum salicifolium,* the erect sparsely branched forb *Verbena bonariensis,* the evergreen perennial shrublet *Gomphostigma virgatum,* the deciduous shrub or small tree *Salix mucronata,* the sedge *Cyperus latifolius,* the dense multi-stemmed shrub *Protasparagus laricinus* and the evergreen perennial shrublet *Asclepias fruticosa* (Species Group I, Table 1).

Ordination

The relevés representing the different plant communities are grouped and restricted to specific areas in the scatter diagram (Figure 4). This result supports the classification. The vegetation gradient revealed by the distribution of relevés concurs with an

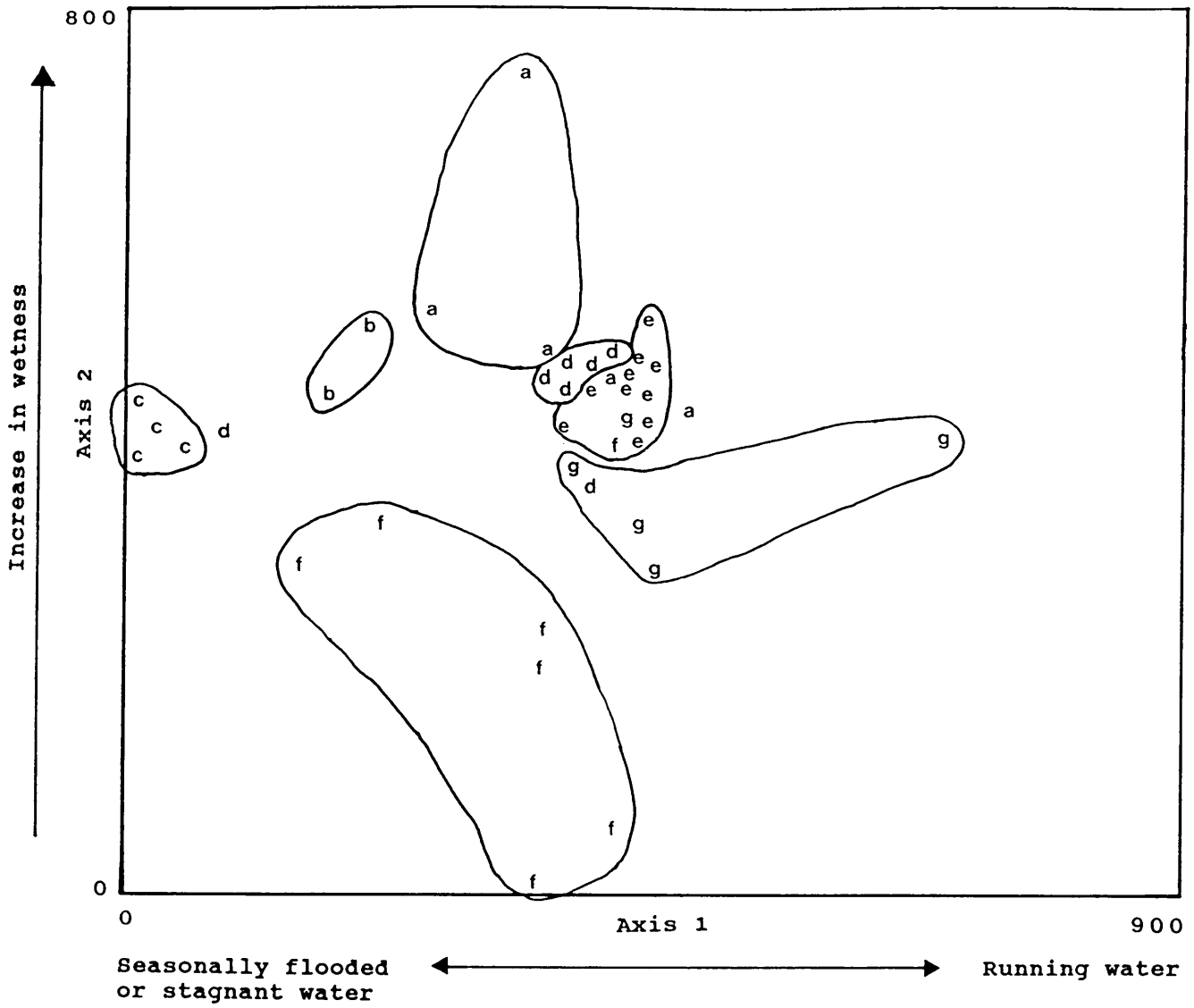

Figure 4. A DCA ordination diagram the vegetation of the Wetlands in the study area. a = the *Leersia hexandra - Eragrostis plana* Wetland; b = the *Leersia hexandra - Eragrostis planiculmis* Seasonal Wetland; c = the *Leersia hexandra - Phragmites australis* Wetland; d = the *Leersia hexandra - Fimbristylis complanata* Seasonal Wetland; e = the *Themeda triandra - Setaria sphacelata* Seasonal Wetland; f = the *Themeda triandra - Pennisetum sphacelatum* Seasonal Wetland; g = the *Sium repandum - Diospyros lyciodes* Wetland.

environmental gradient on axis 1 where plant communities of seasonally flooded habitats, or stagnant water, are located to the left, and plant communities associated with running water located to the right of the diagram. Although not so clear, axis 2 suggests a gradient from drier habitats at the bottom to wetter habitats at the top of the diagram. The *Sium repandum - Diospyros lycioides* Wetland to the right (axis 1) is situated in the central part along axis 2. This is probably due to the fact that this community is partly situated in the flowing water of the river, and partly on periodically flooded drier river banks.

Concluding remarks

All plant communities could be related to specific environmental conditions and are therefore floristically and ecologically distinguishable and interpretable. Plant community variations are mainly ascribed to differences in streamflow, streambed incision, streambank wetness and period of wetness. Soil characteristics and geology do not play a major role due to similarities in soil type and alluvial substrate.

Within farm and conservation management programs, wetland communities should be regarded as distinct management units. It is of special importance to fence the wetlands from the rest of the grassland especially in grazing programs. Due to the more palatable vegetation of the wetlands (Tainton 1981), these areas are more subjected to overgrazing and therefore ecologically more sensitive than the rest of the grassland. The overgrazing of these areas will result in the deterioration of the wetland ecosystems. Of major

concern at present, not only in South Africa but all over the world, is the increased evidence that man has succeeded in irreversibly degrading vast areas of wetland and seasonal wetland by development and poor land-use practices (Walmsley 1988). In spite of the relatively low plant species diversity encountered in the wetlands, specific species are restricted to these habitats. These habitats are also of special interest for many bird and amphibian species. Therefore special care should be taken in conserving these areas in management programs.

Acknowledgements

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CHAPTER 9

GENERAL DISCUSSION AND CONCLUSION

The Braun - Blanquet method was successfully applied, resulting in 32 plant communities and 11 variations. All plant communities and most of the variations could be related to specific environmental conditions and are therefore ecologically distinguishable and interpretable. The classification is mostly supported by the results of ordination by means of the program DECORANA (except within the grassland (Chapter 6)) and the ordinations also provides an understanding of the vegetation gradients and associated habitat gradients between plant communities. The scatter diagram of the Grasslands was not presented because no environmental gradients were detected. This may be due to the high occurrence of common dominant grass species such as *Setaria sphacelata, Themeda triandra* and *Eragrostis racemosa*. Due to the high Braun - Blanquet cover-abundance values, these species are weighted heavily and diagnostic species with low values play an inferior role in the ordination program.

Although the descriptions of the plant communities are based on a hierarchical classification, no attempt was made to formally fix names or ranks of syntaxa. More phytosociological data and classifications of the grasslands within the eastern and southern Transvaal are needed to construct meaningful syntaxonomical classification for the grassland of these part of the Transvaal and syntheses of these classifications are now of great priority. However this study contributes greatly to the present scanty knowledge of the synecology and syntaxonomy of the Pretoria-Witbank-Heidelberg area.

The vegetation of the Ba and Ib land types within the Pretoria-Witbank-Heidelberg area is divided into four distinct vegetation groups:

The northern parts of the area, situated at lower altitudes, consist of the Sub-humid Warm Temperate Mountain Bushveld (Chapter 6) which is associated with warmer north facing slopes of rocky outcrops and ridges and also with undulating plains below 1 250 m. This vegetation is characterized by predominantly large trees (> 5 m) on the footslopes, and shrubs that become progressively smaller at higher altitudes to the top of the ridges.

Bordering the Sub-humid Warm Temperate Mountain Bushveld to the south, mainly on the cooler south facing slopes of the ridges and rocky outcrops, is the Sub-humid Cool Temperate Mountain Bushveld. This vegetation is also characterized by trees (5-10 m) and shrubs (< 5 m) and is restricted to an altitude from 1 240 to 1 450 m.

Bordering these two communities at higher altitudes and mostly to the south, is the undulating Grassland. The Grassland is associated with higher altitudes (> 1 450 m) and cooler conditions. This vegetation consists predominantly of graminoids and forbs, with shrubs (< 5 m high) or trees (5 - 10 m) only on localized areas. The Sub-humid Warm and Cool Temperate Mountain Bushveld and Moist Cool Temperate Grassland represent the transitional zone between the Grassland and Savanna Biomes. The fourth vegetation group, the wetlands, is situated predominantly within the Grassland and is characterized by sedges and hydrophillic graminoids and is found in bottomland situations around streams, rivers and pans.

The study area includes parts of both the Savanna and the Grassland Biomes. In this area various vegetation units occur, ranging from bushveld to grassland communities, within a relatively small area . According to the map and veld type descriptions of Acocks (1953, 1988), most of these vegetation units are situated in the Bankenveld (Veld Type 61). The ecological interpretation of the Bankenveld have been a problem for many years. Acocks (1953, 1988) interpret this area as a false grassland that was originally a bushveld which is now controlled and maintained as grassland by fire. This study however indicates that the Bankenveld is represented by a mosaic of Upper Sub-humid (Temperate) Mountain Bushveld and Cool or Cold Temperate Grassland (Werger 1978). The grass species composition of the Bankenveld (Acocks 1953, 1988) occurs only on the rocky, undulating plains with shallow soils and moderate slopes situated above 1 450 m above sea level. Many of the plant communities in the area that Acocks (1953, 1988) described as the Central Variation of the Bankenveld rather represent Savanna veld types. The vegetation units recognised in this study are in accordance to the classification of Werger (1978).

According to Acocks (1953, 1988), the northern border of the Bankenveld lies from Pretoria to Witbank in a fairly straight line. This study revealed that this is not the case. Acocks identified dominant species in the Mixed and Sourish Mixed Bushveld as *Acacia caffra, Combretum apiculatum, Dichrostachys cinerea, Lannea discolor, Terminalia sericea, Burkea africana, Sclerocarya birrea, Peltophorum africanum, Ochna pulchra, Digitaria eriantha* and *Eragrostis* spp. The part of the Ba land type that is situated in the Mixed Bushveld and Sourish Mixed Bushveld map units of Acocks (1953, 1988), to the north- and south west of Verena, should also be regarded as Bankenveld. The vegetation units

that are found in those areas are classified within the *Bewsia biflora - Digitaria brazzae* Grassland (Coetzee *et al.* 1993c), typical of the Bankenveld. Diagnostic species that were found in this area are *Tristachya rehmannii, Panicum natalense, Bewsia biflora, Trachypogon spicatus and Justicia anagalloides.* These species are not typical of the Mixed and Sourish Mixed Bushveld of Acocks (1953, 1988), and woody species are absent or rare in these communities.

Acocks (1953, 1988) stated that the Bankenveld is a False Grassland as a result of excessive burning. Although the role of fire in the suppression of bush and other woody vegetation is not denied, the results of this study indicate that the Woodland and Grassland vegetation units are associated with altitude and the corresponding climatic conditions. It is therefore suggested that altitude and the associated climatic conditions are primary environmental factors contributing to the mosaic distribution of woodland and grassland communities within Acocks' Bankenveld (see also Werger 1978; Bredenkamp & Van Vuuren 1987).

Acocks (1953, 1988) mapped the northern Variation of the *Cymbopogon - Themeda* Veld as an area between Johannesburg, Heidelberg and Delmas. However this study indicated that a large part that was mapped as Bankenveld actually represents *Cymbopogon - Themeda* Veld (Coetzee *et al.* 1993c).

In summary, Acocks' Bankenveld is presently interpreted as a mosaic of grassland and bushveld communities, which include Bankenveld grassland of cool rocky mountain or plateaux environments, *Cymbopogon - Themeda* grassland, Sour Bushveld and Sourish

Mixed Bushveld. The latter two Bushveld communities may become dwarfed and impoverished in species composition as far as woody species are concerned along a climatic / altitude gradient which eventually merge into typical Bankenveld rocky grassland.

Communities within the study area are subjected to degradation and are therefore ecologically sensitive as a result of human activities and mismanagement. Large parts of the study area are also invaded by exotic invader species such as *Acacia mearnsii, Acacia dealbata, Acacia podalyriifolia, Sesbania punicea, Eucalyptus* spp., *Populus* spp. and *Melia azedarach.* Many of these areas represent riparian vegetation (*Hemarthria altissima -Paspalum dilatatum* Wetland) with a high conservation status. In such areas the communities are usually replaced by these exotic species. Some communities have a restricted distribution. Communities that are subjected to the above mentioned situations, and therefore have a high conservation priority are the following:

- All the communities within the wetlands (Chapter 8);
- The *Aristida transvaalensis - Diospyros lycioides* Closed Woodland (26°29'S, 28°35'E).
- The *Acacia karroo - Maytenus polyacantha* Variation (26°27'S, 28°8'E).
- The *Acacia karroo - Adenia digitata* Variation (25°51'S, 28°26'E).
- The *Setaria lindenbergiana* Bush-clumps (on the Magaliesberg).
- All the communities of the Sub-humid Warm Temperate Mountain Bushveld (Chapter 5) (on the Magaliesberg and other rocky ridges in the study area) except the *Faurea saligna -Terminalia sericea* Woodland.
- The *Eragrostis racemosa - Digitaria tricholaenoides* Grassland (26°2'S, 28°47').

Areas that have a high conservation priority, because of high biotic diversity and some times with a restricted distribution are:

- The Magaliesberg area and other quartzite ridges, not only because of the high biodiversity but this area contains also rare species such as *Aloe peglerae, Streptocarpus vandeleurii, Haemanthus humilis, Gladiolus sp.* and *Lithops lesliei*
- The farm Witklipbank (26°3'S, 28°42'E) where the Bronkhorstspruit stream flows through a kloof resulting in a variety of habitats and associated communities
- The farm Witpoort (25°56'S, 28°51'E) where the Wilge River flows through a kloof also resulting in a high biodiversity and aesthetic value
- The farm Oude Swaankraal (25°54'S, 28°40'E) with natural grassland that is well managed (generally, very few areas within the grassland were found to be in a good condition) and therefore in a fire-grazing climax state.

A summary of the total classification of the vegetation within the Pretoria-Witbank-Heidelberg area is as follows:

The Sub-humid Warm Temperate Mountain Bushveld

1. *Burkea africana - Ochna pulchra* Woodland
   1.1. *Burkea africana - Faurea saligna* Closed Woodland
      1.1.1. *Faurea saligna - Terminalia sericea* Woodland
   1.2. *Burkea africana - Bequaertiodendron magalismontanum* Open Woodland.
      1.2.1. *Dovyalis zeyheri - Croton gratissimus* Closed Shrubland
         1.2.1.1. *Dovyalis zeyheri - Koeleria capensis* Variation
         1.2.1.2. *Dovyalis zeyheri - Elephantorrhiza burkei* Variation
      1.2.2. *Helichrysum kraussii - Ziziphus mucronata* Closed Shrubland
      1.2.3. *Sporobolus pectinatus - Chaetacanthus setiger* Sparse Shrubland
         1.2.3.1. *Sporobolus pectinatus - Euphorbia schinzii* Variation
         1.2.3.2. *Sporobolus pectinatus - Phymaspermum athanasioides* Variation

1.2.4. *Digitaria brazzae - Panicum natalense* Sparse Shrubland
1.2.5. *Coleochloa setifera - Cheilanthes hirta* Sparse Shrubland

The Sub-humid Cool Temperate Mountain Bushveld

2. *Acacia caffra - Euclea crispa* Woodland
2.1. *Aristida transvaalensis - Diospyros lycioides* Closed Woodland
2.2. *Protea caffra - Athrixia elata* Open Woodland
2.3. *Acacia karroo - Lippia javanica* Closed Woodland
2.3.1. *Acacia karroo - Maytenus polyacantha* Variation
2.3.2. *Acacia karroo - Adenia digitata* Variation
2.3.3. *Acacia karroo - Teucrium trifidum* Variation
2.4. *Setaria lindenbergiana - Ehretia rigida* Bush-clumps
2.4.1. *Setaria lindenbergiana - Commelina africana* Variation
2.4.2. *Setaria lindenbergiana - Cheilanthes viridis* Variation
2.4.3. *Setaria lindenbergiana - Panicum maximum* Variation
2.4.4. *Setaria lindenbergiana - Hypoestes forskaolii* Variation
2.5. *Acacia caffra - Setaria sphacelata* Closed Woodland

The Moist Cool Temperate Grassland

3. *Bewsia biflora - Digitaria brazzae* Grassland
3.1. *Bewsia biflora - Monocymbium ceresiiforme* Grassland
3.1.1. *Eragrostis racemosa - Digitaria tricholaenoides* Grassland
3.1.2. *Themeda triandra - Ledebouria ovatifolia* Grassland
3.1.3. *Loudetia simplex - Rhus magalismontanum* Grassland
3.1.4. *Aristida junciformis - Stoebe vulgaris* Grassland
3.1.5. *Loudetia simplex - Monocymbium ceresiiforme* Grassland
3.2. *Bewsia biflora - Tristachya biseriata* Grassland
3.2.1. *Themeda triandra - Tristachya biseriata* Grassland
3.2.2. *Hyparrhenia hirta - Aristida congesta* Grassland
3.2.3. *Trachypogon spicatus - Bewsia biflora* Grassland

The Moist Cold Temperate Grassland

4. *Helichrysum rugulosum - Conyza podocephala* Grassland
4.1. *Themeda triandra - Setaria sphacelata* Grassland
4.1.1. *Themeda triandra - Brachiaria serrata* Grassland
4.1.2. *Themeda triandra - Heteropogon contortus* Grassland
4.1.3. *Themeda triandra - Hyparrhenia hirta* Grassland
4.1.4. *Themeda triandra - Ledebouria revoluta* Grassland
4.2. *Eragrostis gummiflua- Cynodon dactylon* Grassland
4.2.1. *Eragrostis gummiflua - Pogonarthria squarrosa* Grassland
4.2.2. *Eragrostis gummiflua - Aristida congesta* Grassland

Wetlands (Azonal vegetation)

5. *Hemarthria altissima - Paspalum dilatatum* Wetland
   5.1. *Themeda triandra - Berkheya radula* Seasonal Wetland
      5.1.1. *Themeda triandra - Pennisetum sphacelatum* Seasonal Wetland
      5.1.2. *Themeda triandra - Setaria sphacelata* Seasonal Wetland
   5.2. *Leersia hexandra - Paspalum dilatatum* Stagnant and slow flowing streams
      5.2.1. *Leersia hexandra - Fimbristylis complanata* Seasonal Wetland
      5.2.2. *Leersia hexandra - Eragrostis plana* Wetland
      5.2.3. *Leersia hexandra - Phragmites australis* Wetland
      5.2.4. *Leersia hexandra - Eragrostis planiculmis* Seasonal Wetland
   5.3. *Sium repandum - Diospyros lycioides* Wetland

CHAPTER 10

PLANT SPECIES LIST

A species list of all the species collected or recorded during the survey is presented. The families and species are arranged alphabetically (Pteridophyta, Monocotyledonae and Dicotyledonae separately), making the location of species easier. In the list taxon names are followed by author names, and the number without parenthesis is applicable to the genus name (Gibbs Russell *et al.* 1985, 1987). Naturalized exotic taxa are marked with an asterisks (*) and protected species (Ordinance 12 1983) are marked by a double cross (#).

Species taken up in the H.G.W.J. Schweickerdt Herbarium (PRU), and collected by J.P. Coetzee, are followed by a number (voucher number) in parenthesis. Scientific names of taxa confirm to those of Gibbs Russell *et al.* (1985, 1987), and subsequent changes and additions published in many different issues of *Bothalia*.

A total of 583 species were collected during the survey. The relationship between the number of families, genera and species of Pteridophyta, Monocotyledonae and Dicotyledonae is given in Table 1. The most prominent families and genera are given in Tables 2 and 3 respectively. Lists of naturalized exotic and protected (Ordinance 12 1983) plant species are given in Tables 4 and 5 respectively.

Table 1. The relationship between the number of families, genera and species.

	Families		Genera		Species	
	No.	%	No.	%	No.	%
Pteridophyta	1	1,1	2	0,6	3	0,5
Monocotyledonae	12	13,6	94	30,0	195	33,6
Dicotyledonae	75	85,2	220	69,6	385	66,0
TOTAL	88		316		583	

Table 2. Most prominent families (families represented by more than 9 species).

Poaceae	104
Asteraceae	83
Fabaceae	53
Cyperaceae	35
Liliaceae	21
Rubiaceae	16
Acanthaceae	13
Anacardiaceae	12
Scrophulariaceae	12
Euphorbiaceae	11
Lamiaceae	11
Iridaceae	10
Asclepiadaceae	10

Table 3. Most prominent genera (genera represented by five or more species).

Senecio	16
Indigofera	16
Eragrostis	15
Helichrysum	15
Cyperus	10
Tephrosia	9
Solanum	8
Aristida	8
Gladiolus	7
Rhus	7
Hypoxis	6
Setaria	6
Digitaria	6
Aloe	5
Protasparagus	5
Berkheya	5
Euphorbia	5
Vernonia	5

Table 4. List of naturalized exotic species Gibbs Russell *et al.* (1985, 1987).

Achyranthes aspera
Agrimonia odorata
Ambrosia artemisiifolia
Bidens bipinnata
Bidens pilosa
Conyza sumatrensis
Hypochoeris radicata
Ipomoea purpurea
Lantana camara
Oenothera rosea
Oenothera tetraptera
Plantago virginica
Polycarpaea corymbosa
Pupalia lappacea
Physalis viscosa
Salix babylonica
Sesbania punicea
Solanum elaeagnifolium
Solanum mauritianum
Solanum nigrum
Solanum seaforthianum
Tagetus minuta
Verbena bonariensis

Table 5. List of protected plant species (Ordinance 12 1983).

Aloe peglerae
Aloe pretoriensis
Cheilanthes hirta
Cheilanthes viridis
Crinum bulbispermum
Crinum graminicola
Cussonia paniculata
Eucomis autumnalis
Eulophia clavicornis
Gladiolus crassifolius
Gladiolus dalenii
Gladiolus ecklonii
Gladiolus elliotii
Gladiolus papilio
Gladiolus permeabilis
Haemanthus humilis
Kniphofia porphyrantha
Lapeirousia sandersonii
Nerine rehmannii
Scadoxus puniceus
Streptocarpus vandeleurii
Pellaea calomelanos
Protea caffra

PTERIDOPHYTA

Adiantaceae

Cheilanthes hirta Swartz # 340
Cheilanthes viridis Swartz #

Pellaea calomelanos (Swartz) Link # 360

MONOCOTYLEDONAE

Amaryllidaceae

Boophane disticha (L. f.) Herb. 1168

Crinum bulbispermum (Burm. f.) Milne-Redh. & Schweick. # 1189
Crinum graminicola Verdoorn #

Haemanthus humilis Jacq. # 1167

Nerine rehmannii (Bak.) L. Bol. # (1228) 1175

Scadoxus puniceus (L.) Friis & Nordal # 1167

Commelinaceae

Commelina africana L. 896
Commelina erecta L.
Commelina modesta L.

Cyanotis speciosa (L. f.) Hassk. 904

Cyperaceae

Abildgaardia ovata (Burm. f.) Kral (107B) 471

Bulbostylis burchellii (Fical. & Hiern) C.B. Cl. 471
Bulbostylis oritrephes (Ridley) C.B. Cl. (107C)

Carex glomerabilis Krecz. (1048) 525

Coleochloa setifera (Ridley) Gilly 512

Cyperus denudatus L. f. (204) (294) (324) (664) 459
Cyperus esculentus L. (622) (804)
Cyperus fastigiatus Rottb. (623)

Cyperus latifolius Poir. (1070) (454) (628) (663)
Cyperus leptocladus Kunth (753)
Cyperus longus L. (1018) (1044) (441)
Cyperus marginatus Thunb. (1120) (613) (619)
Cyperus obtusiflorus Vahl
Cyperus rupestris Kunth
Cyperus sphaerospermus Schrad. (1133) (304) (449) (666)

Eleocharis acutangula (Roxb.) Schult. 469
Eleocharis palustris R. Br. (246)

Fimbristylis complanata (Retz.) Link (154) 471

Fuirena coerulescens Steud. 467
Fuirena pubescens (Poir.) Kunth (151) (296) (701)

Kyllinga alba Nees 462
Kyllinga erecta Schumach.
Kyllinga melanosperma Nees

Mariscus capensis (Steud.) Schrad. (283) 459
Mariscus congestus (Vahl) C.B. Cl. (1043) (166)
Mariscus rehmannianus C.B. Cl. (1139)
Mariscus uitenhagensis Steud. (123)

Pycreus macranthus (Boeck.) C.B. Cl. (244) 459
Pycreus nitidus (Lam.) J. Raynal (626)

Schoenoplectus corymbosus (Roth. ex Roem. & Schult.) J. Raynal (207) 468
Schoenoplectus decipiens (Nees) J. Raynal (1047)

Schoenoxiphium sparteum (Wahlenb.) C. B. Cl. (436) 521

Scirpus burkei C.B. Cl. (654) 468

Scleria bulbifera Hochst. ex A. Rich. (273) 515

Hypoxidaceae

Hypoxis acuminata Bak. 1230
Hypoxis hemerocallidea Fisch. & Mey.
Hypoxis iridifolia Bak. (209)
Hypoxis multiceps Buchinger ex Bak. (279)
Hypoxis obtusa Burch. ex Edwards
Hypoxis rigidula Bak.

Iridaceae

Anomatheca grandiflora Bak. (1250) 1316

Gladiolus crassifolius Bak. # 1311
Gladiolus dalenii Van Geel # (420)
Gladiolus ecklonii Lehm. # (1136)
Gladiolus elliotii Bak. # (257)
Gladiolus papilio Hook. f.# (161)
Gladiolus permeabilis Delaroche #
Gladiolus sp. #

Lapeirousia sandersonii Bak. # 1314

Tritonia nelsonii Bak. 1306

Juncaceae

Juncus effusus L. (703) 936
Juncus exsertus Bunchen.
Juncus oxycarpus E. Mey. ex Kunth (245)
Juncus punctorius F. f.

Liliaceae

Albuca setosa Jacq. (437) 1079

Aloe arborescens Mill. 1026
Aloe davyana Schonl.
Aloe peglerae Schonl. #
Aloe pretoriensis Pole Evans #
Aloe transvaalensis Kuntze

Anthericum fasciculatum Bak. (1000) (351) (655) 989
Anthericum longistylum Bak. (374)

Eucomis autumnalis (Mill.) Chitt. # 1088

Haworthia angolensis Bak. (1229) 1029

Kniphofia porphyrantha Bak. # 1024

Ledebouria marginata (Bak.) Jessop 1090
Ledebouria ovatifolia (Bak.) Jessop
Ledebouria revoluta (L. f.) Jessop

Protasparagus africanus (Lam.) Oberm. 1113

Protasparagus angusticladus (Jessop) Oberm. (1202)
Protasparagus laricinus (Burch.) Oberm.
Protasparagus setaceus (Kunth) Oberm.
Protasparagus suaveolens (Burch.) Oberm.

Trachyandra saltii (Bak.) Oberm. (790) 985

Tulbaghia leucantha Bak. (165) 1047

Orchidaceae

Eulophia clavicornis Lindl. # (457) 1648

Poaceae

Agrostis eriantha Hack. 9902430
Agrostis lachnantha Nees

Alloteropsis semialata (R. Br.) Hitchc. 9900940

Andropogon appendiculatus Nees (471) 9900710
Andropogon eucomus Nees
Andropogon schirensis A. Rich.

Aristida aequiglumis Hack. (1131) 9902620
Aristida canescens Henr.
Aristida congesta Roem. & Schult.
Aristida diffusa Trin. (1049)
Aristida junciformis Trin. & Rupr. (1031) (476) (690)
Aristida meridionalis Henr.
Aristida stipitata Hack.
Aristida transvaalensis Henr.

Arundinella nepalensis Trin. (624) 9901730

Bewsia biflora (Hack.) Goossens 9903442

Bothriochloa insculpta (A. Rich.) A. Camus 9900630

Brachiaria brizantha (A. Rich.) Stapf (1055) 9901040
Brachiaria eruciformis (J.E. Sm.) Griseb.
Brachiaria nigropedata (Fical. & Hiern) Stapf
Brachiaria serrata (Thunb.) Stapf

Chrysopogon serrulatus Trin. 9900500

Ctenium concinnum Nees 9902990

Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy 9900720
Cymbopogon marginatus (Steud.) Stapf ex Burtt Davy
Cymbopogon plurinodis (Stapf) Stapf ex Burtt Davy
Cymbopogon validus (Stapf) Stapf ex Burtt Davy

Cynodon dactylon (L.) Pers. 9902960

Digitaria brazzae (Franch.) Stapf 9900890
Digitaria diagonalis (Nees) Stapf
Digitaria eriantha Steud.
Digitaria monodactyla (Nees) Stapf
Digitaria ternata (A. Rich.) Stapf
Digitaria tricholaenoides Stapf

Diheteropogon amplectens (Nees) Clayton 9900810

Diplachne Fusca (L.) Beauv. ex Roem. & Schult. 9903450

Elionurus muticus (Spreng.) Kunth 9900280

Enneapogon pretoriensis Stent (1203) 9903570
Enneapogon scoparius Stapf

Eragrostis capensis (Thunb.) Trin. 9902860
Eragrostis curvula (Schrad.) Nees
Eragrostis gummiflua Nees
Eragrostis hierniana Rendle (1269)
Eragrostis inamoena K. Schum. (1268)
Eragrostis micrantha Hack. (602)
Eragrostis nindensis Fical. & Hiern
Eragrostis plana Nees
Eragrostis planiculmis Nees (612)
Eragrostis racemosa (Thunb.) Steud.
Eragrostis rigidior Pilg.
Eragrostis sclerantha Nees (1249)
Eragrostis stapfii De Winter (1134)
Eragrostis superba Peyr.
Eragrostis trichophora Coss. & Dur.

Eustachys paspaloides (Vahl) Lanza & Mattei 9903020

Festuca scabra Vahl (384) 9904170

Fingerhuthia africana Lehm. 9903710

Harpochloa falx (L. f.) Kuntze 9902980

Hemarthria altissima (Poir.) Stapf & C.E. Hubb. 9900210

Heteropogon contortus (L.) Roem. & Schult. 9900800

Hyparrhenia filipendula (Hochst.) Stapf 9900730
Hyparrhenia hirta (L.) Stapf
Hyparrhenia tamba (Steud.) Stapf

Hyperthelia dissoluta (Nees ex Steud.) Clayton 9900731

Imperata cylindrica (L.) Raeuschel 9900370

Ischaemum fasciculatum Brongn. (11275) 9900100

Koeleria capensis (Steud.) Nees (381) 9903740

Leersia hexandra Swartz 9901590

Loudetia simplex (Nees) C.E. Hubb. 9901751

Melinis nerviglume (Franch.) Zizka 9901340
Melinis repens (Willd.) Zizka

Microchloa caffra Nees 9902940

Miscanthus junceus (Stapf) Pilg. (445) 9900380

Monocymbium ceresiiforme (Nees) Stapf 9900750

Panicum maximum Jacq. 9901160
Panicum natalense Hochst.
Panicum repentellum Napper (600)

Paspalum dilatatum Poir. 9901070

Pennisetum sphacelatum (Nees) Dur. & Schinz (610) 9901390

Perotis patens Gand. 9902800

Phragmites australis (Cav.) Steud. 9902140

Pogonarthria squarrosa (Roem. & Schult.) 9903340

Schizachyrium jeffreysii (Hack.) Stapf 9900680
Schizachyrium sanguineum (Retz.) Alst.

Setaria incrassata (Hochst.) Hack. 9901280

Setaria lindenbergiana (Nees) Stapf (786)
Setaria megaphylla (Steud.) Dur. & Schinz
Setaria nigrirostris (Nees) Dur. & Schinz
Setaria sphacelata (Schumach.) Moss
Setaria verticillata (L.) Beauv.

Sporobolus conrathii Chiov. (291) 9902830
Sporobolus festivus A. Rich. (1116)
Sporobolus pectinatus Hack.
Sporobolus pyrimidalis Beauv.

Themeda triandra Forssk. 9900830

Trachypogon spicatus (L.f.) Kuntze 9900780

Tragus berteronianus Schult. 9902740

Tricholaena monachne (Trin.) Stapf & C.E. Hubb. 9901330

Trichoneura grandiglumis (Nees) Ekman 9903530

Tristachya biseriata Stapf 9901740
Tristachya leucothrix Nees
Tristachya rehmannii Hack.

Urelytrum agropyroides (Hack.) Hack. 9900170

Urochloa mosambicensis (Hack.) Dandy 9901100

Potamogetonaceae

Potamogeton thunbergii Cham. & Schlechtd. (616) 58

Typhaceae

Typha capensis (Rohrb.) N.E. Br. 49

Velloziaceae

Xerophyta retinervis Bak. 1247
Xerophyta viscosa Bak.

DICOTYLEDONAE

Acanthaceae

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

Crabbea acaulis N. E. Br. 7972
Crabbea angustifolia Nees
Crabbea hirsuta Harv.
Crabbea ovalifolia Fical. & Hiern.

Crossandra greenstockii S. Moore 7985

Hypoestes forskaolii (Vahl) R. Br. 8032

Isoglossa grantii C.B. Cl. 8079

Justicia anagalloides (Nees) T. Anders. 8094

Thunbergia atriplicifolia E. Mey. ex Nees (676) 7914
Thunbergia neglecta Sond.

Aizoaceae

Psammotropha myriantha Sond. 2379

Amaranthaceae

Achyranthes aspera L. * 2328

Pupalia lappacea (L.) Juss. * 2314

Anacardiaceae

Lannea discolor (Sond.) Engl. 4563
Lannea edulis (Sond.) Engl.

Rhus dentata Thunb. 4594
Rhus lancea F. f.
Rhus leptodictya Diels
Rhus magalismontana Sond.
Rhus pyroides Burch.
Rhus rigida Mill.
Rhus zeyheri Sond.

Ozoroa paniculosa (Sond.) R. & A. Fernandes 4589
Ozoroa sphaerocarpa R. & A. Fernandes

Sclerocarya birrea (A. Rich.) Hochst. 4558

Apiaceae

Centella asiatica (L.) Urb. 5894

Heteromorpha trifoliata (Wendl.) Eckl. & Zeyh. (485) 5992

Peucedanum magalismontanum Sond. 6116

Sium repandum Welw. ex Hiern 6038

Apocynaceae

Acokanthera oppositifolia (Lam.) Codd 6558

Carissa bispinosa (L.) Desf. ex Brenan 6559

Diplorhynchus condylocarpon (Muell. Arg.) Pichon 6589

Landolphia capensis Oliv. 6562

Araliaceae

Cussonia paniculata Eckl. & Zeyh. # 5872

Asclepiadaceae

Asclepias adscendens (Schltr.) Schltr. 6791
Asclepias affinis (Schltr.) Schltr.
Asclepias aurea (Schltr.) Schltr.
Asclepias fruticosa L.

Pachycarpus schinzianus (Schltr.) N.E. Br. 6787

Pentarrhinum insipidum E. Mey. 6810

Periglossum angustifolium Decne (715) 6783

Sarcostemma viminale (L.) R. Br. 6849

Tenaris rubella E. Mey. (1117) (271) 6921

Xysmalobium undulatum (L.) Ait. 6777

Asteraceae

Ambrosia artemisiifolia L. * (1244) 9146

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

Artemisia afra Jacq. ex Willd. 9358

Aster squamatus (Spreng.) Hieron. (1129) 8900

Athrixia elata Sond. 9055

Berkheya carlinopsis Welw. ex O. Hoffm. 9438
Berkheya pinnatifida (Thunb.) Thell.
Berkheya radula (Harv.) de Wild.
Berkheya seminivea Harv. & Sond.
Berkheya setifera DC.

Bidens bipinnata L. * 9237
Bidens pilosa L. *

Brachylaena rotundata S. Moore 8936

Conyza sumatrensis (Retz.) E.H. Walker * 8926
Conyza podocephala DC.

Crepis hypochoeridea (DC.) Thell. 9605

Dicoma anomala Sond. 9501
Dicoma macrocephala DC.
Dicoma zeyheri Sond.

Felicia filifolia (Vent.) Burtt Davy 8919
Felicia muricata (Thunb.) Nees

Gazania krebsiana Less. 9434

Geigeria burkei Harv. 9090

Gerbera viridifolia (DC.) Sch. Bip (393) 9528

Haplocarpha lyrata Harv. 9432
Haplocarpha scaposa Harv.

Helichrysum aureonitens Sch. Bip. (1062) (312) (673) 9006

Helichrysum acutatum DC.
Helichrysum caespititium (DC.) Harv.
Helichrysum callicomum Harv. (1036) (218) (307)
Helichrysum cephaloideum DC.
Helichrysum chionosphaerum DC.
Helichrysum coriaceum Harv. (108) (505)
Helichrysum dasymallum Hilliard
Helichrysum harveyanum Wild (259)
Helichrysum kraussii Sch. Bip.
Helichrysum lepidissimum S. Moore (394) (788)
Helichrysum nudifolium (L.) Less.
Helichrysum pulchellum DC.
Helichrysum rugulosum Less.
Helichrysum setosum Harv.

Hypochoeris radicata L. * 9572

Lactuca capensis Thunb. (141) 9596

Launaea nana (Bak.) Chiov. 9593

Lopholaena coriifolia (Sond.) Phill. & C.A. Sm. 9401

Macowania tenuifolia M.D. Henderson (383) 9053

Nidorella anomala Steetz 8925
Nidorella hottentotica DC. (1114)

Osteospermum jucundum (Phill.) T. Norl. (287) 9427
Osteospermum muricatum E. Mey. ex DC.

Phymaspermum athanasioides (S. Moore) Kallersjo 9336

Pseudognaphalium oligandrum (DC.) Hilliard & Burtt (1035) 8992

Pulicaria scabra (Thunb.) Druce (1073) (638) 9078

Schistostephium crataegifolium (DC.) Fenzl ex Harv. 9356
Schistostephium heptalobum (DC.) Oliv. & Hiern

Senecio affinis DC. 9411
Senecio asperulus DC. (1013)
Senecio cephalophorus (Compton) Jacobs.
Senecio coronatus (Thunb.) Harv.
Senecio erubescens Ait.
Senecio glandulosa-pilosus Volkens & Muschl.
Senecio gregatus Hilliard (444)

Senecio inornatus DC.
Senecio isatideus DC.
Senecio laevigatus Thunb. (1012)
Senecio lydenburgensis Hutch. & Burtt Davy (220) (658) (780)
Senecio othonniflorus DC. (113)
Senecio oxyriifolius DC.
Senecio polyodon DC. (468) (633)
Senecio striatifolius DC. (789)
Senecio venosus Harv.

Sonchus integrifolius Harv. (470) 9595
Sonchus nanus Sond. ex Harv.
Sonchus maritimus L. (159)

Stoebe vulgaris Levyns 9037

Tagetus minuta L. * 9311

Tolpis capensis (L.) Sch. Bip. (121) 9561

Ursinia nana DC. 9431

Vernonia galpinii Klatt 8751
Vernonia hirsuta (DC.) Sch. Bip. (388)
Vernonia oligocephala (DC.) Sch. Bip. ex Walp.
Vernonia poskeana Vatke & Hildebr.
Vernonia staehelinoides Harv.

Campanulaceae

Wahlenbergia banksiana A. DC. (803) 8668
Wahlenbergia undulata (L. f.) DC. (295) (409)

Capparaceae

Cleome maculata (Sond.) Szyszyl. 3082
Cleome monophylla L.
Cleome rubella Burch. (1028)

Caryophyllaceae

Polycarpaea corymbosa (L.) Lam. * 2455

Celastraceae

Maytenus heterophylla (Eckl. & Zeyh.) N.K.B. Robson 4626
Maytenus polyacantha (Sond.) Marais

Maytenus tenuispina (Sond.) Marais
Maytenus undata (Thunb.) Blakelock

Chrysobalanaceae

Parinari capensis Harv. 3405

Clusiaceae

Hypericum aethiopicum Thunb. 5168
Hypericum lalandii Choisy

Combretaceae

Combretum apiculatum Sond. 5538
Combretum molle R. Br. ex G. Don
Combretum zeyheri Sond

Terminalia sericea Burch. ex DC. 5544

Convolvulaceae

Ipomoea bathycolpos Hallier F. (251) 7003
Ipomoea crassipes Hook.
Ipomoea ommaneyi Rendle
Ipomoa purpurea (L.) Roth *

Merremia palmata Hallier F. 6997
Merremia tridentata (L.) Hallier F.

Turbina oblongata (E. Mey. ex Choisy) A. Meeuse 7008

Crassulaceae

Adromischus umbraticola C.A. Sm. 3175

Cotylodon orbiculata L. 3164

Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. 3168
Crassula setulosa Harv.
Crassula swaziensis Schonl.

Kalanchoe paniculata Harv. 3166
Kalanchoe rotundifolia (Haw.) Haw.
Kalanchoe thyrsiflora Harv.

Cucurbitaceae

Cucumis hirsutus Sond. 8599
Cucumis zeyheri Sond.

Kedrostis africana (L.) Cogn. (795) 8568

Zehneria scabra (L. f.) Sond. (794) 8564

Dichapetalaceae

Dichapetalum cymosum (Hook.) Engl. 4283

Dipsacaceae

Cephalaria zeyheriana Szabo 8541

Scabiosa columbaria L. 8546

Ebenaceae

Diospyros lyciodes Desf. 6406
Diospyros whyteana (Hiern.) F. White

Euclea crispa (Thunb.) Guerke 6404

Ehretiaceae

Ehretia rigida (Thunb.) Druce 7043

Elatinaceae

Bergia decumbens Planch. ex Harv. (475) 5230

Ericaceae

Erica woodii H. Bol. 6237

Euphorbiaceae

Acalypha angustata Sond. 4407
Acalypha caperonioides Baill.
Acalypha petiolaris Hochst.

Clutia pulchella L. 4448

Croton gratissimus Burch. 4348

Dalechampia capensis Spreng. F. 4422

Euphorbia clavarioides Boiss. 4498
Euphorbia heterophylla L. (796)
Euphorbia ingens E. Mey. ex Boiss.
Euphorbia schinzii Pax
Euphorbia striata Thunb.

Fabaceae

Acacia caffra (Thunb.) Willd. 3446
Acacia karroo Hayne

Argyrolobium speciosum Eckl. & Zeyh. (410) 3673
Argyrolobium tuberosum Eckl. & Zeyh. (438)

Burkea africana Hook. 3474

Cassia comosa (E. Mey.) Vogel 3536
Cassia italica (Mill.) Lam ex F.W. Andr.
Cassia mimosoides L.

Dichrostachys cinerea (L.) Wight & Arn. 3452

Elephantorrhiza burkei Benth. 3462
Elephantorrhiza elephantina (Burch.) Skeels

Eriosema burkei Benth. 3898

Indigofera acutisepala Conrath 3702
Indigofera atrata N.E. Br. (1130)
Indigofera comosa N.E. Br.
Indigofera confusa Prain & Bak. f. (270) (651)
Indigofera daleoides Benth. ex Harv.
Indigofera egens N.E. Br. (315)
Indigofera filipes Benth. ex Harv.
Indigofera hedyantha Eckl. & Zeyh.
Indigofera heterotricha DC. (647)
Indigofera hilaris Eckl. & Zeyh. (104) (173) (269)
Indigofera obscura N.E. Br. (1076)
Indigofera oxalidea Welw. ex Bak. (1136)
Indigofera pilgerana Schltr.
Indigofera setiflora Bak.
Indigofera sordida Benth. ex Harv. (219)
Indigofera zeyheri Spreng. ex Eckl. & Zeyh. (500)

Lessertia stricta L. Bol. (450) 3756

Lotononis eriantha Benth. (182) 3657
Lotononis foliosa H. Bol.

Mundulea sericea (Willd.) A. Chev. 3719

Pearsonia sessilifolia (Harv.) Duemmer 3657

Peltophorum africanum Sond. 3561

Rhynchosia adenodes Eckl. & Zeyh. 3897
Rhynchosia monophylla Schltr.
Rhynchosia nitens Benth.
Rhynchosia totta (Thunb.) DC. (695)

Sesbania punicea (Cav.) Benth. * 3747

Sphenostylis angustifolia Sond. 3907

Tephrosia acaciifolia Bak. (771) 3718
Tephrosia capensis (Jacq.) Pers. (499)
Tephrosia glomeruliflora Meisn. (230)
Tephrosia linearis (Wild) Pers. (483)
Tephrosia longipes Meisn. (785)
Tephrosia multijuga R.G.N. Young
Tephrosia polystachya E. Mey. (712)
Tephrosia semiglabra Sond. (1100)
Tephrosia villosa (L.) Pers. (787)

Trifolium africanum Ser. 3690

Vigna vexillata (L.) A. Rich. 3905

Zornia linearis E. Mey. 3804
Zornia milneana Mohlenbr.

Flacourtiaceae

Dovyalis zeyheri (Sond.) Warb. 5328

Kiggelaria africana L. 5296

Scolopia zeyheri (Nees) Harv. 5304

Gentianaceae

Chironia palustris Burch. (482) 6503

Sebaea leiostyla Gilg 6481

Geraniaceae

Monsonia attenuata Harv. 3925
Monsonia burkeana Planch. ex Harv.

Pelargonium pseudofumarioides Knuth 3928

Gesneriaceae

Streptocarpus vandeleurii Bak. f. & S. Moore # 7823

Haloragaceae

Gunnera perpensa L. 5836

Icacinaceae

Apodytes dimidiata E. Mey. ex Arn. 4686

Illecebraceae

Dianthus mooiensis F.N. Williams 2502

Pollichia campestris Ait. 2462

Lamiaceae

Acrotome hispida Benth. 7236

Becium angustifolium (Benth.) N.E. Br. (1200) (769) 7366
Becium obovatum (E. Mey. ex Benth.) N.E. Br.

Hemizygia canescens (Guerke) Ashby (321) (360) (390) 7365
Hemizygia pretoriae (Guerke) Ashby (372)

Leonotis ocymifolia (Burm.) Iwarsson 7264

Plectranthus madagascariensis (Pers.) Benth. 7350

Salvia repens Burch. ex Benth. 7290
Salvia runcinata F. f.

Stachys natalensis Hochst. (395) 7281

Teucrium trifidum Retz. 7217

Lobeliaceae

Monopsis decipiens (Sond.) Thulin (698) 8695

Loganiaceae

Buddleja saligna Willd. 6473
Buddleja salviifolia (L.) Lam.

Gomphostigma virgatum (L. F) Baill. 6470

Nuxia congesta R. Br. ex Fresen. 6469

Strychnos pungens Lam. 6460
Strychnos spinosa Lam.

Malpighiaceae

Sphedamnocarpus galphimiifolius (Juss.) Szyszyl. 4219

Malvaceae

Hibiscus calyphyllus Cav. 5013
Hibiscus engleri K. Schum.
Hibiscus trionum L.

Sida ovata Forssk. 4998
Sida rhombifolia L.

Mesembryanthemaceae

Khadia acutipetala (N.E. Br.) N.E. Br. 2405

Moraceae

Ficus abutilifolia Miq. 1961
Ficus ingens (Miq.) Miq.
Ficus thonningii Blume

Myrothamnaceae

Myrothamnus flabellifolia (Sond.) Welw. 3282

Myrsinaceae

Myrsine africana L. 6313

Ochnaceae

Ochna pretoriensis Phill. 5112
Ochna pulchra Hook.

Olacaceae

Ximenia caffra Sond. 2136

Oleaceae

Olea europaea L. 6434

Onagraceae

Oenothera rosea L'Herit. ex Ait. * 5804
Oenothera tetraptera Cav. *

Oxalidaceae

Oxalis obliquifolia Steud. ex Rich. 3936

Passifloraceae

Adenia digitata (Harv.) Engl. 5370

Periplocaceae

Cryptolepis oblongifolia (Meisn.) Schltr. 6740

Raphionacme hirsuta (E. Mey.) R.A. Dyer ex Phill. 6747

Pittosporaceae

Pittosporum viridiflorum Sims 3252

Plantaginaceae

Plantago virginica L. * 8116

Polygalaceae

Polygala hottentotta Presl 4273
Polygala uncinata E. Mey. ex Meisn.

Polygonaceae

Polygonum lapathifolium L. 2201

Polygonum pulchrum Blume
Polygonum salicifolium Willd.

Rumex crispus L. (439) 2195

Portulacaceae

Anacampseros subnuda V. Poelln. 2412

Portulaca kermesina N.E. Br. 2421

Proteaceae

Faurea saligna Harv. 2034

Protea caffra Meisn. # 2035

Ranunculaceae

Clematis brachiata Thunb. 2542

Clematopsis scabiosifolia (DC.) Hutch. 2542

Ranunculus multifidus Forssk. 2546

Rhamnaceae

Rhamnus prinoides L'Herit. 4875

Ziziphus mucronata Willd. 4861
Ziziphus zeyheriana Sond.

Rosaceae

Agrimonia odorata Mill. * 3376

Rubiaceae

Anthospermum hispidulum E. Mey. ex Sond. (396) 8438

Canthium gilfillanii (N.E. Br.) O.B. Miller 8352
Canthium mundianum Cham. & Schlechtd.

Fadogia homblei de Wild 8359

Kohautia amatymbica Eckl. & Zeyh. 8136
Kohautia cynanchica DC.

Oldenlandia herbacea (L.) Roxb. 8136

Pavetta gardeniifolia A. Rich. 8383
Pavetta zeyheri Sond.

Pentanisia angustifolia (Hochst.) Hochst. 8348
Pentanisia prunelloides (Klotzsch ex Eckl. & Zeyh.) Walp. (413)

Psydrax livida (Hiern) Bridson 8352

Pygmaeothamnus zeyheri (Sond.) Robyns 8351

Richardia brasiliensis Gomes 8464

Rothmannia capensis Thunb. 8285

Tapiphyllum parvifolium (Sond.) Robyns 8351

Vangueria infausta Burch. 8351

Rutaceae

Vepris reflexa Verdoorn 4076
Vepris undulata (Thunb.) Verdoorn & C.A. Sm.

Zanthoxylum capense (Thunb.) Harv. 3991

Salicaceae

Salix babylonica L. * 1873
Salix mucronata Thunb.

Santalaceae

Osyris lanceolata Hochst. & Steud. 2108

Thesium deceptum N.E. Br. (642) 2118
Thesium utile A.W. Hill (1115)

Sapindaceae

Pappea capensis Eckl. & Zeyh. 4784

Sapotaceae

Bequaertiodendron magalismontanum (Sond.) Heine & J.H. Hemsl. 6377

Mimusops zeyheri Sond. 6386

Scrophulariaceae

Craterostigma wilmsii Engl. ex Diels 7560

Cycnium adonense E. Mey. ex Benth. (781) 7623
Cycnium tubulosum (L. f.) Engl. (484)

Graderia subintegra Mast. 7614

Manulea parviflora Benth. (1138) 7516

Nemesia fruticans (Thunb.) Benth. (1101) 7476
Nemesia umbonata (Hiern) Hilliard & Burtt (408)

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

Sutera aurantiaca (Burch.) Hiern 7519
Sutera palustris Hiern (1042) (1232)

Zaluzianskya elongata Hilliard & Burtt (1211) 7523

Selaginaceae

Hebenstretia angolensis Rolfe (804A) 7566

Walafrida densiflora (Rolfe) Rolfe 7568

Solanaceae

Physalis viscosa L. * 7401

Solanum elaeagnifolium Cav. * 7407
Solanum incanum L.
Solanum mauritianum Scop. *
Solanum nigrum L. *
Solanum panduriforme E. Mey.
Solanum rigescens Jacq.
Solanum seaforthianum Andr. *
Solanum supinum Dun.

Sterculiaceae

Dombeya rotundifolia (Hochst.) Planch. 5053

Hermannia antonii Verdoorn (1066) 5056
Hermannia depressa N.E. Br.
Hermannia lancifolia Szyszyl.
Hermannia transvaalensis Schinz

Thymelaeaceae

Gnidia capitata F. f. 5435
Gnidia kraussiana Meisn.
Gnidia microcephala Meisn. (132)
Gnidia sericocephala (Meisn.) Gilg ex Engl.

Tiliaceae

Corchorus asplenifolius Burch. 4953

Grewia occidentalis L. 4966

Triumfetta sonderi Ficalho & Hiern 4975

Ulmaceae

Celtis africana Burm. F. 1898

Urticaceae

Obetia tenax (N.E. Br.) Friis 1979

Pouzolzia mixta Solms 1992

Verbenaceae

Clerodendrum glabrum E. Mey. 7191
Clerodendrum triphyllum (Harv.) H. Pearson (1054)

Lantana camara L. * 7144
Lantana rugosa Thunb.

Lippia javanica (Burm. F.) Spreng. 7145
Lippia scaberrima Sond.

Plexipus adenostachyus (Schauer) R. Fernandes 7148

Verbena bonariensis L. * 7138

Vitaceae

Rhoicissus tridentata (L.F.) Wild & Drum. 4917

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SUMMARY

PHYTOSOCIOLOGY OF THE Ba AND Ib OF LAND TYPES IN THE PRETORIA-WITBANK-HEIDELBERG AREA

by

JOHANNES PETRUS COETZEE

Supervisor: Prof. Dr. G.J. Bredenkamp

Co-supervisor: Dr N. van Rooyen

DEPARTEMENT OF PLANTKUNDE

UNIVERSITY OF PRETORIA

MAGISTER SCIENTIAE

The aims of this study were to identify, classify, describe and interpret ecologically the major vegetation units, plant communities and their variations in the Ba and Ib land types within the Pretoria-Witbank-Heidelberg area. The identification of priority areas for conservation in this area, resulting from knowledge of the vegetation is a further aim of the study.

The study area was stratified according to land types and terrain units. The position of

the sample plots were chosen subjectively within each of these units to ensure homogeneous physiognomy and physiography within each sample plot. A total of 265 sample plots were used to survey the area of approximately 11 250 km^2. A floristic survey, according to Braun - Blanquet procedures, and a habitat survey were carried out. The data were classified by means of TWINSPAN and refined by Braun - Blanquet procedures.

The classification of the floristic data resulted in the identification of eight vegetation units, 32 plant communities and 11 variations. All identified plant communities were classified, described and ecologically interpreted.

The study area is situated within the transition zone between the Grassland and Savanna Biomes and the described plant communities gave an indication of the transition of vegetation from the Savanna to the Grassland Biome. It was also found that this transition is mainly due to the differences in altitude and associated climate. The vegetation maps of Acocks (1953, 1988) from this area was also revised. Various communities and areas with a high conservation priority were identified.

OPSOMMING

FITOSOSIOLOGIE VAN DIE Ba EN Ib LANDTIPES
BINNE DIE PRETORIA-WITBANK-HEIDELBERG GEBIED

deur

JOHANNES PETRUS COETZEE

Studieleier: Prof. dr. G.J. Bredenkamp
Medeleier: Dr. N van Rooyen

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UNIVERSITEIT VAN PRETORIA

MAGISTER SCIENTIAE

Die doel van die studie was die identifisering, klassifisering, en ekologiese interpretering van die plantegroei-eenhede, hulle plantgemeenskappe en variasies van die Ba en Ib landtipes binne die Pretoria-Witbank-Heidelberg gebied. Die identifisering van prioriteitsareas vir natuurbewaring, voortspruitend uit kennis oor die plantegroei in die gebied, was 'n verdere doel van die studie.

Die gebied is gestratifieër op grond van landtipes en terrein-eenhede. Die monsterpersele is ewekansig in elk van die eenhede uitgeplaas om homogene fisionomie en fisiografie binne elke monster perseel te verseker. 'n Totaal van 265 monsterpersele is in die studiegebied uitgeplaas. 'n Floristies opname deur middel van die Braun - Blanquet-metode, as ook 'n habitat opname, is uitgevoer. Die data is met behulp van TWINSPAN geklassifiseer en daarna verfyn deur die toepassing van Braun - Blanquet prosedures.

Die klassifisering van die floristiese data het tot die onderskeiding van agt plantegroei-eenhede, 32 plantgemeenskappe en 11 variasies gelei. Al die geïdentifiseerde plantgemeenskappe is geklassifiseer, beskryf en ekologies geïnterpreteer.

Die studiegebied is in die oorgangsgebied van die Grasveld en Savanna Biome geleë. Die geïdentifiseerde plantgemeenskappe gee 'n aanduiding van die oorgangsgradiënt in plantegroei tussen die Grasveld en Savanna Biome. Die studie het ook aangetoon dat die verskille in plantegroei onder andere toegeskryf kan word aan verskille in hoogte bo seevlak en geassosieerde klimaatsverskille. Die kaart van Acocks (1953, 1988) van die betrokke gebied is ook hersien. Verskeie plantgemeenskappe en gebiede of streke is as prioriteits bewaringsgebiede geïdentifiseer.

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