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PHYTOSOCIOLOGY OF THE NORTH-EASTERN MOUNTAIN SOURVELD

MSc UP 1991

Phytosociology of the North-eastern Mountain Sourveld

by

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Submitted in partial fulfilment of the requirements
for the degree

MAGISTER SCIENTIAE

in the Faculty of Science
(Department of Botany)

University of Pretoria

PRETORIA

Supervisor: Prof. dr. G.J. Bredenkamp
Co-supervisor: Dr. N. van Rooyen

September 1991

Dedicated to my Family and Friends.

ABSTRACT

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The vegetation of the North-eastern mountain sourveld of the Eastern Transvaal Escarpment was classified by means of Braun-Blanquet and TWINSPAN procedures. Stratification was done by using relatively homogeneous units of major attributes such as geology, land form (topography), physiognomy and dominant plant species. The classification of the floristic data resulted in four different major vegetation units, representing the vegetation of the Black Reef Quartzite and associated large rocky outcrops, the dry dolomitic regions, the high altitude hygrophilous vegetation and the relatively low altitude vegetation regions. All identified plant communities were ecologically interpreted and described. The endemic flowering plants of the north-eastern Transvaal Escarpment was analyzed with respect to substrate and species lists were compiled.

UITTREKSEL

Fitososiologie van die Noord-oostelike Berg Suurveld

deur

WAYNE MATTHEWS

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Voorgelê ter vervulling van 'n deel van die vereistes
vir die graad

MAGISTER SCIENTIAE

Die plantegroei van die Noord-oostelike bergsuurveld van die Oos-Transvaalse platorand is geklassifiseer deur die toepassing van Braun-Blanquet prosedures en die gebruik van TWINSPAN. Stratifiëring is gedoen op grond van relatiewe homogene eenhede gebaseer op hoof kenmerke soos geologie, land vorm (topografie), fisionomie en dominante plant spesies. Die klassifisering van die floristiese data het gelei tot die onderskeiding van vier hoof plantegroei-eenhede, naamlik die Swart Rif Kwartsiet en assoseerde groot rotsagtige gebiede, die droë dolomitiese gebiede, die plantegroei van hooggeleë en nat gebiede en die plantegroei van relatiewe laagliggende gebiede. Al die geïdentifseerde plantgemeenskappe is ekologies geïnterpreteer en beskryf. Die endemiese blomplante spesies van die noord-oostelike Transvaalse platorand was ondersoek met betrekking tot geologie en spesieslyste word verskaf.

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CHAPTER 1

INTRODUCTION

The part of the Eastern Transvaal Escarpment under discussion here are those areas classified as North-eastern Mountain Sourveld by Acocks (1988). These areas of rolling grasslands and their associated patches of forest form part of White's (1978, 1983) Afromontane region, an archipelago region associated with high altitude areas in many parts of Africa.

Of the about 23 000 species and infraspecific taxa of seed plants indigenous to the flora of the southern Africa region, an estimated 6 700 occur in the Transvaal. About one third of the latter taxa has been recorded from the Eastern Transvaal Escarpment, therefore one of the richest area for plants species found in the Transvaal. Concomitantly the highest concentration of threatened plant species in the Transvaal is found along the Escarpment area (Fourie 1986; Ferrar et al. 1988).

These areas of the Eastern Transvaal Escarpment are under heavy pressure from the timber industry for land for afforestation. In many areas extensive afforestation has destroyed most of the natural vegetation, and large tracks of land have been severely invaded by alien plants. This is in direct conflict with the need to protect the mountain catchments, to conserve natural ecosystems and to preserve scenic landscapes for the tourist industry (Deall et al. 1989). Rational land-use planning and management is required to resolve such conflict (Ferrar et al. 1988). For nature conservation purposes, the recognition of more specific core sites of high species-richness and/or endemism is important for developing strategies for the protection of the greatest diversity as well as number of plant species plus associated biota.

The relationship between plant ecological studies and land-use planning and management is well known (Pentz 1938; Bayer 1970; Walker 1976; Van Rooyen et al. 1981; Moore & Chapman 1986). In describing the South African Grassland Biome project Mentis & Huntley (1982) stated the necessity to identify, describe and determine the location of the major vegetation types and subtypes within the biome. This was also emphasized by Scheepers (1987). One of the goals of the vegetation classification and

mapping task group of the Botanical Research Institute (now part of the Grassland Research Centre of the Department of Agricultural Development), is the production of a vegetation classification (Scheepers 1986). This would result in ecological interpretable units which can be used for environmental planning, management and conservation.

The first and main aim of this investigation was to classify the vegetation of the study area into homogeneous vegetation units. There are various methods available for mapping and describing vegetation (Küchler 1967; Whittaker 1962, 1967, 1980; Shimwell 1971; Mueller-Dombois and Ellenberg 1974; Greig-Smith 1983). The various approaches fill specific research needs as dictated by the aims of such research. For this project the Braun-Blanquet approach was used (Muller-Dombois & Ellenberg 1974; Werger 1974; Whittaker 1980; Coetzee 1983), as this approach is currently used as standard to classify and describe the vegetation of South Africa.

Other aspects considered were areas of high plant species diversity and/or presence of endemic or rare species. Knowing that land in the Eastern Transvaal Escarpment is in such demand for afforestation as well as being floristical rich, areas of importantance for the preservation of this floristical diversity be highlighted or demarked. In the future these areas could be brought to the attention of conservation authorities so as to be managed as conservation areas or by declaring these areas floral nature reserves and then being managed as such.

This thesis consists of a collection of contributions on the phytososociology of the North-eastern Mountain Sourveld (Acocks 1988) of the Eastern Transvaal Escarpment. These studies were approached with an ultimate phytosociological and syntaxonomical synthesis of the South African Grasslands Biome in mind. In recent years great advance has been made with synecological and syntaxomomical studies in the South African Grassland Biome (Deall 1985, Bezuidenhout 1988, Bloem 1988, Turner 1989, Shackleton 1989, Kooij 1990).

Contributions are in the form of manuscripts, which have been published, accepted for publication, or which have been submitted for publication in various

scientific journals. Although details of the study area, methods, results, discussion and references are presented in the individual contributions, brief chapters on the study area, methods, a general discussion, a preliminary species list and a comprehensive list of references are also included. A synthesis of the principle findings of the work is presented under the Chapter "General Discussion".

The manuscripts present show some stylistic irregularities and repetitiveness. These are primarily due to differences in layout and style required by the various scientific journals and that each manuscript is an entity in itself. To get manuscripts accepted for publication, conformation to some idiosyncrasies of referees and editors was sometimes unavoidable.

CHAPTER 2

METHODS

Terrain reconnoitring

All possible published environmental information and vegetation data relevant to the study area was obtained, to enable a sound stratification of the area for efficient sampling of the representative vegetation types in a limited time. This was followed by the demarcation of the specific locality of the study area on a 1:250 000 scale topographical base map, of Pilgrim's Rest, 2430. Information concerning geology was obtained from 1:250 000 geological survey maps (Geological Survey 1986), and that of land type obtained from the Land Type Survey Staff (1989), was super-imposed onto the base map. The study area was further investigated through traversing the area so as to form a basic idea of the topography, landuse, conservation potential, vegetation variation as well as the accessability of many of the mountain areas to be surveyed. From all this information the area was stratified into relatively homogeneous units, using geology, land form(topography), physiognomy and dominant species as major attributes to delimit stratification units.

Number and distribution of sample plots

According to Bredenkamp (1982) the number of sampling plots are influenced by various factors, for example the scale of the survey, environmental heterogeneity (variation) in the study area, and the scale necessary for the classification. As the results should give a clear reflection of the variation of the vegetation (Bredenkamp 1982), the sample plots were therefore, as far as possible, equally distributed in the different stratification units. A minimum of four sample plots were placed in each of the stratification units recognized.

The exact position of each sample plot within the relevant stratification unit was chosen subjectively according to the methodology of the Zurich-Montpellier approach of phytosociology (Braun - Blanquet 1964). 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 other phytosociological studies in South African

grasslands (Bezuidenhout et al. 1988, Behr & Bredenkamp 1988, Bredenkamp et al. 1989, Bezuidenhout & Bredenkamp 1990, Bredenkamp & Bezuidenhout 1990, Kooij et al. 1990a,b,c & d).

The size of the sample plots was 10m x 10m, and was based on Bredenkamp & Theron (1978) who found that a plot size of 100 m^2 to be adequate for the sampling of South African grassland vegetation for classification purposes. As far as possible, the shape of the sample plot was square, but many times it was necessary to adapt the shape to ensure that the vegetation sample was homogeneous, for example, within seepage lines and rock outcrops. Sampling was carried out from January to May of 1989 and 1990. A total of two hundred sample plots were distributed throughout the study area.

Sampling method

The Braun - Blanquet sampling technique was used, as it is considered to be a standardised method for phytosociological surveys in South Africa (Bredenkamp 1982). A comprehensive floristic and habitat survey was done in each sample plot.

Floristic analysis

The floristic survey included a list of all the species present in a sample plot as well as a cover-abundance value for 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% cover of total plot area.

2 - abundant with between 5 - 25% cover of total sample plot area.

A: 5 - 12%

B: >12 - 25%

3 - greater than 25 - 50% cover of total sample plot area, irrespective of the number of individuals.

4 - greater than 50 -75% cover of total sample plot area, irrespective of the number of individuals.

5 - greater than 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, 1990).

Habitat Analysis

According to Daubenmire (1968) the distribution of plant communities are determined by environmental factors. The physical environment plays an important role in the ecological interpretation of the floristic data (Bezuidenhout 1988). Detailed habitat information is recommended by Morris (1973) and employed by Bredenkamp (1985). The physical environment or habitat is made up of a complex of many interacting factors which result in the plant communities distributions (Bredenkamp 1985). The following habitat factors were investigated:

Geology

The geological descriptions according to the 1:250 000 geological survey maps (Geological Survey 1986) of the study area were used as a guideline for the identification of the geological types and locally at a smaller scale, personal observations in the field. The following geological types were recognized:

1. Chuniespoort Group (dolomite)
2. Black Reef Quartzite Formation
3. Timeball Hill Formation (shale and quartzite)
4. The Wolkberg group
5. Transvaal Diabase
6. Quaternary deposits (alluvium)

Rock cover

The percentage of the sample plot covered by surface rock (rockiness) was estimated, as well as the size of the surface rocks. The size in diameter of the surface

rocks was estimated as follows:

Large rock outcrops: >1 000 mm diameter
Rocks: >300 - 1 000 mm diameter
Small rocks: >50 - 300 mm diameter
Stones or gravel: <50 mm diameter

Topography

The following criteria was 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 types, according to Land Type Survey Staff (1989) namely:
   (1) crests
   (2) scarp
   (3) midslope
   (4) footslope
   (5) valley bottom or floodplain.

3. The gradient by means of a clinometer.
4. The aspect by means of a compass bearing.

General observations and notes.

General observations included the degree of exposure, grazing, as well as signs of fire.

1. Exposure was evaluated as exposed to sun, wind and mist, expressed as sheltered, partly sheltered or exposed.

2. Notes, when available, on when the area was last burnt was obtained from the local authorities.

3. The land type according to 1:250 000 Land Type maps (Land Type Survey Staff, 1989) was also noted for each sample plot, and soil form (MacVicar et al. 1977, Land Type Survey Staff, 1989).

4. Note was made of the nearest relevant weather station (rainfall figures).

Data Processing

A relevé was compiled for each sample plot. A relevé is a list of all the observations made in a sample plot (Coetzee 1972). Two-way indicator species analysis (TWINSPAN) (Hill 1979b) was applied to the basic floristic data set in order to derive a first approximation of the possible plant communities. 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 computer programme BBNEW, available at the Botany Department of the University of Pretoria.

After an ecological interpretation of the major vegetation classes distinguished by the first approximation, the main data set was subdivided into four smaller data sets. These data sets were then processed separately by Braun-Blanquet procedures. This procedure proved successful in the analysis of the Western Transvaal and North-western Orange Free State (Bezuidenhout et al. 1988; Behr & Bredenkamp 1988; Bredenkamp et al. 1989; Bezuidenhout & Bredenkamp 1990; Bredenkamp & Bezuidenhout 1990; Kooij et al. 1990a,b,c & d). The plant communities distinguished were described and interpreted ecologically.

In analyzing some of the data sets, an ordination algorithm, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set in order to determine a possible vegetation and associated habitat gradients, as well as the floristic relationships among the plant communities.

The principles and recommendations of the Code for Syntaxonomic Nomenclature (Barkman et al. 1986) were applied. The results of this study together with those of other similar studies in the Grassland Biome (for example Bredenkamp et al., 1989;

Bezuidenhout & Bredenkamp 1990 & 1991; Du Preey & Bredenkamp 1991) provide adequate knowledge of the grassland vegetation to compile a formel syntaxonomy of some of the plant communities identified in this study. Therefore, the syntaxonomical names of some of the syntaxa were fixed.

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

Data collecting and analysis for the endemic species

Data on the distribution of plant taxa were obtained from PRECIS (Pretoria National Herbarium Computerised Information System). This information was verified and supplemented by a study of herbarium specimens in the National Herbarium (PRE), Pretoria, the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria, and botanical literature.

Extensive fieldwork was conducted, which includes the phytosociological survey fieldwork, and many herbarium specimens were collected. Distributional data was correlated with 1:250 000 scale geological maps (Geological Survey 1986) of Geological Survey, Department of Mineral and Energy Affairs, Pretoria

CHAPTER 3
PHYSICAL ENVIRONMENT

Locality

The study area represents that part of the North-eastern Mountain Sourveld (Acocks, 1988), occurring on the 2430 Pilgrim's Rest and the small part on 2428 Nylstroom (1: 250 000) maps. The area is situated between 24°00' and 25°00' S; 29°55' and 30°55' E, and covers an area of approximately 2 000 km^2. Note: this figure is approximate as the area is dissected by many steep-sided valleys and the actual surface area will be greater than this map-derived calculation (Figure 3.1). This includes a large part of the area defined as the Transvaal Escarpment (Ferrar et al. 1988) also known as the great escarpment of the Drakensberg.

The only towns situated in the study area are Sabie, Graskop and Pilgrim's Rest. Many well known tourist attractions are to be found in the study area such as God's Window, Panorama Gorge, Blyde Canyon, Bourke's Luck Pot Holes as well as many large waterfalls such as the Mac Mac, Lisbon and Berlin Falls. Two of the largest Transvaal Provincial Administration Nature Reserves are located in the area namely Blyderivierspoort Nature Reserve (22 664 ha) and Wolkberg Nature Reserve (19 270 ha). Some of the largest "man made forests" (exotic plantations) in Africa are also found in the area.

Physiography

The study area is mountainous in nature with many peaks, deep valleys and gorges with their associated streams. The altitude varies from 1 100 m to 2 284 m of Mount Anderson. The eastern border of the study area is characterized by the cliffs of the great escarpment of the Drakensberg.

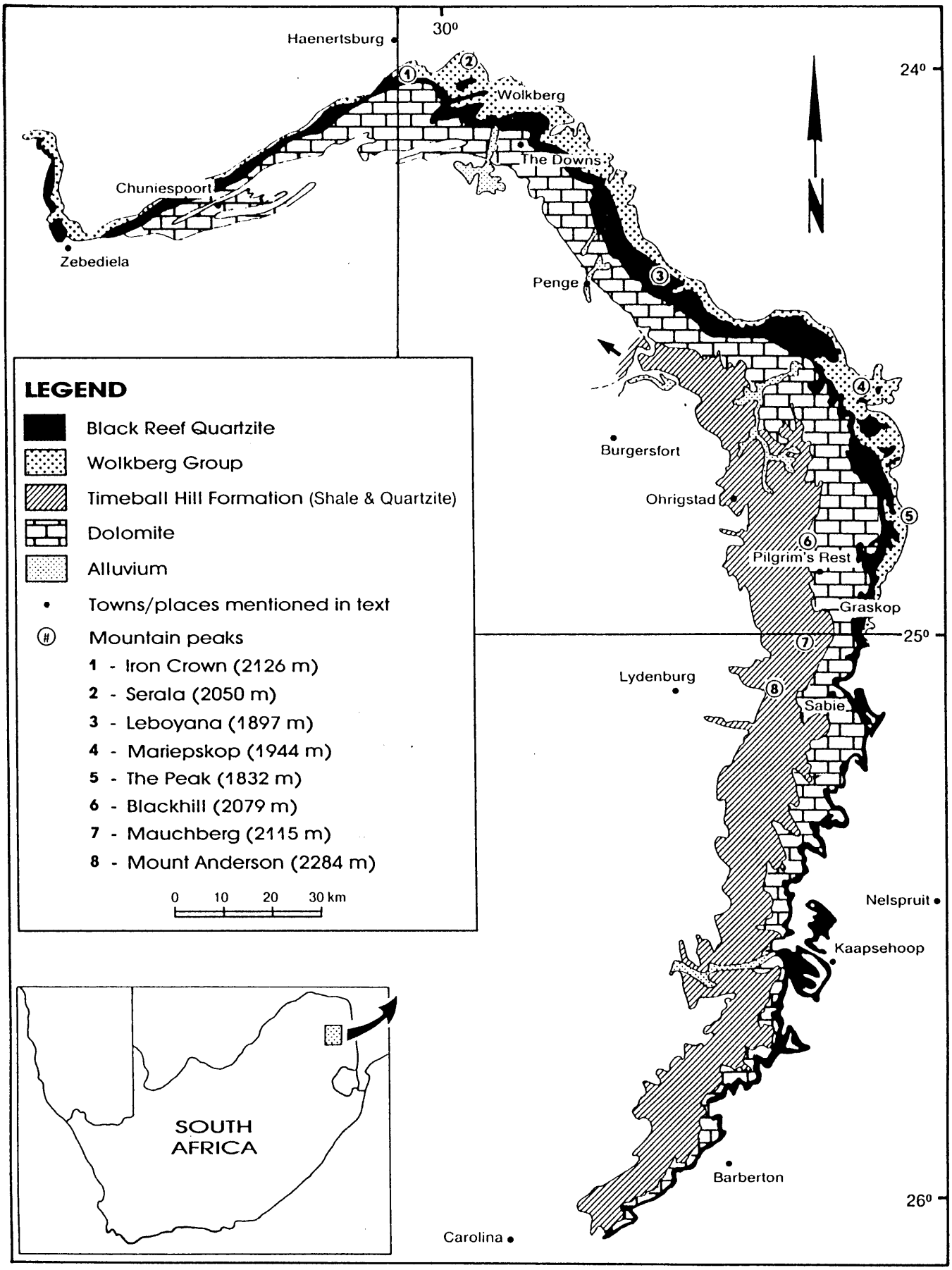


Figure 3.1. Map showing the locality of the study area, simplified geology and position of major mountain peaks (After the 1:1 000 000 Geological Map of South Africa, 1984, Geological Survey, Dept. of Mineral & Energy Affairs, Pretoria). The phytosociology study area is the North-eastern Mountain Sourveld areas north of 25° 00'S and east of 29° 55'E. Diabase and Timeball Hill Formation's quartzites are not plotted as they are distributed randomly, in small to biggish, complex arrangements.

Following the reasoning of Killick (1963), Scheepers (1978) and Deall et al. (1989a), this study area may be divided into the following broad physiographic belts (Figures 3.2 & 3.3), distinguished mainly according to altitude:

1. The Subalpine Belt (Summit) consisting of the rolling plains, level terraces and prominent peaks of the mountain summits, usually above 1 900 m. This can be subdivided into the summit plateau, summit slopes and summit peaks.

2. The steeply sloping Montane Belt (mountain slopes), usually from 1 200 m to 1 900 m. This zone is found between the summit and escarpment zone and is subdivided according to altitude into upper slopes and lower slopes. Slopes can be terraced and/or incised by deep valleys.

3. The complex Submontane belt (escarpment) of the escarpment slopes to the west and east, this includes the escarpment plateau areas to the west of the scarp crest. This is a complex area which is dissected by many valleys and hills, and varies along the entire scarp. This belt can be subdivided into scarp plateau, scarp plateau mountains, scarp crest, scarp upper slopes and scarp lower slopes. Not all these subdivisions are always present throughout this belt.

Belts 1 and 2 are absent from the northern parts of the study area. Here only belt 3, the Submontane belt occurs with it's many subdivisions, although in these areas the altitude is higher than that found in the southern areas of this belt. It must also be noted that in certain areas such as the Blyde River canyon, the Submontane belt can be incised by a very deep valley (Canyon) resulting in free standing areas to the west, of which Mariepskop and Hebronberg are good examples. These areas can be compared with the belts of the northern parts (Figure 3.3).

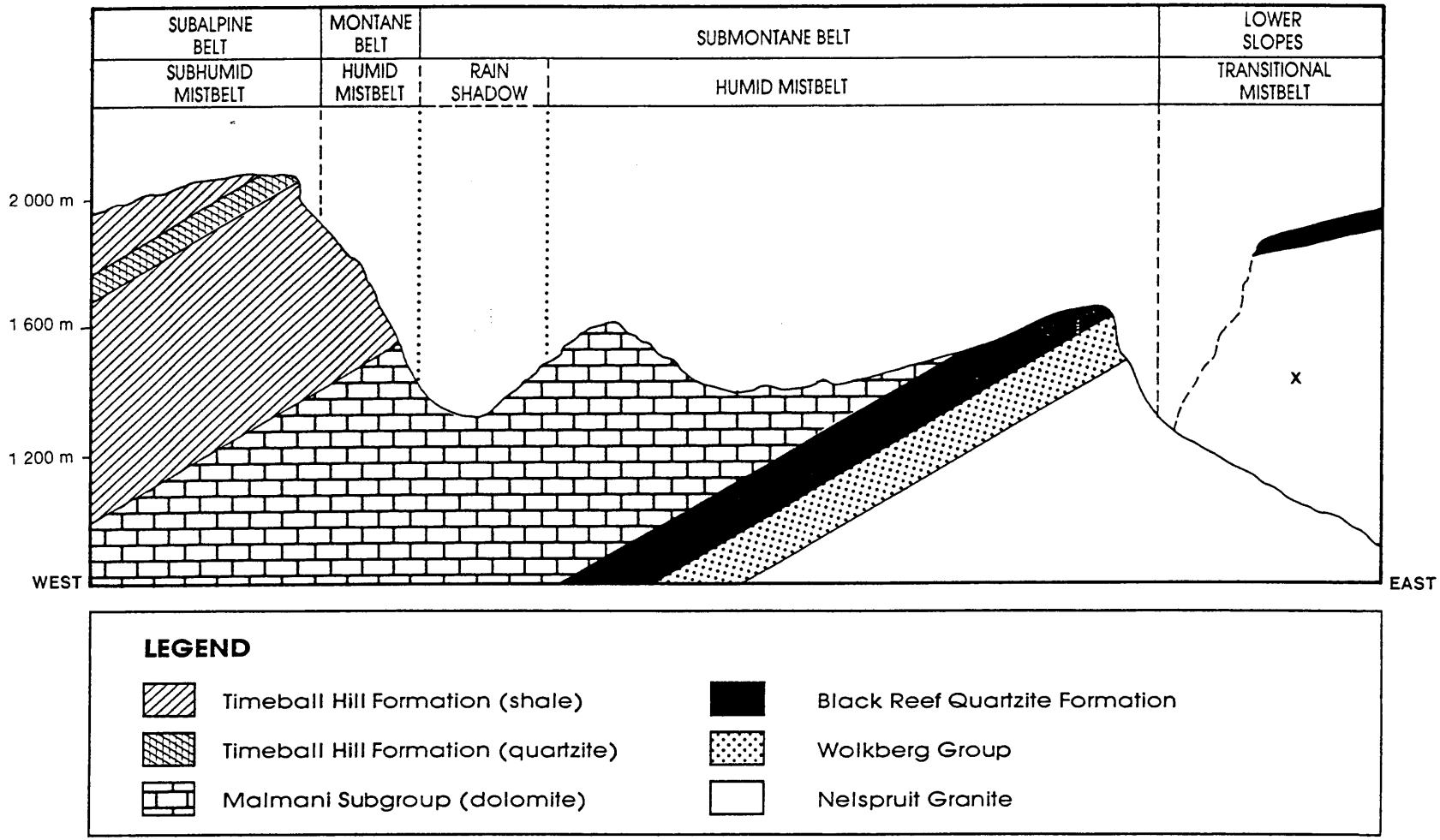


Figure 3.2 A schematic representation of the profile of the central sections of the study area of the Transvaal Escarpment, to show positions of physiographic and mist belts. Note: the dip of the geological layers is exaggerated (actual dip is approximately 7°).
x - Free standing area.

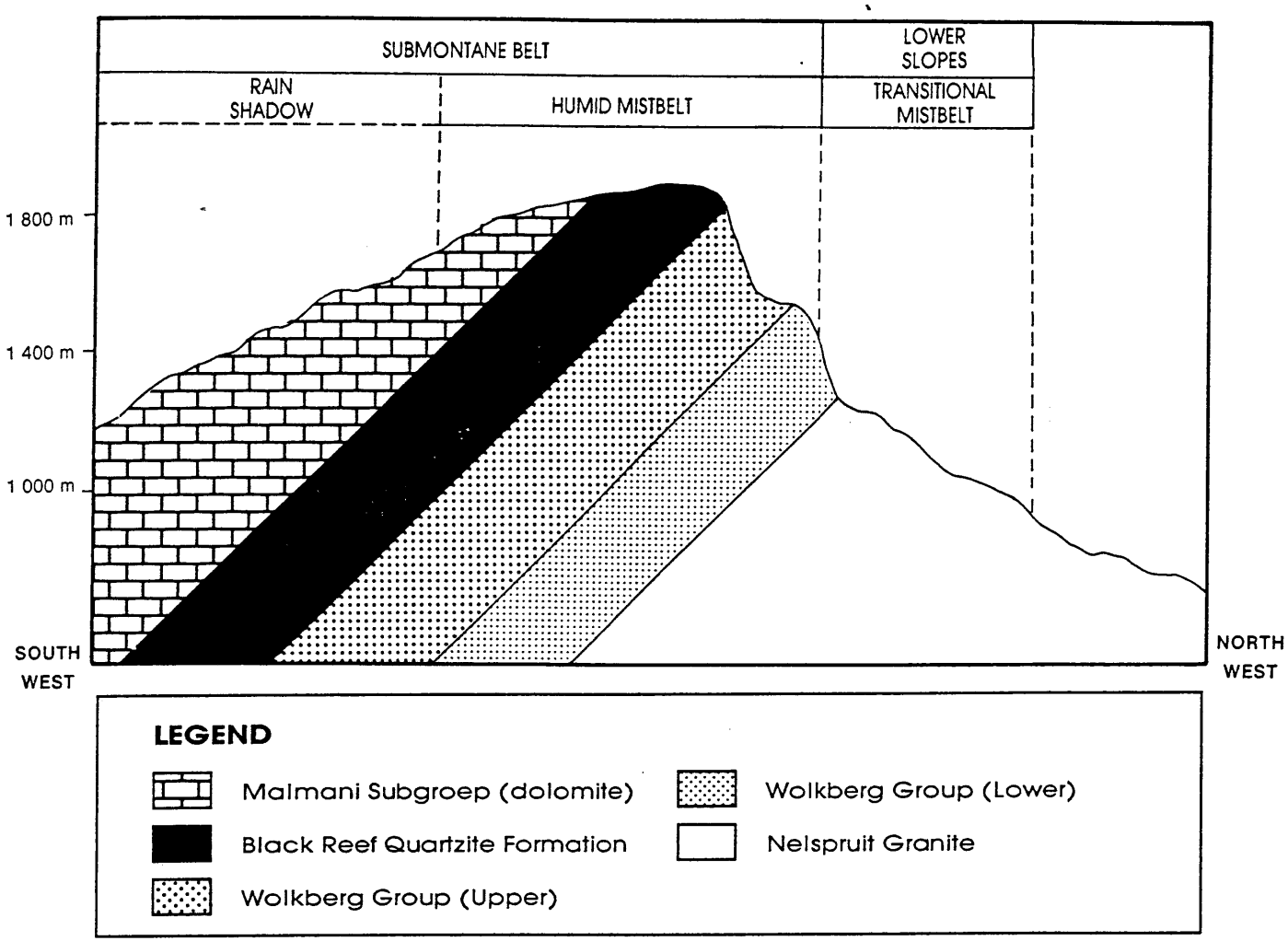


Figure 3.3 A schematic representation of the profile of the northern sections of the study area of the Transvaal Escarpment, to show positions of physiographic and mist belts. Note: the dip of the geological layers is exaggerated (actual dip is approximately 17°).

Drainage

The study area, being a catchment area, contains many streams and rivers and their sources. Many of the major rivers of the area, and surrounding areas, such as the Blyde, Sabie and Ohrigstad Rivers have their sources of origin here. The Blyde River is also a major tributary of the Olifants River. Other important rivers which have their sources in the area are the Treur, Lisbon, Mac Mac, Kadishi and the Mohlapitse (a tributary of the Olifants River) Rivers.

Characteristic of most of the rivers are the many large and small waterfalls that are found along their courses. Many of the rivers and streams drain the dolomitic areas, and where conditions are suitable, form Tufa waterfalls such as the large active Tufa in the Kadishi river, where it falls into the Blyde River Canyon. Tufa (limestone tufa) or Travertine is a hard, concretionary, cavernous material deposited from streams draining dolomitic areas under certain conditions (Martini 1987). Waterfalls with limestone tufa as its underlying material are known as tufa waterfalls.

Geology

A simplified map of the geology of the greater part of the Eastern Transvaal Escarpment is shown in Figure 3.1. Four main geological systems are found in the study area and some of these being intersected by later diabase intrusions. The entire area under discussion represents the eastern rim of the Bushveld Igneous Complex of the central Transvaal. The majority of the variation in topography of the study area (escarpment) is determined by the response of the different underlying geological formations to weathering.

The following discussion is based on SACS (1980), 1:250 000 geological survey maps and explanation booklet (Geological Survey 1986), Ferrar et al. (1988) and Deall et al. (1989a).

The Wolkberg group

These rocks rest on the Swazian floor rocks (Archaean basement), forming the base of the Escarpment. This unit can be divided into six formations which are from the

base: Sekkororo, Abel Erasmus Basalt, Schelem, Selati Shale, Mabin Quartzite and Sadowa Shale. The Abel Erasmus Basalt is the only volcanic unit of this essentially sedimentary succession which is mainly made up of coarse and fine-grained clastic rocks.

Black Reef Quartzite Formation

This formation varies from 0 m to 500 m thick and is a succession of very clean quartzite with, in places, lenses and layers of pebbles and also in places conglomerate occurring at the base. Shale is present especially near the top, on the contact zone with the overlying dolomite.

This formation is very resistant to weathering, especially the clean quartzite, and is largely responsible for the shape of peaks, cliffs and gorges as well as the many interesting shapes of the weathered rock outcrops found throughout the area. Also being largely responsible in this part of the north-eastern Transvaal for forming this part of the Great Escarpment of the Drakensberg, incised by the Olifants and Blyde Rivers.

The Chuniespoort Group

This group is predominantly chemical in origin and overlies the Black Reef Quartzite Formation. It is made up of mainly dolomite as well as limestone, chert, and near contact areas with the Black Reef Quartzite layers, carbonaceous shale and quartzite do occur (Oaktree Formation). This group is on average 400 m thick.

This group is subdivided, with the Malmani Subgroup being of importance here. The Malmani Subgroup can be divided into five formations on the basis of chert content and presence or absences of types of algal structures in the dolomite.

The occurrences of cave and tufa, the last named being found along many of the streams flowing over or near to this rock type, are characteristic of the area. Dolomite rock outcrops in the high rainfall areas are not usually found owing to the high solubility of the limestone. Where rock outcrops are found, mostly in the lower rainfall areas, the typical wrinkled, corrugated texture of it's surface can be seen, resembling that of an elephant's hide, which has given rise to the popular name of "Olifantsklip".

The Pretoria Group

This group which overlies the Chuniespoort Group is made up essentially of sedimentary rocks. It consists predominantly of shale and quartzite rock and varies from 900 m to 1 600 m thick.

The formation which is of importance here is the Timeball Hill Formation. This formation is made up of mainly shales and mudstones with zones of quartzite. The quartzite zone being more resistant to weathering, subsequently giving rise to the mountain peaks and ridges of this geological zone.

This formation is an important part of the escarpment in the southern parts, but does not form part of the escarpment in the northerly areas.

Transvaal Diabase

The numerous diabase and other basic intrusions found mostly in the Pretoria Group, are called the Transvaal Diabase. These intrusions are not found in the Wolkberg Group, but do occur in the Chuniespoort Group although they are scarce.

Quaternary deposits

Quaternary deposits in the study area include alluvial deposits and scree deposits. Alluvial deposits are found along most of the streams traversing the study area. The deposits vary according to the geology of the runoff area but silty and clayey deposits predominate.

Prominent scree deposits including alluvial fans, predominate in the escarpment mountain areas, where they can obscure the underlying geology.

Soil

General

The soil patterns of the study area are very complex being a result of the complex topography and the weathering of the different rock types. Basic soil patterns are however observed, specifically related to the underlying rock type and topographical positions. The nomenclature of the soil forms and series mentioned are in accordance

with Mac Vicar et al. (1977). It must be mentioned though, that soil classification of South Africa has been revised (Grondklassifikasiewerkgroep 1991), this has only recently been published so this amended soil classification could not be used.

Large areas of exposed rock of mountain peaks, cliffs, ridges and of local resistant rock types are characteristic of the area and these areas are associated with shallow soils (lithosols), with the dominant soil forms being the Mispah (orthic A horizon on rock) and Glenrosa forms (orthic A horizon on lithocutonic (weathered rock) B horizon), as well as areas of virtually no soil. The valleys, terraces and plateaux (which may be of resistant rock types) have deeper soils. The commonest soil forms are the Hutton (these soils have a shallow orthic A horizon on a shallow red apedal (structureless) B horizon), Clovelly, Champagne and Magwa. The dolomite rock formation has the deepest and most fertile soils.

The area being in a high rainfall area has resulted in many of the soils showing signs of medium to high leaching as well as been acidic (an average pH of 4.7), with the soils of dolomite being the least acidic.

The following discussion on soils is based on Land Type Survey Staff (1989) and Deall et al. (1989a):

Soils of the Black Reef Quartzite Formation.

Soils on Black Reef Quartzite are mostly very shallow over solid bed rock and in many areas just rock is present, with little or no soil. However, under grassland it has given rise to fairly deep soils. Soils on Black Reef Quartzite are sandy loams, with the highest percentage of sand (78%) of the majority of soils present in the study area. They are also the darkest coloured soils (melanic). Organic, peaty topsoil are common. The dominant soil forms are the Hutton, Clovelly, Mispah, Glenrosa and Champagne. The Champagne form occurs under marsh like conditions. Most of these soils are medium (mesotrophic) to highly (dystrophic) leached.

Soils of the Dolomite (Malmani Subgroup).

Two main soil types can be distinguished on the basis of the geology of the dolomites. Firstly those found on the carbonaceous shale and quartzite (Oaktree Formation) and secondly those found on the rest of the dolomite formations.

Soils of the Oaktree Formation are distinguished from the sandy soils of the Black Reef Quartzite Formation by the increased clay content of the subsoil. These soils are usually clay loams except where in close association with the soils of the Black Reef Quartzite Formation, where here the surface horizons are then darker and contain more sand.

The soils derived from the rest of the dolomite formations are deep and well drained. Only on ridges and steep slopes are the unweathered rocks exposed on the surface. Of all the soils in the area, these have the highest pH and lowest exchange acidity, owing to the limestone origin. Although having the lowest phosphorous levels, the levels of the other important cations are high, making these the most fertile soils in the area. The most dominant soil forms being Hutton and Griffin forms.

Soils of the Timeball Hill Formation.

The soils of the Timeball Hill Formation occur mainly on mountain tops and slopes, and tend to be shallow, except when occurring on terraces and valley bottoms. The soils are well drained clay loams. Subsoils are high in clay content but can become quite sandy in areas. The high content of stones (slate) on the surface is characteristic of these soils. The stones may be loose or compacted into stone lines.

Soils of the Transvaal Diabase

Soils formed from the Transvaal Diabase Formation are not easily recognizable as they are usually buried under topsoil from adjacent rock types (colluvium) and therefore only exist as a type of subsoil. Although rock outcrops of diabase do occur the dominant soil form is the Mispah form.

Climate

The climate of the Eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool dry winters (Fabricius 1988).

Characteristic of the escarpment is the occurrence of mist in the so-called mist belt. The mist belt concept as described by Scheepers (1978) and Deall et al. (1989a) can be applied to this area with modifications. Deall et al. (1989a) recognizes four mistbelt zones namely subhumid mistbelt, humid mistbelt, transitional mistbelt and the mists of the low country. The mist of the transitional mistbelt and that of the low country do not apply in this study. The subhumid mistbelt coincides with the subalpine belt, which in certain areas is not present, therefore only meaningful in the southern parts of the study area where this physiographical unit is present. The other mistbelt division is applicable throughout the entire study area. Although the more northern central sections of the scarp do not have large areas of forest below the humid mist belt, large and small areas of forest may be found occurring in gorges and valleys.

It must be noted however that Deall's (1985) study describes a narrow transect, the varying aspects of the escarpment and prominent mountains occurring on areas of escarpment plateaux resulting in rainfall/mist shadow areas, were not present in the transect he studied. There are therefore areas in the escarpment which do not get exposed to the mists, although occurring in one of the recognized belts.

Temperature

Temperature alone may not be a significant factor in determining major regional vegetation formations, it does however play a part in the determination of floristic variations on a meso- and micro-scale (Schulze & McGee 1978). Such variations result from differential effects of temperature on plant growth rates, seed germination, seedling survival and flowering phenology (Deall et al. 1989a). According to Scheepers (1978) it is not the average temperature that has the greatest effect on vegetation but the extremes of temperature that can have a limiting effect on the plants.

Temperature data for several relevant weather stations are given in Table 3.1. This data is relevant to each physiographic belt. Temperature data relevant to this study is scarce and therefore only few figures can be quoted of which some may not be a true reflection of the true temperature relevant to that physiographic belt. Temperature data of the northern areas of the study area is lacking as no relevant data applicable to the belts was available.

TABLE 3.1. The mean monthly maximum and minimum temperatures (°C) for possible relevant weather stations to the study area.

	Weather Stations					
	Long Tom 2 118 m SMB		Graskop 1 478 m HMB		Vaalhoek 1 158 m RS	
Month	Min.	Max.	Min.	Max.	Min.	Max.
Jan.	6.5	29.0	9.8	28.4	10.1	32.8
Feb.	5.2	28.6	9.7	27.8	9.9	31.6
Mar.	5.9	25.5	8.2	26.6	7.4	30.7
Apr.	3.2	25.5	5.6	25.3	4.5	29.4
May.	1.2	23.5	2.3	24.7	0.6	27.9
Jun.	-4.0	19.0	0.1	23.3	-1.9	25.3
Jul.	-2.1	21.2	-0.1	23.4	-1.5	26.0
Aug.	-1.0	25.0	0.6	26.3	-0.7	28.5
Sep.	-2.3	27.2	2.7	29.2	1.6	32.7
Oct.	1.3	28.1	5.8	30.8	4.3	31.9
Nov.	4.0	29.1	6.4	30.1	7.3	31.7
Dec.	4.0	27.9	8.8	28.8	10.3	31.8

SMB - Subhumid mistbelt. HMB - Humid mistbelt. RS - Rain shadow belt.

Precipitation

Soil moisture is derived from precipitation mainly in the form of rainfall, as well as mist (which in this study area is common), dew, hail and snow (Deall et al. 1989a).

Rainfall data for specific weather stations spread over the study area and relevant are given in Table 3.2 and Figures 3.4, 3.5, 3.6 and 3.7. Manx and Elandsfontein weather stations are examples of stations showing the drier nature of some of the rain shadow areas compared to the wetter area stations such as Lisbon forest station and Mac Mac forest station on the escarpment.

It must be noted however that weather stations lying in the mist belt zones receiving mist, the rainfall figures would be higher than those recorded just from rain. As found by Schulze & McGee (1978) at Kranskop in the so-called Natal Mistbelt, there was an average of 4 fog days per month from November to February. In the higher lying areas in the foothills of the Natal Drakensberg the orographic fog contribution at 1 800 m altitude is an additional 403 mm per annum - one third of the mean annual precipitation.

In Figures 3.4, 3.5 and 3.6 examples of the annual march of mean monthly rainfall for specific weather stations in the different belts as well as relevant to northern and southern areas, as discussed, are shown. From these figures it can be seen that the Subalpine and Montane belts receive less rainfall than the areas of the Submontane belt. It can also be shown that the rainfall of the rain shadow areas is substantially lower than the rest of the study area. It can be seen that the areas of highest rainfall lie below escarpment crest for example Marite weather stations.

The weather stations in the northern areas show lower rainfall figures, but weather station in these areas are scarce, so data is scarce and nearly always not completely relevant. Therefore no real comparisons between north and south can be made at this stage, but the rainfall patterns can be presumed to be similar. It must be remembered, also, that the alpine and montane belts, in these northern areas, are absent so rainfall patterns associated with these belts will be absent as well.

Table 3.2. Mean annual and absolute maximum and minimum rainfall for relevant weather stations of the Eastern Transvaal Escarpment.*

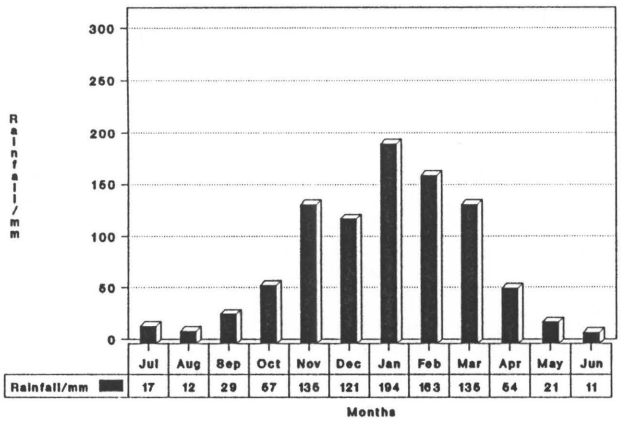
Stations Grid	Altit. (m)	Period (Yrs)	Annual Rainfall (mm)		
			Min	Max	Mean
1. Lisbon F.S 24°53'S 30°51'E	1402	21	1000	2354	1579
2. Marite F.S. 24°55'S 30°54'E	1065	30	977	2602	1539
3. Mac Mac F.S 24°59'S 30°49'E	1360	59	814	2331	1515
4. Graskop 24°56'S 30°51'E	1487	24	708	1821	1321
5. Mariepskop F.S 24°35'S 30°52'E	1400	40	683	2601	1308
6. Blyde F.S 24°50'S 30°50'E	1433	49	314	1931	1130
7. Schelm 24°08'S 30°18'E	840	54	453	2194	1022
8. "The H" 24°06'S 30°11'E	1250	31	605	1711	1003
9. The Downs 24°08'S 30°11'E	1350	56	524	1701	948
10. Clewer House 24°54'S 30°41'E	1750	21	543	1379	943
11.Pilgrim's Rest 24°55'S 30°46'E	1240	56	526	1502	938
12. Morgezon F.S. 24°53'S 30°43'E	1630	27	384	1162	800
13. Frankfort 24°49'S 30°45'E	1300	28	537	1094	777
14. Elandsfontein 24°37'S 30°46'E	1219	61	196	1405	649
15. Fertilis 24°08'S 30°06'E	1103	25	88	1340	556
16. Manx 24°43'S 30°47'E	1140	50	262	1087	541

* Compiled from Rainfall Deciles for Transvaal Region (Erasmus 1987).
F.S. - Forestry Station

Figure 3.4 Monthly distribution of rainfall for selected weather stations for the central sections of the Transvaal Escarpment. (After Erasmus, 1987)

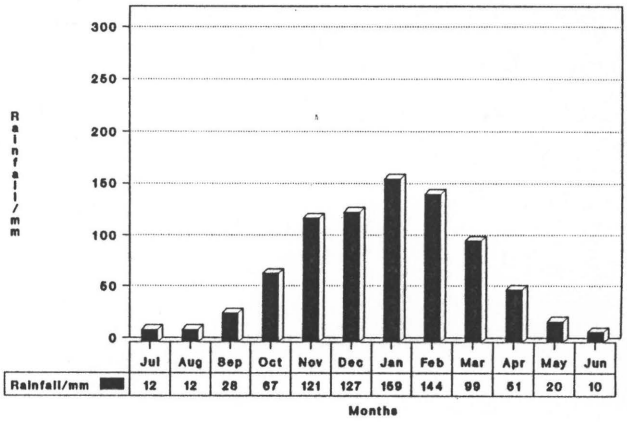
A - Weather stations of subalpine and montane belt
B - Weather stations of submontane belt
C - Weather stations of rainshadow belt

Clewer house weather station



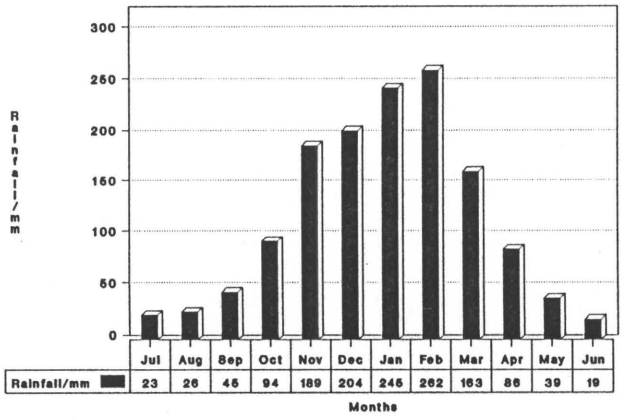
A

Morgenzon forestry weather station



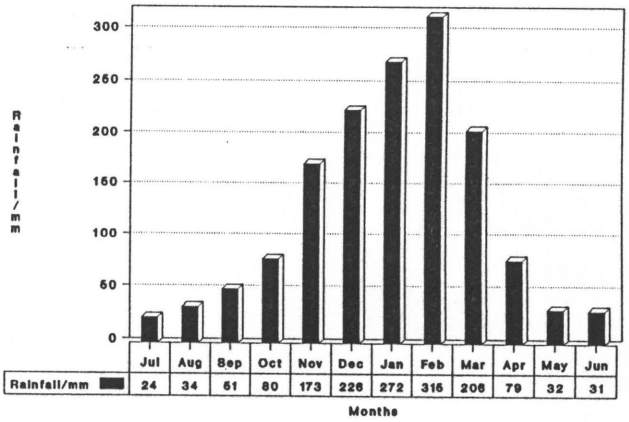
A

Graskop weather station



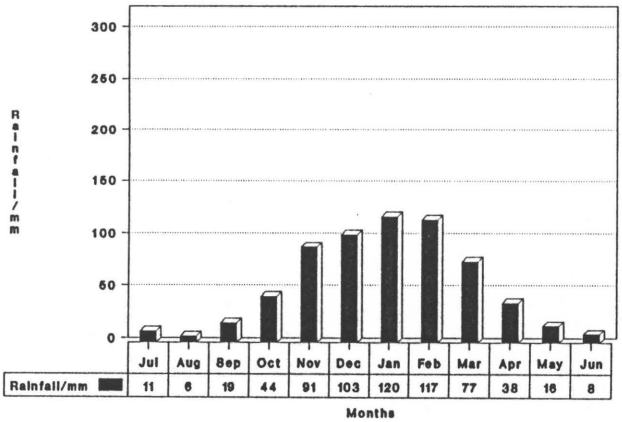
B

Lisbon forestry station



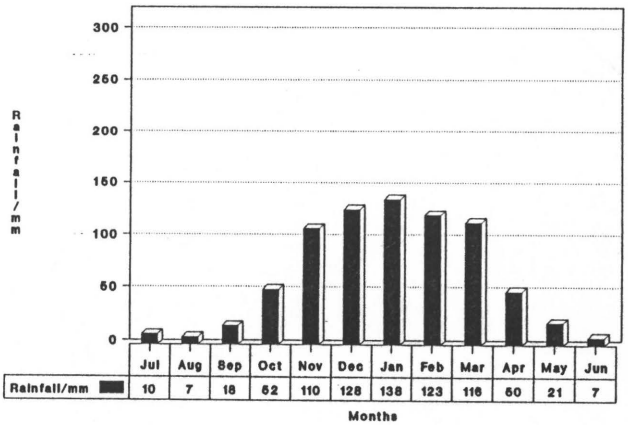
B

Elandsfontein weather station



C

Frankfort weather station

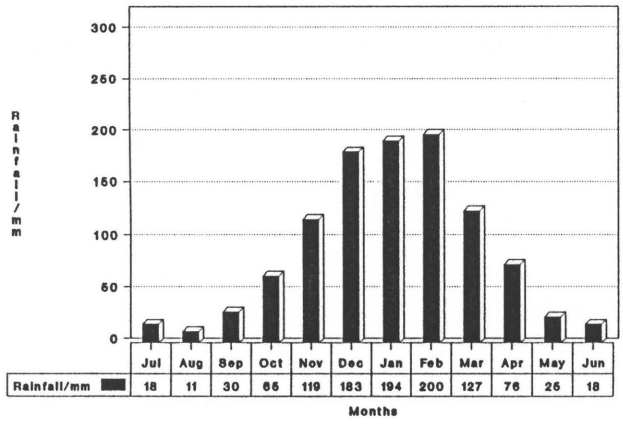


C

Figure 3.5 Monthly distribution of rainfall for selected weather stations for the northern sections of the Transvaal Escarpment. (After Erasmus, 1987)

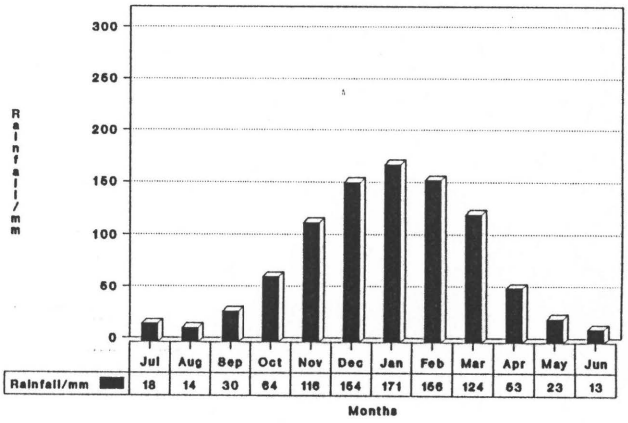
B - Weather stations of submontane belt
C - Weather stations of rainshadow belt
D - Weather station of the escarpments lower slopes (part of Deall's transitional mist belt, Deall et al. 1989a) of the northern areas

"The H" weather station



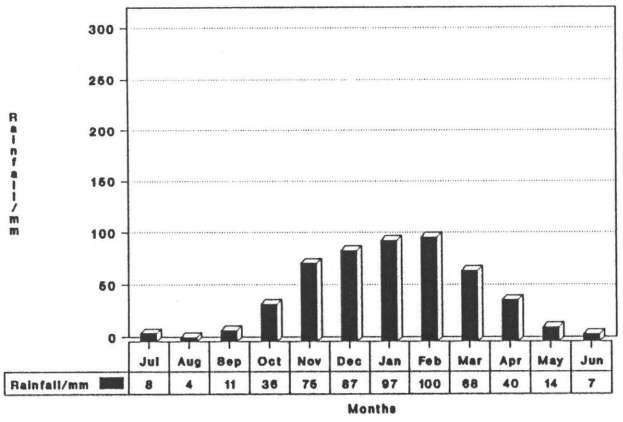
B

The Downs weather station



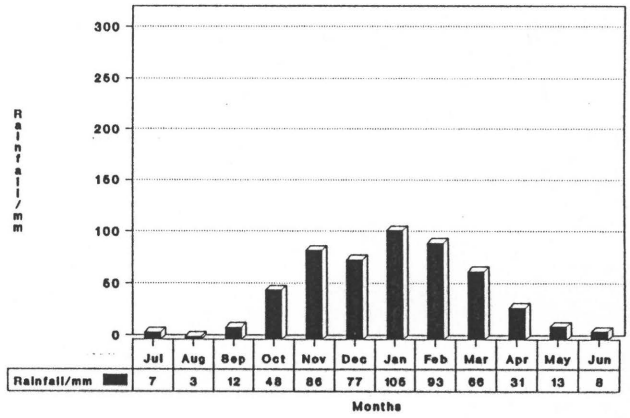
B

Manx weather station



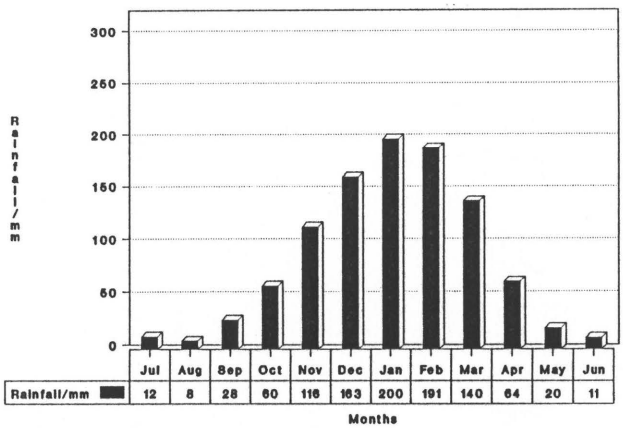
C

Fertilis weather station



C

Scheim weather station

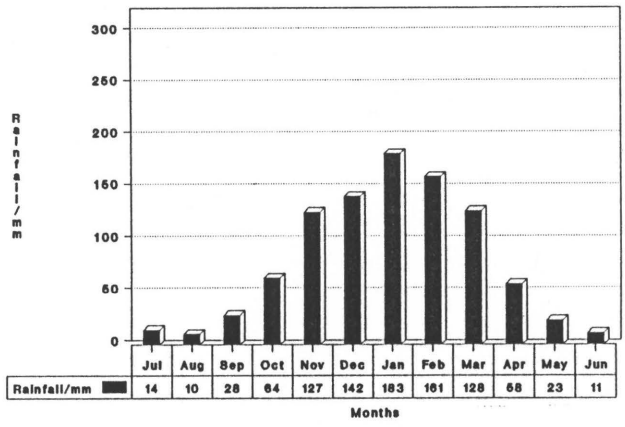


D

Figure 3.6 Monthly distribution of rainfall for selected weather stations along the Transvaal Escarpment. (After Erasmus, 1987)

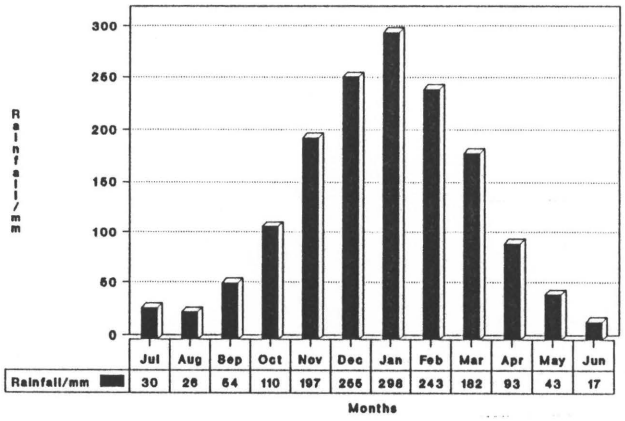
B - Weather stations of submontane belt
D - Weather station of the escarpments lower slopes (part of Deall's transitional mist belt, Deall et al. 1989a) of the central areas
E - Weather station of free standing area

Pilgrim's Rest weather station



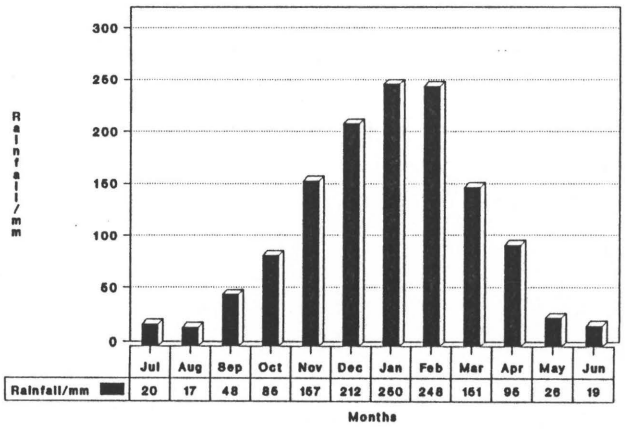
B

Marite forestry weather station



D

Mariepskop forestry weather station



E

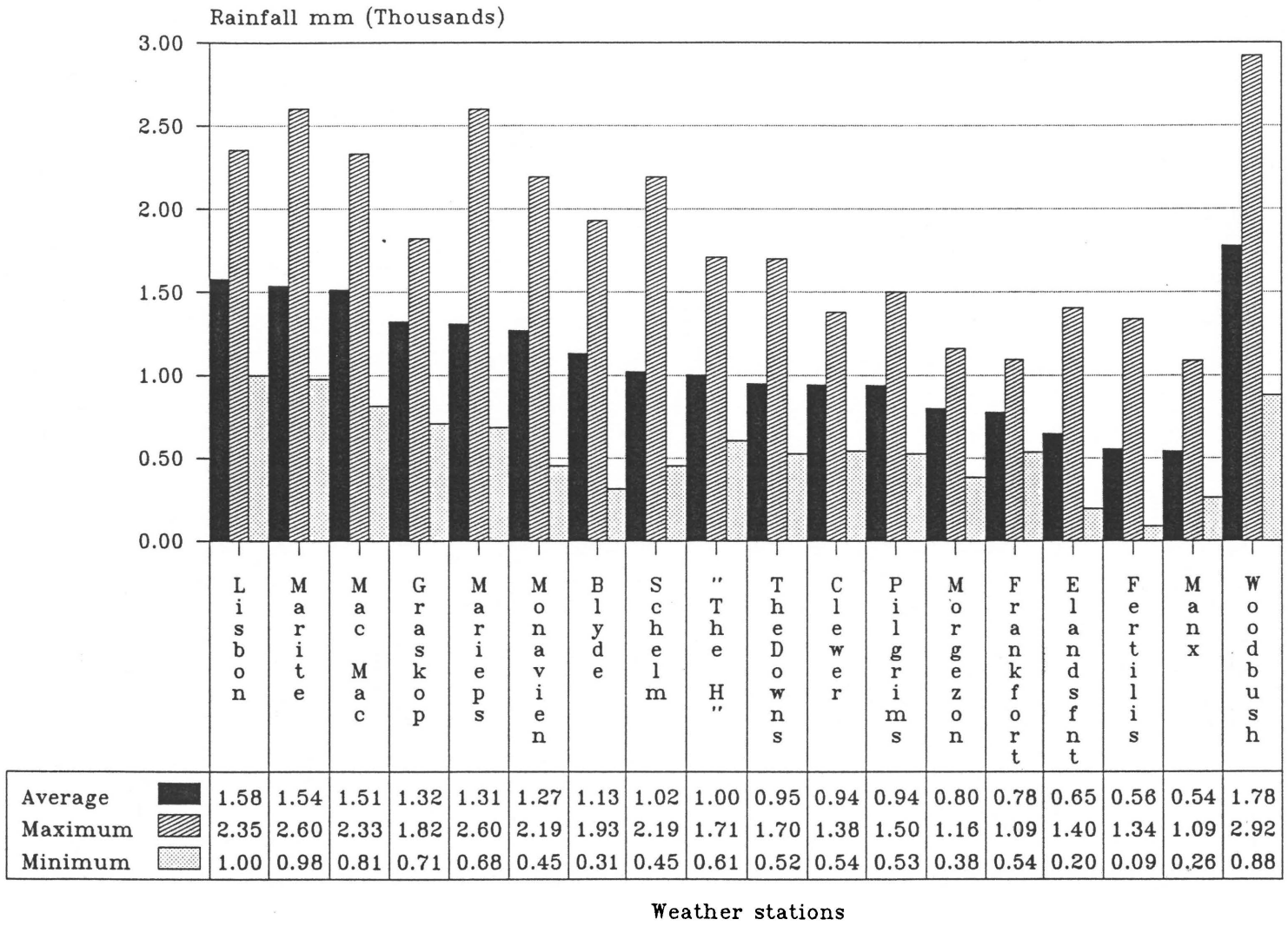
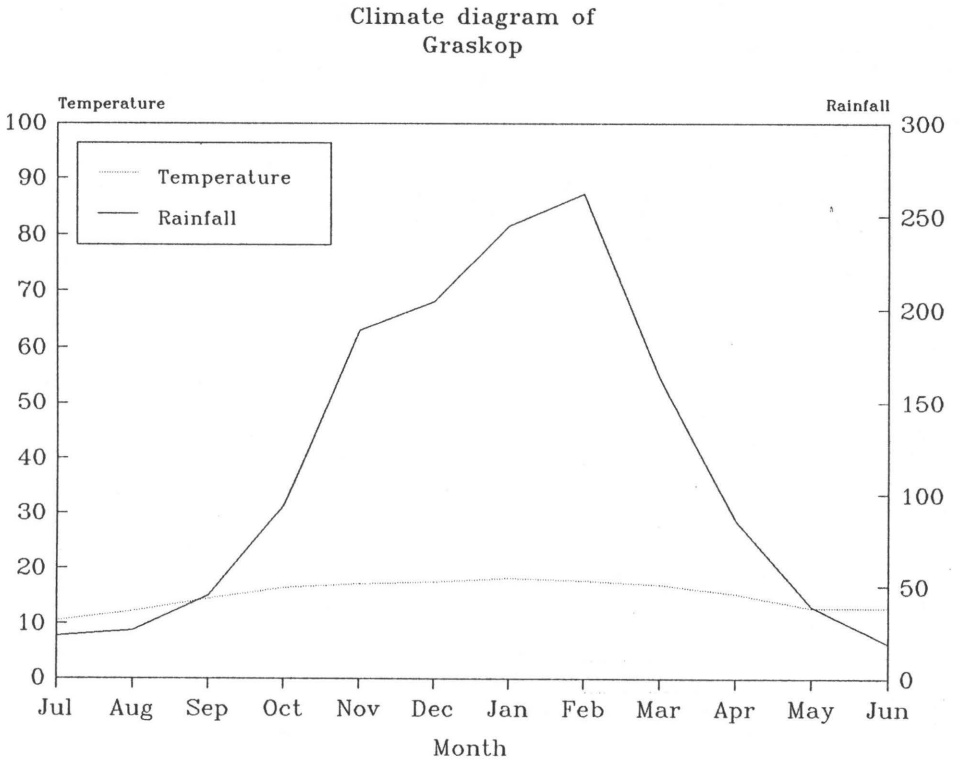
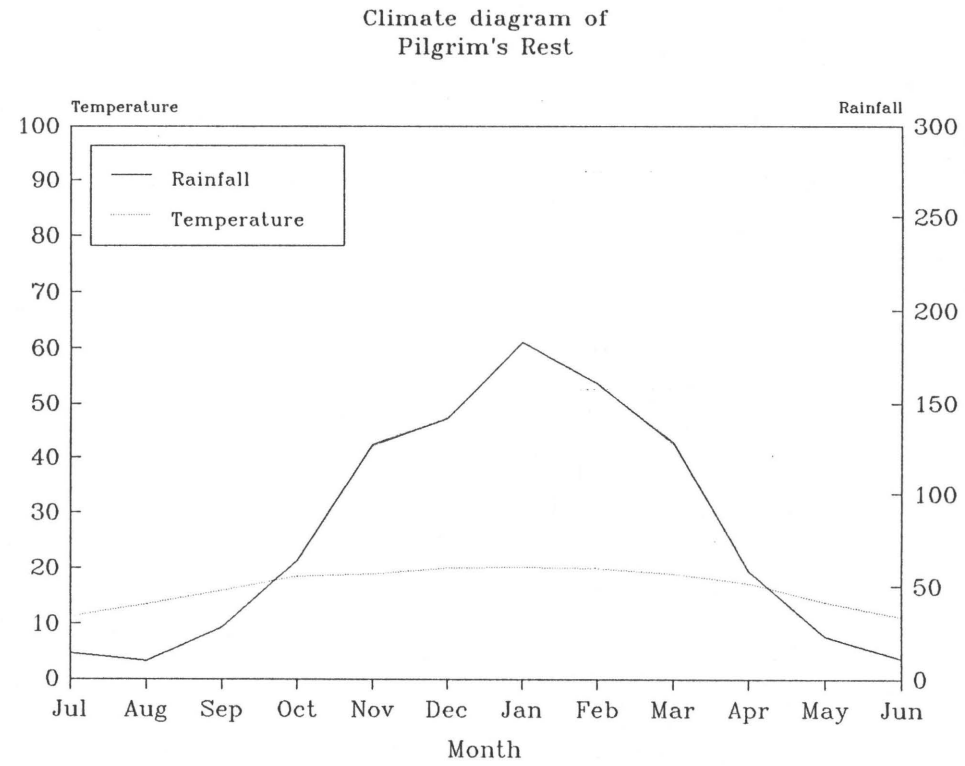


Figure 3.7 Mean annual and absolute maximum and minimum rainfall figures for selected weather stations along the Transvaal Escarpment. (From Erasmus, 1987). Woodbush weather station is included, although falling just out of the study area, as it has the highest recorded rainfall figures.

Marieps = Mariepskop
Pilgrims = Pilgrims Rest
Elandsfnt = Elandsfontein

Figure 3.8 Climatic diagrams for the study area





CHAPTER 4

RESULTS

The grassland associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the Transvaal Escarpment.

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Published in The South African Journal of Botany.

Abstract

An analysis of the vegetation of the large rock outcrops of the Transvaal escarpment is presented. Relevé 's were compiled in 26 stratified random sample plots. A TWINSPAN - classification, refined by Braun - Blanquet procedures revealed four plant communities, which can be classified under two major communities. This was confirmed by ordination of the communities. All communities are related to specific environmental conditions. Description of the communities are given.

Uittreksel

'n Analise van die plantegroei van die groot rots areas van die Transvaalse eskarpement, word aangebied. Relevé 's is in 26 gestratifiseerde ewekansige-gekose monsterpersele saamgestel. 'n TWINSPAN - klassifikasie verfyn deur die Braun - Blanquet tegnieke toon vier plantgemeenskappe, wat in twee hoof - gemeenskappe gegroepeer kan word en wat bevestig word deur ordening van die gemeenskappe. Die geïdentifiseerde gemeenskappe kan verklaar word aan die hand van spesifieke omgewingsfaktore. Die plantgemeenskappe word beskryf.

Keywords: Black Reef Quartzite, Braun-Blanquet procedure, classification, forest biome, grassland biome

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Introduction

The Eastern Transvaal Escarpment, represented by Acocks's (1988) North-eastern mountain sourveld (veld type 8) is under heavy pressure from the timber industry for land for afforestation. As stated by Deall et al. (1989a) this is in direct conflict with the need to protect the mountain catchments, to conserve natural ecosystems and to preserve scenic landscapes for the tourist industry. Rational land-use planning is required to resolve such conflict (Ferrar et al. 1988).

The relationship between plant-ecological studies and land-use planning and management is well known (Pentz 1938; Bayer 1970; Walker 1976; Van Rooyen et al. 1981; Moore & Chapman 1986).

In describing the South African Grassland Biome project Mentis & Huntley (1982) stated the necessity to identify, describe and determine the location of the major vegetation types and subtypes within the biome. This was also emphasized by Scheepers (1987). One of the goals of the vegetation classification and mapping task group of the Botanical Research Institute, (now part of the Grassland Research center of the Department of Agricultural Development) is the production of a vegetation classification (Scheepers 1987). This would result in ecological interpretable units which can be used for planning and management.

The study area

The location of the main study area is shown in Figure 1. A large part of the area has been utilized by the timber industry for afforestation and lot more natural areas will be destroyed in this way in the future.

A detailed description of the physical environment of the area is given by Matthews et al. (in prep). The main rock types found in the study area are quartzite, dolomite and shales. The area that is of concern here are the large isolated rock outcrops of quartzite. These are spread throughout the area and occur in places such as on top of peaks for example, Mauchberg and Iron Crown, and the peaks themselves for example, Blackhill and on plateau's and along the plateau edges for example, God's Window.

Soils of these Quartzite rocky outcrops are mostly very shallow lithosols, with the dominant soil form being Mispah and Glenrosa.

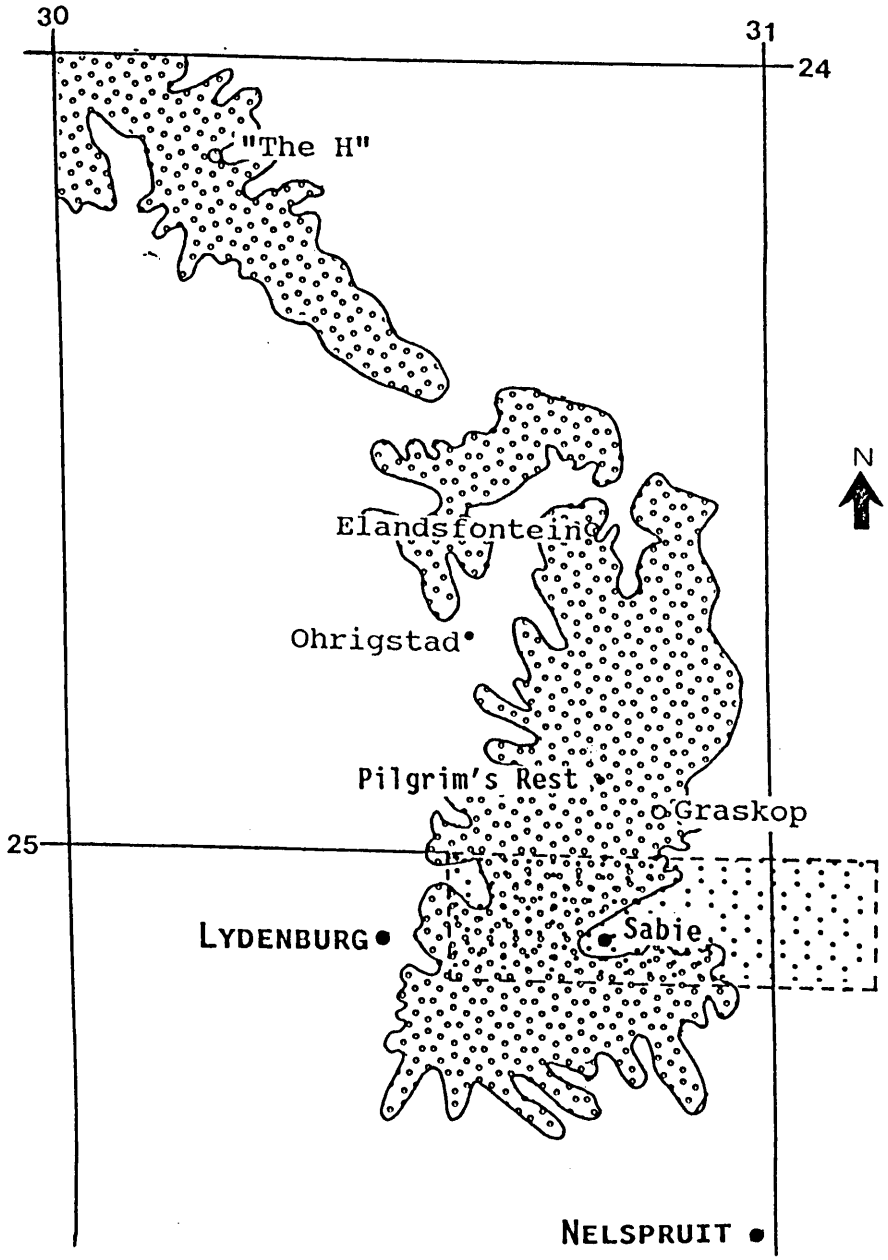


Figure 1. The location of the study area (based on Acocks's veld type map 1988). Legend: north-eastern mountain sourveld: area indicated by large dots; study area of Deall et al. (1989): area in dashed-line rectangle with small dots; weather stations: indicated by open circles (O).

The climate of the Eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool dry winters (Fabricius 1988). Characteristic of the escarpment is the occurrence of mist in the so called mist belt. The mist belt areas are described by Scheepers (1978), Deall (1985) and Deall et al. (1989a). Rainfall data for specific stations relevant to the habitats discussed in this paper are given in Table 1. The three positions of these stations are given in Figure 1.

Table 1. Mean annual and absolute maximum and minimum rainfall for 3 relevant weather stations of the Eastern Transvaal Escarpment.*

Station	Altitude (m)	period (yrs)	Annual rainfall (mm) mean	max.	min.
Graskop	1487	24	1321	1821	708
"The H" **	1250	31	1003	1711	605
Elandsfontein	1219	61	649	1405	196

* Compiled from Rainfall Deciles for Transvaal Region (Erasmus 1987).
** Haffenden heights.

Elandsfontein weather station is an example of a station in a drier area, falling in a rain shadow area (valley behind an escarp). Additionally to these rainfall figures, the amount of precipitation as a result of mist can be quite substantial (Fabricius 1969).

Methods

Two hundred 100 m^2 sample plots (10 m x 10 m) were distributed in a stratified random manner throughout the main study area. The plots were as far as possible equally distributed in the different physiographical - physiognomically homogenous units, distinguished on the basis of physiognomy, dominant species composition and abundance. This resulted in thirty four sample plots being placed in the broad unit described in this paper. Sampling was carried out from January to May 1990. Taxa names conform to those of Gibbs-Russell et al. (1985, 1987, 1990).

The following aspects were recorded for each sample plot:

1. The total floristic composition as well as a cover-abundance values for each of these species were estimated using the Braun-Blanquet cover-abundance

scale as described by Mueller-Dombois & Ellenberg (1974).

2. Altitude, read from 1:50 000 topographical maps.
3. Gradient, with use of a clinometer.
4. Aspect, with use of a compass.
5. Rockiness, estimated as a percentage of the ground cover.
6. Size of rocks as follows: Large rock outcrops(>1 000 mm iameter), rocks(300 - 1 000 mm diameter), small rocks(50 - 300 mm diameter) and stones or gravel(<50 mm diameter).
7. Topographical position based on terrain types, according to Land Type Survey Staff (1989) namely (1) crests, (2) scarp, (3) midslope, (4) footslope and (5) valley bottom or floodplain.
8. Geology, according to 1:250 000 geological survey maps Geological Survey 1986).
9. Land type according to 1:250 000 landtype map, Land Type Survey Staff (1989).
10. Exposure, as exposed to sun, wind and mist, expressed as heltered, partly sheltered or exposed.

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

In order to determine a possible vegetation gradient and associated habitat gradients, as well as the floristic relationships among the plant communities an ordination algorithm, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set. In this ordination relevés 14 and 102 were excluded, as these relevés were added at a later stage to the phytosociological table (Table 2).

Results

Classification

The results are presented in a phytosociological table (Table 2) in which species occuring less than two times were excluded from the table.

In the analysis of the vegetation two main communities were identified. The vegetation of the large rock quartzite outcrops can overall be classified as the *Cyperus pseudoleptocladus* - *Smilax kraussiana* bush clumps. A second major community represents the natural forested areas.

The plant communities recognized in the study area can be classified as follows:

1. The *Cyperus pseudoleptocladus* - *Smilax kraussiana* bush clumps on large Quartzite rock outcrops.

1.1. The *Rhus tumulicola* - *Aloe arborescens* mist belt bush clumps.

1.1.1. The *Myrsine africana* - *Aloe arborescens* mist belt bush clumps on miscellaneous rock outcrops.

1.1.2. The *Indigofera melanadenia* - *Aloe arborescens* mist belt bush clumps on Black Reef Quartzite rock outcrops.

1.1.2.1. The *Syncolostemon eriocephalus* variant, representing a drier micro-habitat variation.

1.1.2.2. The *Blechnum capense* variant, representing a wetter micro-habitat variation.

1.2. The *Helichrysum kraussii* - *Bequaertiodendron magalismontanum* bush clumps on Black Reef Quartzite in drier areas.

2. The *Psychotria zombamontana* - *Xymalos monospora* forest areas.

Description of the communities.

1. The *Cyperus pseudoleptocladus* - *Smilax kraussiana* bush clumps.

These bush clumps are restricted to large rock outcrops with an estimated rockiness cover higher than 50%. The rock outcrops can be in an isolated group or along an escarpment edge as those found in the area of God's window and Blyde river canyon.

From Table 2 it can be seen that this vegetation unit is characterized by species group G. *Cyperus pseudoleptocladus* and *Smilax kraussiana* are diagnostic species of these rock outcrops. *Aeschynomene nodulosa* and *Loudetia simplex* (species group G) are dominant species (high constancy and cover), but it must be mentioned that they are also dominant species throughout most of the main study area. Most of the other species in group G are also common species found in the rest of the study area. The number of species recorded per sample plot ranges from a minimum of 19 to a maximum 54 with

an average of 30 species per plot (Table 2).

1.1. The *Rhus tumulicola - Aloe arborescens* mist belt bush clumps.

These bush clumps are restricted to the mist belt rock Quartzite outcrops in the wetter habitats such as those found along the escarpment edge (weather stations Graskop and "The H", Table 1). The altitude of these areas ranges from 1 400 m to more than 2 000 m.

This community is characterized by species group E (Table 2). The most conspicuous diagnostic species are *Aloe arborescens*, *Rhus tumulicola*, *Passerina montana*, *Otiophora cupheoides*, *Senecio junodii* and *Ekebergia pterophylla*. An average of 31 species were recorded per sample plot (Table 2).

These bush clumps are structurally dominated by a dense shrubby layer, 1 - 3 m tall which includes species such as *Myrsine africana*, *Vaccinium exul*, *Cliffortia serpyllifolia*, *Rabdosiella calycina*, *Aloe arborescens*, *Rhus tumulicola*, *Passerina montana*, *Plectranthus rubropunctatus*, *Syncolostemon eriocephalus*, *Ekebergia pterophylla*, *Psychotria capensis*, *Rapanea melanophloeos* and *Myrica pilulifera*. Only a few individuals of mainly *Schefflera umbellifera* and other less constantly present species penetrate beyond the shrub layer and reach tree height. In the more open areas *Protea roupelliae* may be conspicuously present.

Within the bush clump the herbaceous layer is patchy, occurring mostly between rocks, or in rock crevices. Herbaceous species of this habitat include the ferns *Cheilanthes multifida*, *Asplenium friesiorum*, *Blechnum capense* and *Rumohra adiantiformis* and also the herbs *Otiophora cupheoides*, *Senecio junodii*, *Helichrysum rudolfii*, *Indigofera melanadenia*, *Stachys reticulata* including the grass species *Trichopteryx dregeana*, *Eragrostis acraea* and the sedge *Cyperus pseudoleptocladus*. In the open spaces between the rock outcrops grass species such as *Loudetia simplex*, *Trachypogon spicatus*, *Andropogon schirensis* and forbs such as *Senecio coronatus*, *Aeschynomene nodulosa*, *Helichrysum polycladum* and the sedge *Scleria transvaalensis* are prominently present.

Due to the complex topography and geomorphology within this major plant community, variation in habitats exists, resulting in different subcommunities.

1.1.1. The *Myrsine africana - Aloe arborescens* mist belt bush clumps.

This plant community is found on the rocky Quartzite outcrops of the Wolkberg group and the Pretoria group but not on Black Reef Quartzite.

These bush clumps are characterized by species group A (Table 2). The diagnostic species are *Myrsine africana* and *Asplenium friesiorum*. Other prominent diagnostic species which are constantly present (>50% constancy) are *Pterocelastrus echinatus* and *Vaccinium exul*. The latter species according to Van Wyk (pers. comm.) being endemic to the escarpments of Africa. An average of 35 species were recorded per sample plot (Table 2).

The most prominent shrubs in this community are *Passerina montana* and *Rhus tumulicola*.

1.1.2. The *Indigofera melanadenia - Aloe arborescens* mist belt bush clumps.

This plant community is restricted to the rock outcrops of Black Reef Quartzite and is characterized by species group B (Table 2). The diagnostic species being *Indigofera melanadenia*, *Senecio coronatus* and *Rabdosiella calycina*. An average of 28 species were recorded per sample plot (Table 2).

The most prominent shrubs in this community are *Rabdosiella calycina* and *Plectranthus rubropunctatus*. The herb *Senecio junodii* is also a conspicuous species.

1.1.2.1. The *Syncolostemon eriocephalus* variant.

This variant is the result of micro-habitat differences found in the rock clusters. This could be ascribed to the rocky outcrops, which in this variant cover large areas and are plate-like. This in turn could result in a drier habitat.

It is characterized by species group C (Table 2). The presence of the scanty shrub *Syncolostemon eriocephalus* also being endemic to the Transvaal Escarpment, the geophyte *Scilla natalensis* and Shrubby *Protea roupelliae* and the forbs *Senecio oxyriifolius* and *Rhynchosia thörncroftii* are characteristic of this variant.

1.1.2.2. The *Blechnum capense* variant.

This variant is the result of micro-habitat differences found in the rock clusters. This could be ascribed to the rocky outcrops being large boulder-like in isolated groups

and which could result in a relative wetter habitat to that of the other variant.

It is characterized by species group D (Table 2) and the presence of the ferns *Blechnum capense* and *Cheilanthes viridis* is characteristic of this variant.

1.2. The *Helichrysum kraussii* - *Bequaertiodendron magalismontanum* bush clumps.

This plant community is found on the rock outcrops of Black Reef Quartzite in relatively drier areas (Table 1. Elandsfontein weather station) than of those discussed before. The altitude of these areas ranges from 1 200 m up to 1 400 m. The altitude on average is lower than that of the other mist belt bush clumps.

This plant community is characterized by species group F (Table 2) and the most prominent diagnostic species being the shrub *Bequaertiodendron magalismontanum*, the semi-woody herb *Helichrysum kraussii* and the ground creeper *Rhynchosia monophylla*. Other prominent species which are constantly present (>50% constancy) are *Pellaea calomelanos*, *Bulbostylis burchellii, Fadogia tetraquetra*, *Pearsonia sessilifolia*, *Vernonia centaureoides* and *Parinari capensis*. An average of 26 species were recorded per sample plot (Table 2).

Other forbs not mentioned before include *Senecio venosus*, *Anthospermum pumilum*, *Raphionacme galpinii*, *Hypoxis rigidula* and *Dicoma anomala*. The grass *Loudetia simplex* is interesting in that it is found throughout the study area. Although it is not so common in the other bush clumps, in this community it is very prominent. In this drier community the grass layer is well developed. The most prominent species being *Loudetia simplex*, *Schizachyrium sanguineum* and *Andropogon schirensis*. Other grass species include *Monocymbium ceresiiforme*, *Melinis repens*, *Sporobolus pectinatus*, *Diheteropogon amplectens*, *Diheteropogon filifolius*, *Eragrostis racemosa*, *Aristida aequiglumis*, *Panicum natalense* and *Trachypogon spicatus*.

The species composition of this community shows affinities to Bakenveld vegetation (Bredenkamp & Theron 1978).

2. The *Psychotria zombamontana* - *Xymalos monospora* forest areas.

These forests, when occurring in the grassland, are restricted to protected kloofs and valleys.

It appears as if the community is characterized by species group H (Table 2). The most

prominent trees found in this community were *Xymalos monospora, Schefflera umbellifera*, *Maytenus acuminata* and *Schrebera alata*. The most prominent shrubs being *Psychotria zombamontana* and *Psychotria capensis*. An average of 31 species were recorded per sample plot (Table 2).

It must be noted however that the sample size is too small to make a phytosociological diagnosis of this community. This vegetation type is however descibed in detail by Deall et al. (1989b). They divide the forests of this area into 4 major units of which 3 would apply here namely:

1. Humid Mistbelt forest associated with Timeball Hill Shale and Klapperkop Quartzite.
2. Humid Mistbelt forest associated with Dolomite, Lower Mountains.
3. Humid Mistbelt forest associated with Black Reef Quartzite outcrops.

The present study however concentrates on the grassland and associated vegetation and this brief delimitation of the forests is therefore accepted as adequate.

Ordination

The distribution of the relevé's along the first and second axis of ordination is shown in Figure 2. A third axis of ordination contributes very little to the interpretation of the communities and is therefore excluded from this result.

In the scatter diagram no distinct discontinuity can be observed among the identified plant communities. The identified plant communities, however are largely confined to certain areas of the diagram.

The diagram illustrates a moisture gradient along the second axis, with drier habitats at the bottom and wetter habitats to the top of the diagram. The floristic relationships among communities 1.1.1. the *Myrsine africana - Aloe arborescens* mist belt bush clumps, 1.1.2.1. the *Syncolostemon eriocephalus* variant and 1.1.2.2. the *Blechnum capense* variant are confirmed by this result. The result also emphasizes the differences in moisture regime between habitats 1.1.2.1. the *Syncolostemon eriocephalus* variant and 1.1.2.2. the *Blechnum capense* variant.

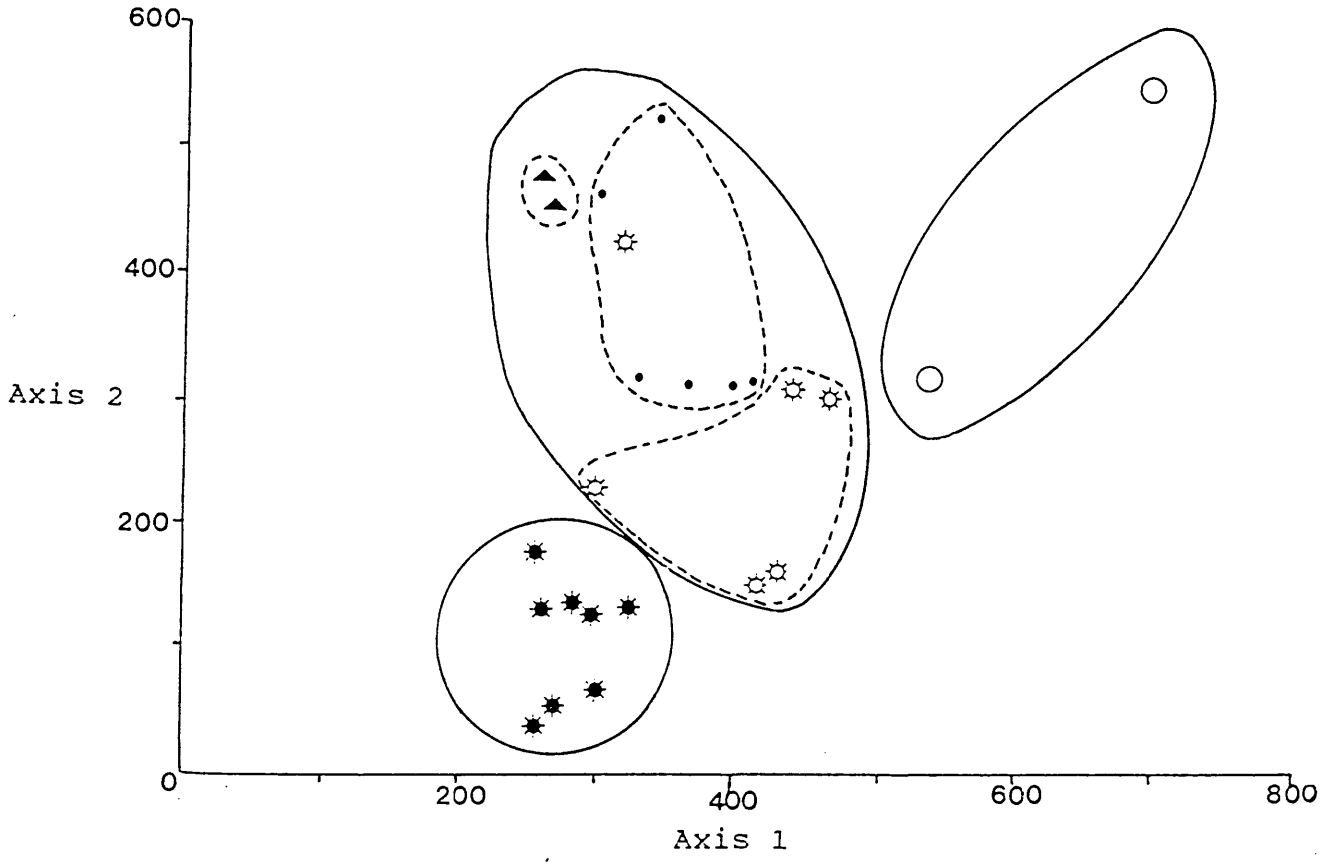


Figure 2. The ordination of the vegetation of the quartzite rock outcrops.

1.1.1. The *Myrsine africana* - *Aloe arborescens* mist belt bush clumps - indicated by dots;

1.1.2.1.The *Syncolostemon eriocephalus* variant - open sun signs;

1.1.2.2.The *Blechnum capense* variant - filled triangles;

1.2. The *Helichrysum kraussii* - *Bequaertiodendron magalismontanum* bush clumps - filled sun signs;

2. The *Psychotria zombamontana* - *Xymalos monospora* forest areas - open circles.

The gradient along the first axis represents a clear gradient in vegetation structure, relatively dense forest to the right of the diagram, merging through dense bush clumps in the center and open bush clumps to the left of the diagram.

Discussion

The existance of these bush clumps are most likely as a result of being protected by the rocks from fire which occurs regularly in the surrounding grasslands. It can also be seen that some of the species of the wetter bush clumps are also found in the forests such as *Psychotria capensis*, *Schefflera umbellifera*, *Myrsine africana*, *Myrica pilulifera* and *Podocarpus latifolius*. This shows that there is some affinities between the two groups.

The restriction of forest to kloofs, could be a result of protection from fire, deeper soils and the greater availability of water resulting from these kloofs being runoff valleys. These factors will be favourable for the development of forest.

The drier *Helichrysum kraussii - Bequaertiodendron magalismontanum* bush clumps are related to certain Bankenveld communities example, on granite of the Suikerbosrand Nature Reserve (Bredenkamp & Theron 1978) and also some Bankenveld communities (Westfall 1981). The distribution of Bankenveld related communities outside the Bankenveld area could present some information on the origin and affinities of the Bankenveld.

The aim of this study was to identify, characterize and interpret ecologically, the major vegetation units and their variations that occur in the North-eastern mountain sourveld of the Transvaal Escarpment by using habitat characteristics. Since ecologically interpretable plant communities were distinguished, the general descriptions and proposed classification can be used for the synecological and syntaxonomical synthesis of grassland biome vegetation (Bezuidenhout & Bredenkamp 1990) as well as for landuse planning and management.

The results of the ordination not only confirm the classification, but also gives an indication of floristic and associated habitat gradients.

Acknowledgements

This research was partially supported by the Foundation for Research Development.

References

ACOCKS, J.P.H. 1988. Veld Types of South Africa. 3rd edn. *Mem. bot. Surv. S. Afr.* 40: 1-128.

BAYER, A.W. 1970. Plant ecology in the service of man in southern Africa. *S. Afr. J. Sci.* 66: 71-77.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. *S. Afr. J. Bot.* 54: 525-533.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom - Ventersdorp - Randfontein area, South Africa. *Phytocoenologia* 18: 387-403.

BREDENKAMP, G.J., THERON, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve. 1. The phytosociology of the Witwatersrand geological system. *Bothalia* 12: 513-529.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. *S. Afr. J. Bot.* 55: 199-206.

DEALL, G.B. 1985. A plant-ecological study of the Eastern Transvaal Escarpment in the Sabie area. M.Sc. Thesis, University of Pretoria, Pretoria.

DEALL, G.B., SCHEEPERS, J.C. & SCHUTZ, C.J. 1989a. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. *Bothalia* 19: 53-67.

DEALL, G.B., THERON, G.K. & WESTFALL, R.H. 1989b. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 2. Floristic classification. *Bothalia* 19: 69-89.

ERASMUS. J.F. 1987. Rainfall Deciles for Transvaal Region. Department of Agriculture and Water supply.

FABRICIUS, A.F. 1969. In Schutte, J.M. 1971. Die onttreking van water uit die newellaag en lae wolke by Mariepskop. S.A Department of water Affairs, Division Hydrological Research, Technical note 20: 1-21.

FABRICIUS, A.F. 1988. Klimageographie-Sudafrika (Moqambique, Swaziland, Republik Sudafrika). Africa-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

FERRAR, A.A., ISAACS, G. & STACEY, J.R. (eds). 1988. Environmental conservation features of the Transvaal Escarpment: an information base for regional planning.

Occasional Report No. 31. FRD, CSIR, Pretoria.

GEOLOGICAL SURVEY. 1986. Geology map 1:250 000 geological series. 2430 Pilgrim's Rest. Government Printer, Pretoria.

GIBBS-RUSSELL, G.E., REID, C., VAN ROOY, J & SMOOK, L. 1985. List of species of southern African plants. 2nd edn, Part 1, *Mem. bot. Surv. S. Afr.* 51: 1-152.

GIBBS-RUSSELL, G.E., WELMAN, W.G., RETIEF, E.,IMMELMAN, K.L., GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M., NICOHOLAS, A., DE WET, C., MOGFORD, J.C. & MULVENA, J. 1987. List of species of southern African plants. 2nd edn, Part 2, *Mem. bot. Surv. S. Afr.* 56: 1-270.

GIBBS-RUSSELL, G.E., WATSON, L.,KOEKEMOER, M., SMOOK, L., BARKER, N.P., ANDERSON, H.M.P. & DALLWITZ, M.J. 1990. Grasses of Southern Africa. *Mem. bot. Surv. S. Afr.* 58: 1-437.

HILL, M.O. 1979a. DECORANA. A FORTRAN programme for detrended correspondence analysis and reciprocal averaging. Department of Ecology and Systematics, Cornell University. Ithaca, New York.

HILL, M.O. 1979b. TWINSPAN. A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University. Ithaca, New York.

LAND TYPE SURVEY STAFF. 1989. Land types of the maps 2330 Tzaneen and 2430 Pilgrim's Rest. *Mem. agric. nat. Resour. S. Afr.* No. 12.

MATTHEWS, W.S. (In prep.). Phytosociology of the North-eastern Mountain Sourveld. M.Sc. Thesis, University of Pretoria, Pretoria.

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. *S. Afr. Nat. Sci. Prog.* Report No. 62, CSIR, Pretoria.

MOORE, P.D. & CHAPMAN S.B. (eds). 1986. Methods in Plant Ecology. Blackwell Scientific Publications, London.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation Ecology. John Wiley & Sons, New York.

PENTZ, J.A. 1938. The value of botanical survey and the mapping of vegetation as applied to farming systems in South Africa. *Mem. bot. Surv. S. Afr.* No. 19: 1-15.

SCHEEPERS, J.C. 1978. Vegetation of Westfalia Estate on the North-Eastern Transvaal Escarpment. *Mem. bot. Surv. S. Afr.* 42: 1-230

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR,

Pretoria.

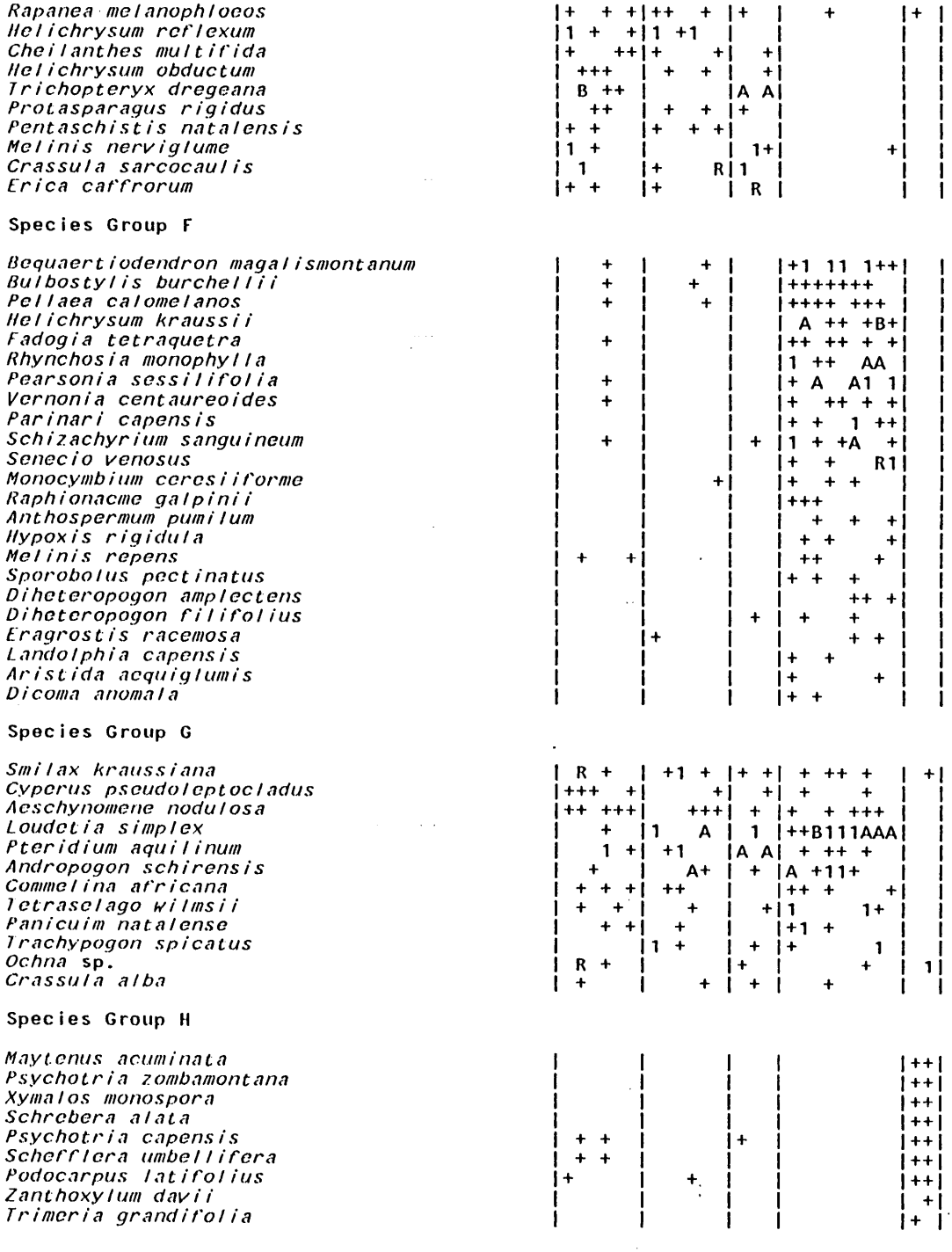
VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. *Jl. S. Afr. Bot.* 47: 213-246.

WALKER, B.H. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. *S. Afr. J. Wildl. Res.* 6: 1-32.

WESTFALL, R.H. 1981. The plant ecology of the farm Groothoek, Thabazimbi district. M.Sc. Thesis. University of Pretoria, Pretoria.

Table 2. A phytosociological table of the vegetation of the Black Reef Quartzite and associated large rock outcrops in the North-eastern mountain sourveld of the Transvaal escarpment.

Community numbers	1				2
	1.1			1.2	
	1.1.1	1.1.2			
Relevé number	000000	101111	101	001111111	11
	312336	896837	819	382333990	49
	488281	113427	845	649013892	54
Number of species per relevé	343522	222232	252	422212213	33
	184426	744705	703	055690689	01
Species Group A					
Myrsine africana	1++ +	+			++
Asplenium friesiorum	++ + +				
Pterocelastrus echinatus	++ + +			++ +	
Stachys reticulata	++ +				
Helichrysum polycladum	++ +		+	+	
Vaccinium exul	1 +	+			
Cliffortia serpyllifolia	1 4	1			
Helichrysum wilmsii	+ 1		+		
Lycopodium cernuum	+ +				
Anthospermum welwitschii	+ +	+			
Canthium inerme	+ +	+			
Bryophyta sp.	+ +				
Cheilanthes inaequalis	+ +				
Hebenstretia dura	+ +				
Species Group B					
Indigofera melanadenia	+	++ 1 +	+ R	+ +	
Senecio coronatus	+	++1 +	++		
Rabdosiella calycina	+	1 ++ +	++		
Species Group C					
Syncolostemon eriocephalus	+	+ ++			
Scilla natalensis		++ +			
Protea roupelliae		++ +			
Eragrostis acraea	+	1 +			
Senecio oxyriifolius	+	+ +		+	
Rhynchosia thorncroftii	+	+ 1		+	
Clerodendrum glabrum		+ +			
Species Group D					
Blechnum capense			+++		
Rumohra adiantiformis			+ +		
Cheilanthes viridis			++	+	
Species Group E					
Aloe arborescens	1A++ +	++ ++	1+1	+	
Rhus tumulicola	1++++1	+ + +	+++		
Senecio junodii	+++ +	++ + +	++1		
Plectranthus rubropunctatus	+1 +	+++++	+++		
Scleria transvaalensis	1 +A	++++	+1+		
Passerina montana	A+2 +	+ 1	+ +		
Otiophora cupheoides	+ ++	+ ++	+ +		
Helichrysum rudolfii	+++ +	+ ++ 1	+ +		
Myrica pilulifera	+++ +	+ 1 +	+		++



Trimeria grandifolia					+
Strophanthus speciosus					+
Streptocarpus sp.					+
Pavetta kotzei					+
Oplismenus hirtellus					+
Ilex mitis					+
Halleria lucida					+
Ficus craterostigma					+
Bersama swinnyi					+
Clivia specie					+
Maytenus mossambicensis					+
Plectranthus grallatus					+
Mackaya bella					+
Peddiea africana					+
Myrsiphyllum asparagoides					+
Rhus chirindensis	+				+
Maesa lanceolata		+			+

Spesies with an occurance of less than two have been ommitted.

The vegetation of the dry dolomitic regions of the North-eastern Mountain Sourveld of the Transvaal Escarpment, South Africa.

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Accepted for publication in Phytocoenologia

Abstract

A syntaxonomical and synecological analysis of the vegetation of the dry dolomitic regions of the Transvaal escarpment is presented. Relevés were compiled in 64 stratified sample plots. A TWINSPAN - classification, refined by Braun - Blanquet procedures, revealed ten plant communities, which can be classified under two major communities. A description of the communities is given. The classification was confirmed by DECORANA - ordination of the floristic data. One alliance, four associations and six subassociations are newly described. All syntaxa are related to specific environmental conditions.

Keywords: Braun-Blanquet procedure, Blyde River valley, classification, Dolomite, Grassland Biome

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Introduction

The Eastern Transvaal Escarpment, represented by North-eastern mountain sourveld (Acocks 1988) is under heavy pressure from the timber industry for land for afforestation. As stated by Deall et al. (1989a) this is in direct conflict with the need to protect the mountain catchments, to conserve natural ecosystems and to preserve scenic landscapes for the tourist industry. Rational land-use planning is required to resolve such conflict (Ferrar et al. 1988).

The relationship between plant ecological studies and land-use planning and management is well known (Pentz 1938; Bayer 1970; Walker 1976; Van Rooyen et al. 1981; Moore & Chapman 1986). In describing the South African Grassland Biome project Mentis & Huntley (1982) stated the necessity to identify, describe and determine the location of the major vegetation types and subtypes within the biome. This was also emphasized by Scheepers (1987). One of the goals of the vegetation classification and mapping task group of the Botanical Research Institute, (now part of the Grassland Research centre of the State Department of Agricultural Development), is the production of a vegetation classification (Scheepers 1987). This would result in ecological interpretable units which can be used for environmental planning and management.
In recent years great advance was made with synecological and syntaxomomical studies in the South African Grassland Biome (Bezuidenhout & Bredenkamp 1991). It was therefore decided to describe the identified syntaxa formally. All syntaxa described are new.

The study area

The location of the study area is shown in Figure 1. This area of the Transvaal is very mountainous and much of the area is undeveloped, with those areas which are developed (mainly by forestry) been found in a central area in the vicinity of the towns Sabie, Pilgrim's Rest and Graskop. The very nature of this area makes most of it inaccessible to normal vehicles and still many more areas, especially to the north, are nearly completely inaccessible, except for long excursions on foot or by the use of specialized vehicles. The undeveloped nature of these areas has also resulted in a shortage of certain environmental data such as rainfall and temperature.

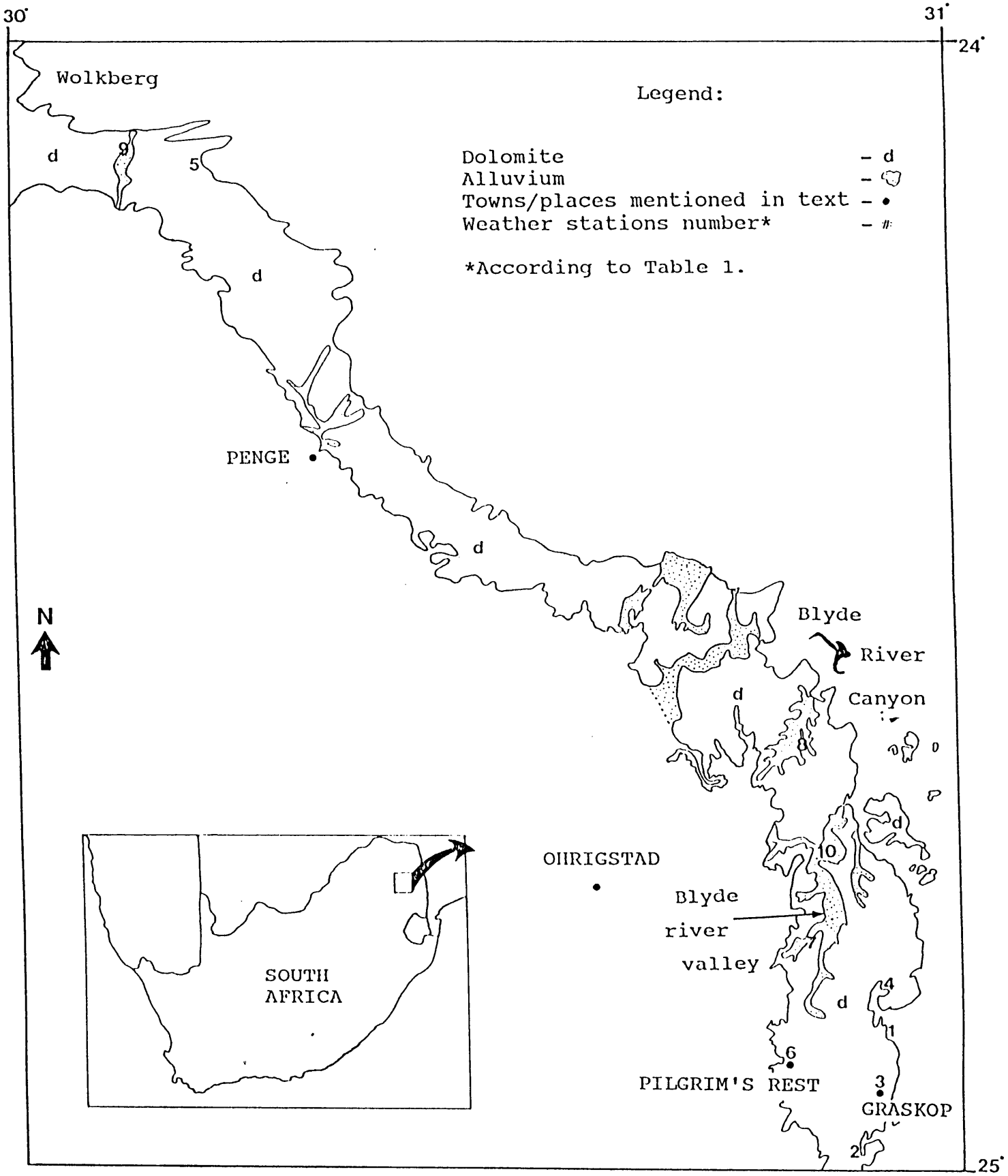


Figure 1. The Location of the Study area (based on Geological Survey map 1986).

A detailed description of the physical environment of the area is given by Matthews (1991). The main rock types found in the study area are quartzite, dolomite and shale. The areas that are of concern here are the large, relatively dry, dolomitic zone. These are usually found in rain shadow areas, in this case also protected from the mists coming in from the east. These areas represent protected valleys or extensive areas behind mountains, for example the Blyde River valley south of the Blyde River canyon and the Vaalhoek area north of Pilgrim's Rest.

Soils of these dolomite areas are mostly of the shallow Hutton form (MacVicar et al. 1977), found on the floodplains and the valley sides. These soils have a shallow orthic A horizon on a shallow red apedal (structureless) B horizon. The rocky outcrops and many of the valley sides are characterized by shallow lithosols, with the dominant soil forms being the Mispah (orthic A horizon on rock) and Glenrosa forms (orthic A horizon on lithocutonic (weathered rock) B horizon).

The climate of the Eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool dry winters (Fabricius 1988). Characteristic of the escarpment is the occurrence of mist in the so-called mist belt, but in the areas under discussion here the mist having little or no effect. Rainfall data for specific stations relevant to the habitats discussed in this paper are given in Table 1. Manx and Elandsfontein weather stations are examples of stations showing the drier nature of these areas compared to the wetter area stations such as Lisbon forest station and Mac Mac forest station on the escarpment, which are not situated in the rain and mist shadow.

Table 1. Mean annual and absolute maximum and minimum rainfall for relevant weather stations of the Eastern Transvaal Escarpment.*

Station	Altitude (m)	period (yrs)	Annual rainfall (mm) mean	max.	min.
1.Lisbon F.S.	1402	21	1579	2354	1000
2.Mac Mac F.S.	1360	59	1515	2331	814
3.Graskop	1487	24	1321	1821	708
4.Blyde F.S.	1433	49	1130	1931	314
5.The Downs	1350	56	948	1701	524
6.Pilgrims Rest	1240	56	938	1502	526
7.Frankfort	1300	28	777	1094	537
8.Elandsfontein	1219	61	649	1405	196
9.Fertilis	1103	25	556	1340	88
10.Manx	1140	50	541	1087	262

* Compiled from Rainfall Deciles for Transvaal Region (Erasmus 1987).
F.S. - Forestry Station

Methods

Two hundred 100 m^2 sample plots (10 m x 10 m) were distributed in a stratified manner throughout the main study area which is more extensive and floristically more heterogeneous than the area discussed in this report. The plots were as far as possible equally distributed in the different physiographical - physiognomically homogenous units, distinguished on the basis of physical environment, physiognomy, dominant species composition and abundance. This resulted in 64 sample plots being placed in the dolomite unit described in this paper. Sampling was carried out from January to May 1990. Taxa names conform to those of Gibbs-Russell et al. (1985, 1987, 1990).

The following information was recorded for each sample plot:

1. The total floristic composition, as well as a cover-abundance value for each species, was recorded by using the Braun-Blanquet cover-abundance scale as described by Mueller-Dombois & Ellenberg (1974).
2. Altitude, read from 1:50 000 topographical maps.
3. Gradient, with use of a clinometer.
4. Aspect, with use of a compass.
5. Rockiness, estimated as a percentage of the ground cover.
6. Size of rocks as follows: Large rock outcrops (>1 000 mm diameter), rocks

(300 - 1 000 mm diameter), small rocks (50 - 300 mm diameter) and stones or gravel (<50 mm diameter).

7. Topographical position based on terrain types, according to Land Type Survey Staff (1989) namely (1) crests, (2) scarp, (3) midslope, (4) footslope and (5) valley bottom or floodplain.
8. Geology, according to 1:250 000 geological survey maps (Geological Survey 1986) and locally at a smaller scale, personal observations in the field.
9. Land type according to 1:250 000 land type map, Land Type Survey Staff (1989).
10. Exposure, as exposed to sun, wind and mist, expressed as sheltered, partly sheltered or exposed.

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

In order to determine a possible vegetation gradient and associated habitat gradients, as well as the floristic relationships among the plant communities, an ordination algorithm, Detrended Correspondence Analysis (DECORANA) (Hill 1979a) was applied to the floristic data set.

Results

Classification

The results are presented in a phytosociological table (Table 2).

In the analysis of the vegetation 10 plant communities were identified which can be classified into two major communities. The major grassland community of the dry dolomite areas can be classified as the Helichryso nudifolii - Hyparrhenion filipendulae. The second major community represents wooded areas occurring at sheltered positions, scattered in the grassland. The hierarchical classification of the vegetation reinforces the correlation between habitat and communities (Figures 2 & 3).

The plant communities recognized in the study area are classified as follows:

1. The Helichryso nudifolii - Hyparrhenion filipendulae, a grassland of drier dolomite areas.

1.1 The Eragrosto curvulae - Hyparrhenietum filipendulae, a grassland of valley bottoms.

1.1.1 The Eragrosto curvulae - Hyparrhenietum filipendulae - hyparrhenietosum tambae, a grassland on alluvium in the valley bottoms.

1.1.2 The Eragrosto curvulae - Hyparrhenietum filipendulae - zornietosum capensis, a grassland of raised non-alluvial areas scattered within the alluvium.

1.2 The Hemizygio tranvaalensis - Loudetietum simplex, a grassland of valley sides and slopes.

1.2.1 The Hemizygio tranvaalensis - Loudetietum simplex -barlerietosum ovatae, a grassland of moister valley sides and slopes.

1.2.1.1 The Rendlia altera variant.

1.2.1.1.a. The Monocymbium ceresiiforme facies.

1.2.1.1.b. The Helichrysum acutatum facies.

1.2.1.2 The Bewsia biflora - Barleria ovata variant.

1.2.2 The Hemizygio tranvaalensis - Loudetietum simplex -indigoferetosum oxalidea, a grassland of the drier valley sides and slopes.

1.3 The Rhoicisso tridentatae - Rhynchosietum nitentis, a grassland on rocky areas.

1.3.1 The Rhoicisso tridentatae - Rhynchosietum nitentis - ozoroetosum sp. nov., a grassland of relatively rocky areas.

1.3.2 The Rhoicisso tridentatae - Rhynchosietum nitentis - aloetosum castaneae, a grassland of rock outcrops.

2. The Acacio ataxacanthae - Celtietum africanae woody areas.

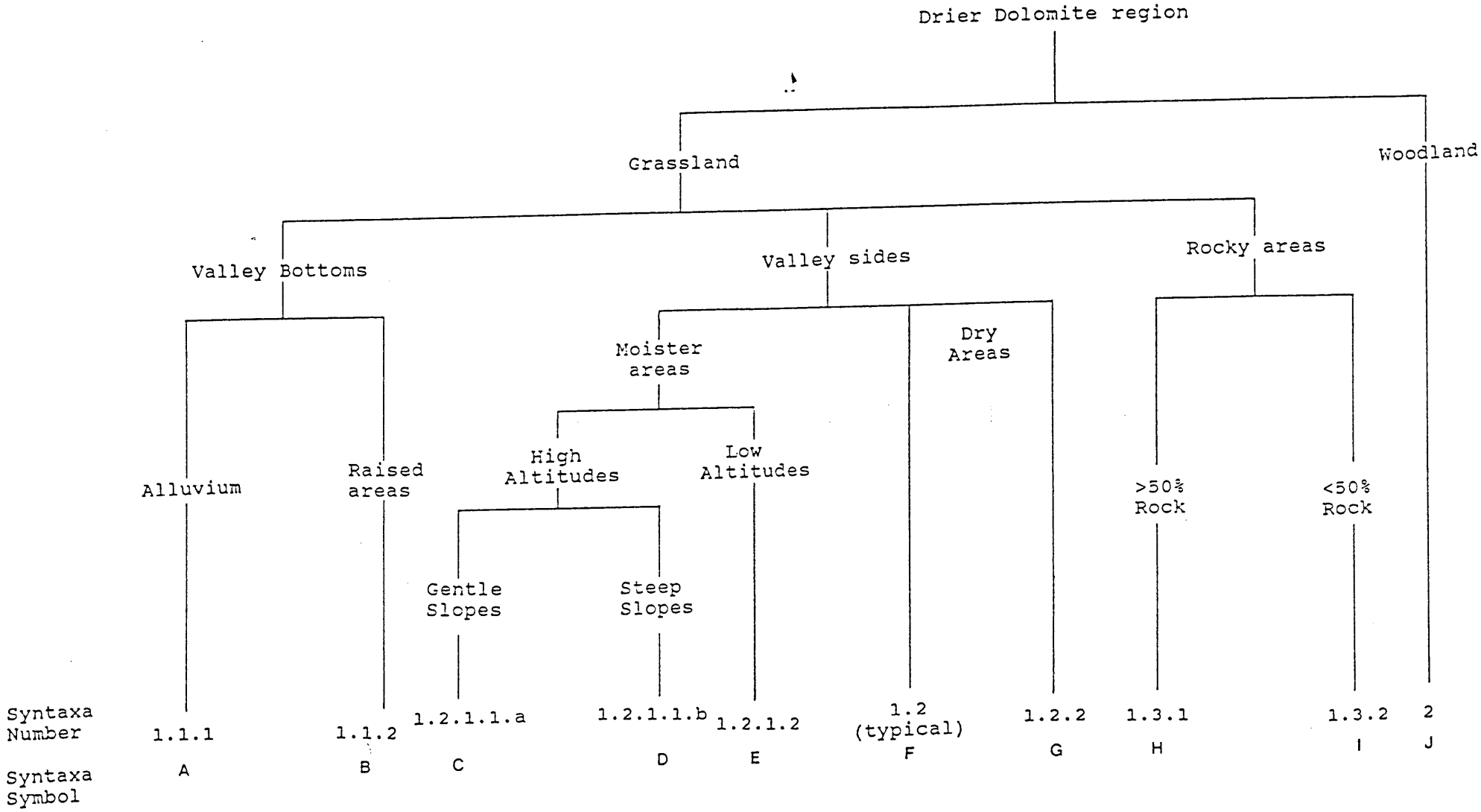


Figure 2. Dendrogram to illustrate the habitat relationships of the syntaxa. (See text for explanation of the syntaxa).

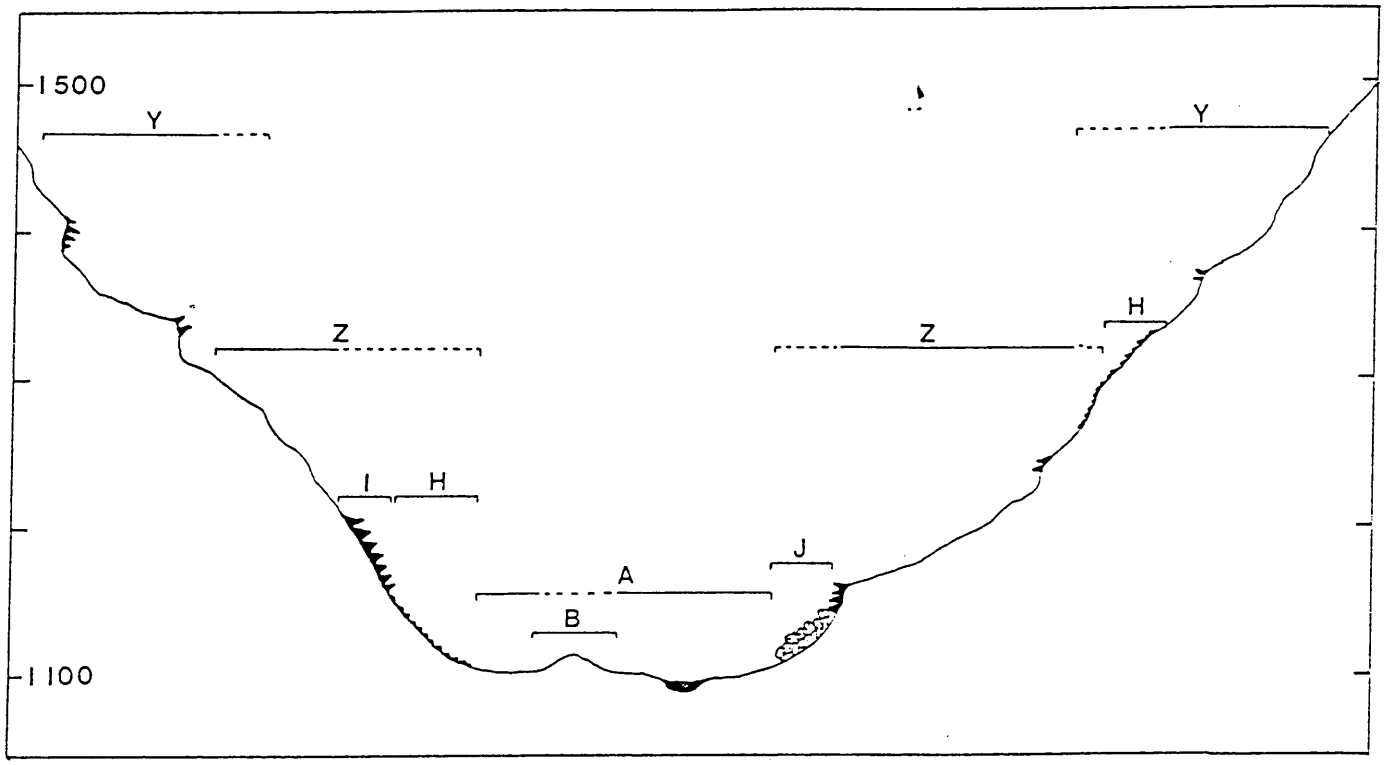


Figure 3. A schematical representation of the topographical distribution of the syntaxa in a mountain valley.

A:The Eragrosto curvulae - Hyparrhenietum filipendulae - hyparrhenietosum tambae.
B:The Eragrosto curvulae - Hyparrhenietum filipendulae - zornietosum capensis.
H:The Rhoicisso tridentatae - Rhynchosietum nitens - ozoroetosum sp. nov.
I:The Rhoicissus tridentatae - Rhynchosietum nitens - aloetosum castaneae.
J:The Acacio ataxacanthae - Celtietum africanae.
Y:The Rendlia altera variant.
Z:The Hemizygio tranvaalensis - Loudetietum simplex excluding the Rendlia altera variant.

Broken lines indicate overlapping distributions.

Description of the communities

1. The Helichryso nudifolii - Hyparrhenion filipendulae Alliance nov. Type relevé : 78.

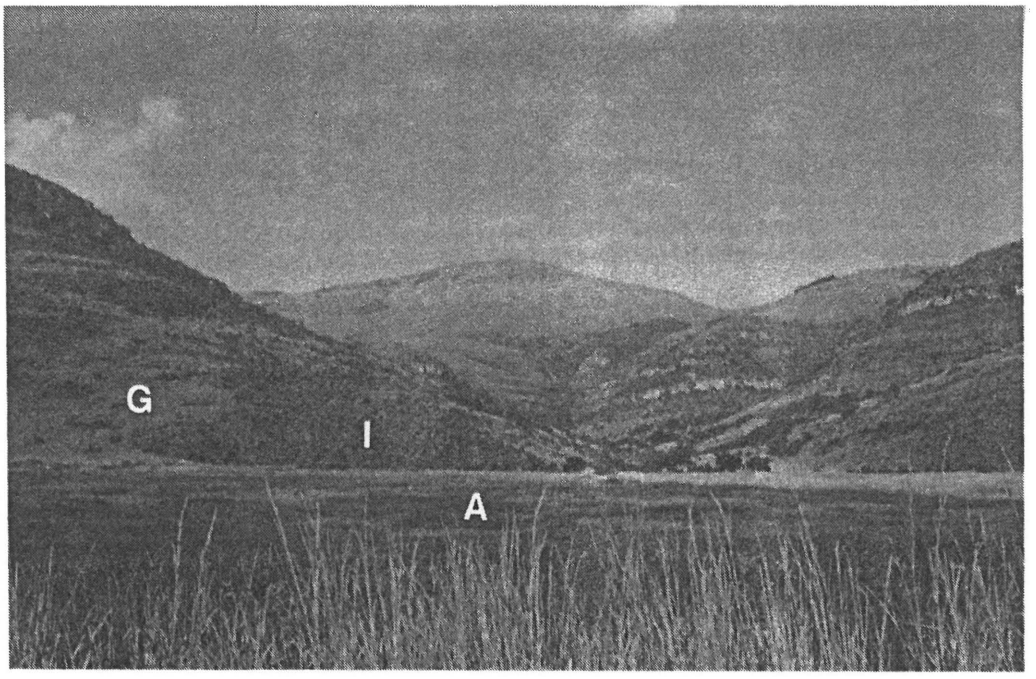
These grasslands are restricted to dolomite areas with an average rainfall of less than 1000 mm (compare Table 1 which shows rainfall figures for the relatively drier region and those of the rest of the area investigated). The rainfall of this region is lower than the average of the rest of the North-eastern mountain sourveld of the Transvaal Escarpment. A large part of the dolomite area is situated in a rain shadow behind the higher escarpment areas. An example is the Vaalhoek valley through which the Blyde River flows (see Figure 4 which shows some of the syntaxa of this alliance, occurring in the Blyde River valley). The low lying areas of the North-eastern mountain sourveld, the altitude of which ranges from 1 100 m up to 1 400 m, also forms part of this study area.

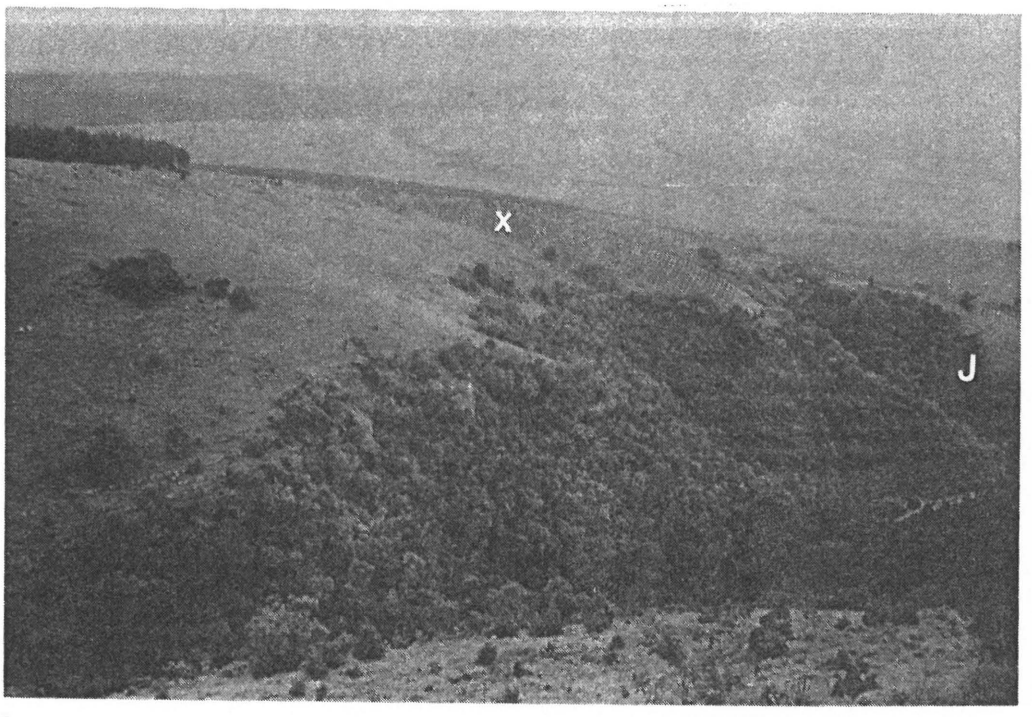
This vegetation unit is large and heterogenous and is characterized by species group O (Table 2). The grass species Hyparrhenia filipendula, Cymbopogon excavatus, Setaria sphacelata var. sphacelata, Themeda triandra, Eragrostis capensis, Hyparrhenia hirta, Melinis repens subsp. repens, Cymbopogon validus and the forbs Helichrysum nudifolium, Hermannia lancifolia, Athrixia phylicoides, Senecio venosus, Tenrhynea phylicifolia, Vernonia oligocephala and Oxalis obliquifolia are the most prominent diagnostic species of this syntaxon. The number of species recorded per sample plot ranges from a minimum of 11 to a maximum of 48 with an average of 26 species per relevé (Table 2).

Due to the complex and heterogenous topography within this Alliance, great variation in habitats exists, resulting in many different Associations and Subassociations.

Figure 4. The habitat of some syntaxa in the Blyde river valley area:
A:The Eragrosto curvulae - Hyparrhenietum filipendulae - hyparrhenietosum tambae.
I:The Rhoicissus tridentatae - Rhynchosietum nitens - aloetosum castaneae.
G:The Hemizygio tranvaalensis - Loudetietum simplex -indigoferetosum.
J: The Acacio ataxacanthae - Celtietum africanae.

Notice the afforestation (x) taking place on the plateaux.





1.1 The Eragrosto curvulae - Hyparrhenietum filipendulae Ass. nov. Type relevé : 65

This grassland is found along floodplains, low lying drainage valleys and valley floors.

This community is characterized by species group A (Table 2). The diagnostic species are the herbaceous Helichrysum rugulosum, Conyza bonariensis, Oenothera tetraptera, Cassia mimosoides and the grass Eragrostis curvula, which may be dominant at certain localities. An average of 19 species was recorded per relevé (Table 2).

Within this plant community two subassociations were identified:

1.1.1 The Eragrosto curvulae - Hyparrhenietum filipendulae - hyparrhenietosum tambae Subass. nov. Type relevé : 65

This grassland is restricted to the valley floodplain with alluvium as the underlying material.

This subassociation is characterized by species group B (Table 2). The diagnostic species being the 1m or taller growing, dominant grass Hyparrhenia tamba, the semi-woody small shrub Pseudarthria hookeri var. hookeri, the weedy forbs Verbena bonariensis, Nidorella auriculata, Wahlenbergia krebsii subsp. krebsii and Agrimonia odorata, as well as the sedge Mariscus sumatrensis.

An average of 17 species was recorded per relevé (Table 2).

The herbaceous layer is well developed in this grassland, where small semi-woody shrubs of Lippia javanica and Pseudarthria hookeri var. hookeri are found scattered about. The most prominent grass species are Hyparrhenia filipendula, Hyparrhenia tamba and Eragrostis curvula. Prominent forbs are Helichrysum rugulosum, Helichrysum nudifolium and Cassia mimosoides. Also present are some well known weeds and pioneer plants such as Conyza bonariensis, Verbena bonariensis, Oenothera tetraptera, Nidorella auriculata and Agrimonia odorata, indicating the state of degradation caused by grazing cattle of farmers living in the area.

This community partly resembles a Themeda triandra - Hyparrhenia hirta grassland community described by Bezuidenhout & Bredenkamp (1990) from the dolomitic region of the Potchefstroom -Ventersdorp - Randfontein area, some 450 kilometers to the south-west, in a completely different climatic zone.

1.1.2 The Eragrosto curvulae - Hyparrhenietum filipendulae - zornietosum capensis Subass. nov. Type relevé : 58

This grassland is found in relatively drier, slightly raised areas of the floodplain with the underlying material which may be gravel or contain small rocks.

This subassociation is characterized by species group C (Table 2). It is characterized by the presence of two forbs Zornia capensis and Leucas cf. glabrata and the absence of species from group B. An average of 20 species was recorded per relevé (Table 2).

The herbaceous layer is well developed, also with scattered small semi-woody shrubs of Lippia javanica, but not Pseudarthria hookeri var. hookeri. Only two prominent grass species are found which are Hyparrhenia filipendula and Eragrostis curvula. Prominent forbs are Helichrysum rugulosum, Helichrysum nudifolium, Cassia mimosoides, Oenothera tetraptera, Geigeria elongata and Anthospermum pumilum subsp. pumilum. The last two species come from species group J (Table 2), showing that this community has some affinities with community 1.2.

1.2 The Hemizygio tranvaalensis - Loudetietum simplex Ass. nov. Type relevé : 78

This is the most extensive grassland found on the relative drier dolomite areas. It's distribution ranges from relative dry areas (Vaalhoek weather station) to relative wet areas (Pilgrim's Rest weather station) (Table 1). This association is associated with valley sides which can be steep or gentle slopes, occurring at an altitude of 1 100 m - 1 400 m. This grassland type is also found in the hotter Wolkberg areas but here, it was found occurring at the cooler, higher altitudes. If rocky, the rock cover is usually not more than 15%.

This association is characterized by species group D (Table 2). The most prominent diagnostic species being the dominant grass species Loudetia simplex, the subdominant grass species Eragrostis racemosa, Diheteropogon amplectens, Bewsia biflora and Themeda triandra, the semi-woody to herbaceous Hemizygia transvaalensis, Senecio microglossum, Indigofera atrata, Triumfetta welwitschii var. welwitschii, Hermannia staurostemon and Geigeria elongata. The forbs Fadogia tetraquetra var. tetraquetra, Pentanisia angustifolia, Clutia monticola, Vernonia natalensis, Anthospermum pumilum subsp. pumilum and Parinari capensis which has woody

subterranean parts, protruding only 10 cm above the soil and the geophyte Hypoxis rigidula var. rigidula, are also prominently present.
An average of 30 species was recorded per relevé (Table 2).

Within this Association various syntaxa of lower ranks are distinguished:

1.2.1 The Hemizygio tranvaalensis - Loudetietum simplex -barlerietosum ovatae Subass. nov. Type relevé : 55
This grassland is found on the relative wetter areas of the drier dolomite region, as seen from the rainfall figures for Pilgrims Rest's weather station, compared with the other weather stations (Table 1).

This subassociation is characterized by species group E (Table 2). The diagnostic species being the forbs Barleria ovata, Aeschynomene nodulosa var. nodulosa, Helichrysum miconiifolium, Hypericum aethiopicum subsp. sonderi, Lopholaena disticha, Crabbea hirsuta and the grass species Panicum natalense, which can be prominent at some localities, Trachypogon spicatus and Diheteropogon filifolius. Some of these species may also be common in other wetter areas, therefore confirming that these areas are relatively wetter than the rest of the areas under discussion. An average of 24 species were recorded per relevé (Table 2).

Within this Subassociation two variants were identified:

1.2.1.1 The Rendlia altera variant.

This variant is found at higher altitudes than the other variant, ranging from 1 300 m to 1 560 m.

This variant is characterized by species group F (Table 2). The most prominent diagnostic species being the grass species Rendlia altera, Loudetia sp. nov. (a new, until now undescribed species from this area) and Eulalia villosa. Helichrysum oreophilum and Haplocarpha scaposa are diagnostic forbs with the scanty shrub Erica caffrorum var. caffrorum also being diagnostic. Another characteristic of this variant is the complete absence of Hyparrhenia filipendula.

The herbaceous layer is well developed with scanty shrubs of Erica caffrorum var. caffrorum found scattered about. Prominent forbs are Barleria ovata, Clutia monticola and Indigofera atrata. It also can be seen that the species of the drier areas, such as

those from species group J (Table 2), are absent from this variant, also indicating moister conditions. An average of 33 species was recorded per relevé (Table 2).
Two facies are distinguished in this variant:

1.2.1.1.a. The Monocymbium ceresiiforme facies.

This facies is found on gentle slopes, the gradient being 1-6 degrees. It is also interesting to note that all known fire protected plots in the area (not been burnt for more than five years) occur in this facies.

This facies is characterized by species group G (Table 2) and characteristic is the presence of the grass species Monocymbium ceresiiforme, the forbs Eriosema ellipticifolium, Tetraselago wilmsii, Senecio erubescens, Dicoma anomala subsp. cirsioides, Becium obovatum and the ground creeper Pearsonia obovata.

1.2.1.1.b. The Helichrysum acutatum facies.

This facies is found on steep slopes, the gradient being 20-40 degrees.

This facies is characterized by species group H (Table 2). The presence of the forbs Helichrysum acutatum, Helichrysum pilosellum, Cephalaria pungens and Berkheya echinacea subsp. echinacea is characteristic of this variant.

1.2.1.2 The Bewsia biflora - Barleria ovata variant.

This variant is to be found at lower altitudes than the Rendlia altera variant, ranging from 1 200 m to a maximum of 1 300 m. The rainfall still being higher than the average for the drier dolomite areas.

This variant is characterized by the absence of species' groups F, G and H (Table 2). The herbaceous layer is well developed with the most prominent grass species being Loudetia simplex, Bewsia biflora and Panicum natalense. The most conspicuous forb species are Barleria ovata and Fadogia tetraquetra var. tetraquetra. An average of 29 species were recorded per relevé (Table 2).

1.2.2 The Hemizygio tranvaalensis - Loudetietum simplex -indigoferetosum oxalidea Subass. nov. Type relevé : 56

This grassland is characterized by species group I (Table 2). The most prominent

diagnostic species are the prostrate semi-woody forb Indigofera oxalidea, the forbs Polygala hottentotta, Scabiosa columbaria, Berkheya insignis, the geophyte Hypoxis cf. galpinii, the semi-parasitic root parasite Thesium costatum and the grass species Tristachya leucothrix.

The herbaceous layer is well developed with the most prominent grass species being Loudetia simplex, Eragrostis racemosa, Bewsia biflora and Diheteropogon amplectens. Other conspicuous forbs species are Anthospermum pumilum subsp. pumilum, Pentanisia angustifolia and Indigofera atrata. An average of 33 species was recorded per relevé (Table 2).

1.3 The Rhoicisso tridentatae - Rhynchosietum nitentis Ass. nov. Type relevé : 80

This association covers the areas where large rock outcrops occur as well as areas where the percentage rock cover is more than 25%.

This association is characterized by species group K (Table 2). The most prominent diagnostic species are the conspicuous grey shrublet Rhynchosia nitens, the liana Rhoicissus tridentata, the dwarf shrublet Maytenus tenuispina, the shrub Rhus dentata, the forb Xerophyta retinervis and the tree Seemannaralia gerrardii. An average of 30 species was recorded per relevé (Table 2).

Some interesting species are found in this community, including endemics and species with limited distributions (scarce), for example Salvia dolomitica (Matthews et al. (in prep).

Due to the complex nature of the dolomitic rocky areas, variation in this habitat exists, resulting in two subassociations:

1.3.1 The Rhoicisso tridentatae - Rhynchosietum nitentis - ozoroetosum sp. nov. Subass. nov. Type relevé : 88

This subassociation is found on rock outcrops of dolomite where on average the percentage rock cover is usually less than 50% but more than 15%. This rocky outcrops' vegetation is wide-spread, including the Wolkberg area in the north, but there it is found at a higher altitude. These are moister rock outcrops than those of the aloetosum castaneae. The ozoroetosum sp. nov. Subassociation shows considerable variation which could be the result of its wide distribution, but further investigation is needed to clarify

this.

This subassociation is characterized by species group M (Table 2). The most prominent diagnostic species being a newly discovered Ozoroa sp. yet to be described and an Euphorbia sp., the succulent forbs Crassula sarcocaulis, Kalanchoe rotundifolia, the forbs Gnidia caffra, Pygmaeothamnus zeyheri and Hibiscus engleri, the shrubs Euclea undulata, Scolopia zeyheri, Canthium inerme and the dwarf shrub Myrsine africana. Another species of interest is Protasparagus rigidus which is endemic to the Transvaal Escarpment (Ferrar et al. 1988). An average of 29 species was recorded per relevé (Table 2).

1.3.2 The Rhoicisso tridentatae - Rhynchosietum nitentis - aloetosum castaneae Subass. nov. Type relevé : 80

This Subassociation is found on rock outcrops of dolomite where the percentage rock cover is more than 50%. These are drier rock outcrops than the Rhoicisso tridentatae - Rhynchosietum nitentis - ozoroetosum sp. nov. Subassociation and this syntaxon seems to be localized to the Vaalhoek valley.

This plant community is characterized by species group L (Table 2). The diagnostic species are the succulent shrub Aloe castanea, the shrubs Diospyros whyteana, Plectranthus rubropunctatus, Orthosiphon tubiformis, the semi-woody forbs Helichrysum uninervium, Ruellia cordata, Phyllanthus sp., the forbs Gerbera jamesonii, Stachys reticulata, Cyphia elata, the xerophytic fern Cheilanthes multifida and the grasses Triraphis andropogonoides and Enneapogon scoparius. The tall (2m) shrub Catha edulis can become locally dominant.

Other small shrubs prominent are Athrixia phylicoides and Rhus dentata. Common grass species include Cymbopogon validus, Melinis repens subsp. repens, Setaria sphacelata var. sphacelata and Setaria sphacelata var. torta. Also occurring in this community are species with limited distributions. An average of 31 species was recorded per relevé (Table 2).

2. The Acacio ataxacanthae - Celtietum africanae Ass. nov.
Type relevé : 137

This association is found on rock outcrops near or on the bottom of valleys as well

as in some protected areas on valley sides. This is a woody community showing some affinities with bushveld vegetation.

This association is characterized by species group P (Table 2). The diagnostic tree species are Acacia ataxacantha, Celtis africana, Ziziphus mucronata, Combretum erythrophyllum, Ficus ingens, Acacia karroo and Rhamnus prinoides. The lianas Rumex sagittatus, Ipomoea purpurea, Helinus integrifolius, Rubia horrida, Momordica foetida, Clematis brachiata and the shrubs Grewia occidentalis, Calpurnia aurea subsp. aurea, Buddleja auriculata, Buddleja salviifolia and Dombeya pulchra are also conspicuous. The herbaceous layer is not well developed with the most common grass species being Panicum maximum occurring in the shade of trees and shrubs. The invading tree species Acacia mearnsii was also found occurring in this association. An average of 21 species was recorded per relevé (Table 2).

Ordination

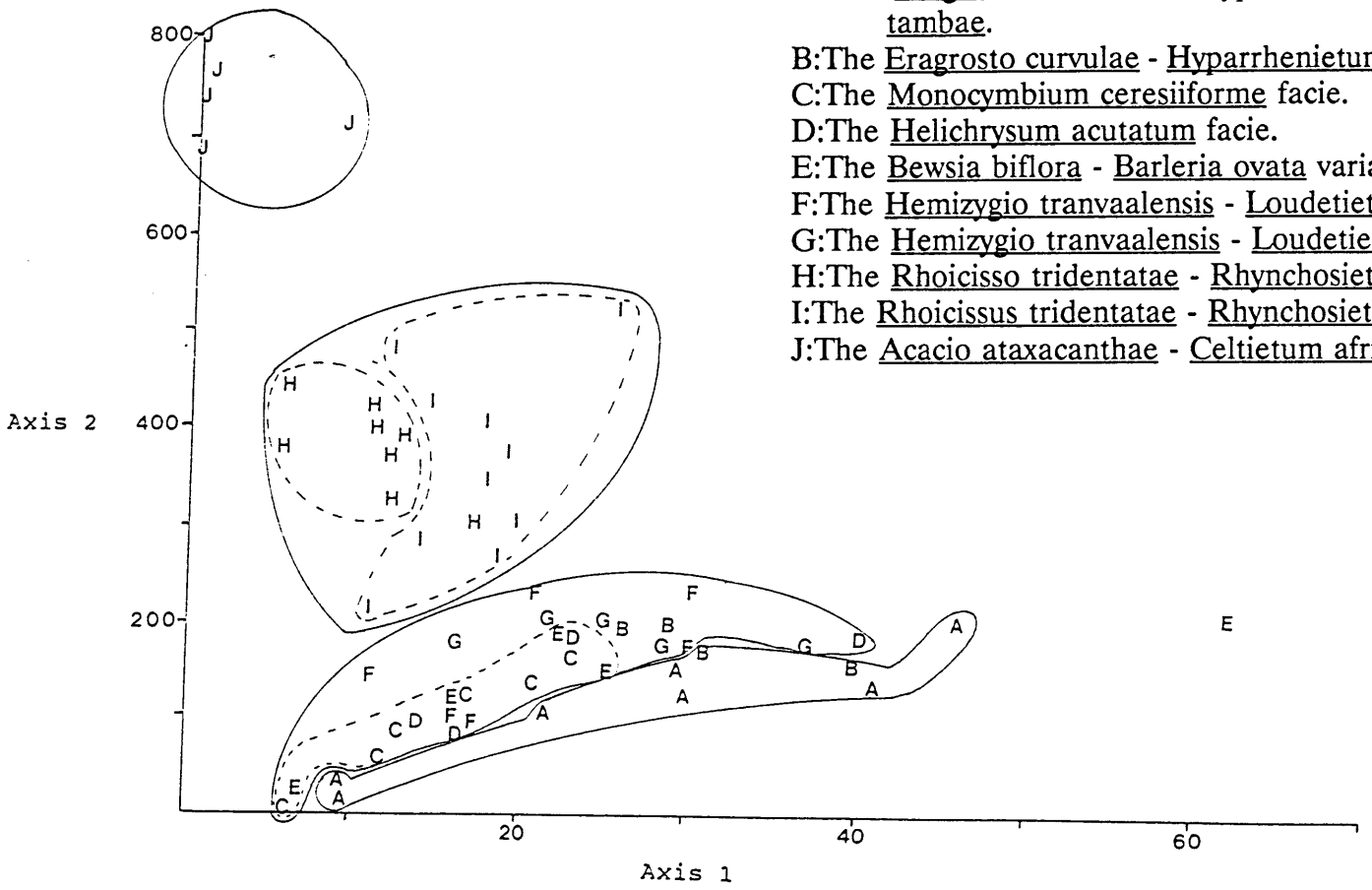
The distribution of the relevés along the first and second axes of ordination is given in Figure 5. A third axis of ordination contributes very little to the interpretation of the communities and is therefore not included in this result.

In the scatter diagram a distinct discontinuity can be observed between the Acacio ataxacanthae - Celtietum africanae (J) and the rest of the syntaxa. Between the rest of the communities no distinct discontinuities can be seen, however, the individual communities are largely confined to certain areas of the diagram. The most constant grouping being formed by the Rhoicisso tridentatae - Rhynchosietum nitentis (H and I) of the rocky zones. The Eragrosto curvulae - Hyparrhenietum filipendulae (A and B) can also be distinguished as a separate group. That the other syntaxa are closely grouped (C, D, E, F and G), confirms that they are related to each other, and should be grouped in a single association, the Hemizygio tranvaalensis - Loudetietum simplex.

The scatter diagram illustrates a moisture gradient along the second axis with the wetter habitats to the bottom and the drier habitats to the top of the diagram.

Figure 5. The ordination of the vegetation of the drier dolomitic regions of the Transvaal escarpment.

A:The Eragrosto curvulae - Hyparrhenietum filipendulae - hyparrhenietosum tambae.
B:The Eragrosto curvulae - Hyparrhenietum filipendulae - zornietosum capensis.
C:The Monocymbium ceresiiforme facie.
D:The Helichrysum acutatum facie.
E:The Bewsia biflora - Barleria ovata variant.
F:The Hemizygio tranvaalensis - Loudetietum simplex Typical.
G:The Hemizygio tranvaalensis - Loudetietum simplex -indigoferetosum X2.
H:The Rhoicisso tridentatae - Rhynchosietum nitens - ozoroetosum sp. nov.
I:The Rhoicissus tridentatae - Rhynchosietum nitens - aloetosum castaneae.
J:The Acacio ataxacanthae - Celtietum africanae.



Discussion

The aim of this study was to identify, characterize and interpret ecologically, by using habitat properties, the major vegetation units and their variations that occur in the North-eastern mountain sourveld of the Transvaal Escarpment. Since, ecologically interpretable plant associations were distinguished, the general descriptions and proposed classification can be used for further studies as well as for land-use planning and management.

Newly described syntaxa include a new alliance, four new associations and six new subassociations. This syntaxonomical study contributes greatly to the syntaxonomical and synecological research program in the grassland biome of Southern Africa.

The results of the ordination not only confirm the classification, but also gives an indication of floristic and associated habitat gradients.

Acknowledgements

This research was partially supported by the Foundation for Research Development.

References

Acocks, J.P.H. 1988. Veld Types of South Africa. Mem. bot. Surv. S. Afr. 40: 1-128.

Bayer, A.W. 1970. Plant ecology in the service of man in southern Africa. S. Afr. J. Sci. 66: 71-77.

Behr, C.M. & Bredenkamp, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. S. Afr. J. Bot. 54: 525-533.

Bezuidenhout, H. & Bredenkamp, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom - Ventersdorp - Randfontein area, South Africa. Phytocoenologia 18: 387-403.

Bezuidenhout, H. & Bredenkamp, G.J. 1991. The vegetation of the Bc land type of the Western Transvaal grassland, South Africa. Phytocoenologia in press.

Deall, G.B. 1985. A plant-ecological study of the Eastern Transvaal escarpment in the Sabie area. M.Sc. Thesis, University of Pretoria, Pretoria.

Deall, G.B., Scheepers, J.C. & Schutz, C.J. 1989a. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. Bothalia 19: 53-67.

Deall, G.B., Theron, G.K. & Westfall, R.H. 1989b. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 2. Floristic classification. Bothalia 19: 69-89.

Erasmus. J.F. 1987. Rainfall Deciles for Transvaal Region. Department of Agriculture and Water supply.

Fabricius, A.F. 1969. In Schutte, J.M. 1971. Die onttreking van water uit die newellaag en lae wolke by Mariepskop. S.A Department of water Affairs, Division Hydrological Research, Technical note 20: 1-21.

Fabricius, A.F. 1988. Klimageographie-Sudafrika (Moqambique, Swaziland, Republik Sudafrika). Africa-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

Ferrar, A.A., Isaacs, G. & Stacey, J.R. (eds). 1988. Environmental conservation features of the Transvaal Escarpment: an information base for regional planning. Occasional Report No. 31. FRD, CSIR, Pretoria.

Geological Survey. 1986. Geology map 1:250 000 geological series. 2430 Pilgrim's Rest. Government Printer, Pretoria.

Gibbs-Russell, G.E., Reid, C., Van Rooy, J & Smook, L. 1985. List of species of southern African plants. 2nd edn, Part 1, Mem. bot. Surv. S. Afr. 51: 1-152.

Gibbs-Russell, G.E., Welman, W.G., Retief, E.,Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M., Nicoholas, A., De Wet, C., Mogford, J.C. & Mulvena, J. 1987. List of species of southern African plants. 2nd edn, Part 2, Mem. bot. Surv. S. Afr. 56: 1-270.

Gibbs-Russell, G.E., Watson, L.,Koekemoer, M., Smook, L., Bavker, N.P., Anderson, H.M.P. & Dallwitz, M.J. 1990. Grasses of Southern Africa. Mem. bot. Surv. S. Afr. 58: 1-437.

Hill, M.O. 1979a. DECORANA. A FORTRAN programme for detrended correspondence analysis and reciprocal averaging. Department of Ecology and Systematics, Cornell University. Ithaca, New York.

Hill, M.O. 1979b. TWINSPAN. A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University. Ithaca, New York.

Land Type Survey Staff. 1989. Land types of the maps 2330 Tzaneen and 2430 Pilgrim's Rest. Mem. agric. nat. Resour. S. Afr. No. 12.

MacVicar, C.N. & co-workers (1977): Soil classification - A binomial system for South Africa. -Dept. Agriculture-technical services, Pretoria.

Matthews, W.S. (In prep.). Phytosociology of the North-eastern Mountain Sourveld. M.Sc. Thesis, University of Pretoria, Pretoria.

Matthews, W.S., Van Wyk, A.E. & Bredenkamp (19–). Endemic flora of the dolomitic areas of the North-eastern Transvaal Escarpment, South Africa. Biol. Conserv. (submitted).

Mentis, M.T. & Huntley, B.J. 1982. A description of the Grassland Biome Project. S. Afr. Nat. Sci. Prog. Report No. 62, CSIR, Pretoria.

Moore, P.D. & Chapman S.B. (eds). 1986. Methods in Plant Ecology. Blackwell Scientific Publications, London.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation Ecology. John Wiley & Sons, New York.

Pentz, J.A. 1938. The value of botanical survey and the mapping of vegetation as applied to farming systems in South Africa. Mem. bot. Surv. S. Afr. No. 19: 1-15.

Scheepers, J.C. 1978. Vegetation of Westfalia Estate on the North-Eastern Transvaal Escarpment. Mem. bot. Surv. S. Afr. 42: 1-230

Scheepers, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR, Pretoria.

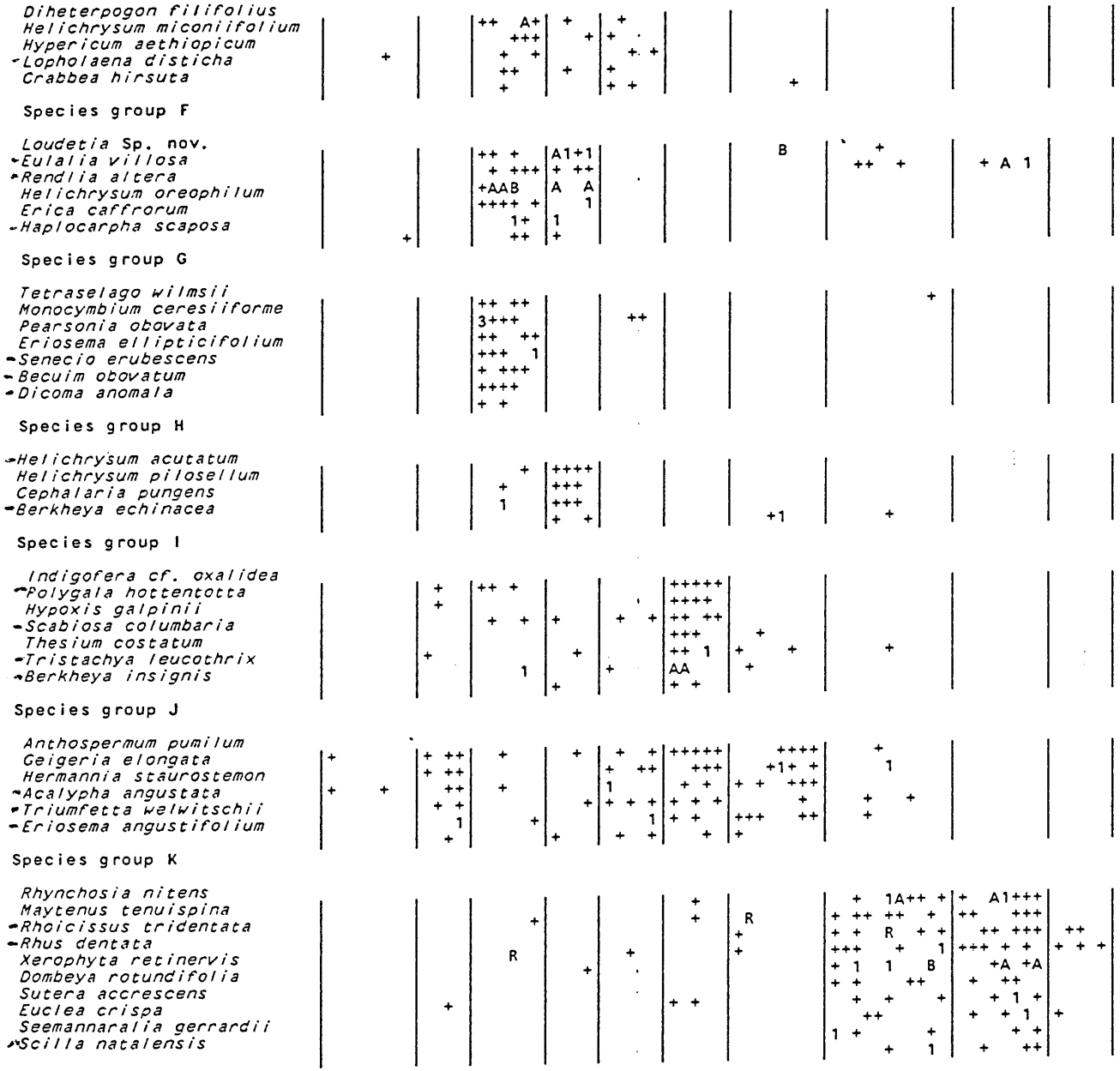
Van Rooyen, N., Theron, G.K. & Grobbelaar, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. Jl. S. Afr. Bot. 47: 213-246.

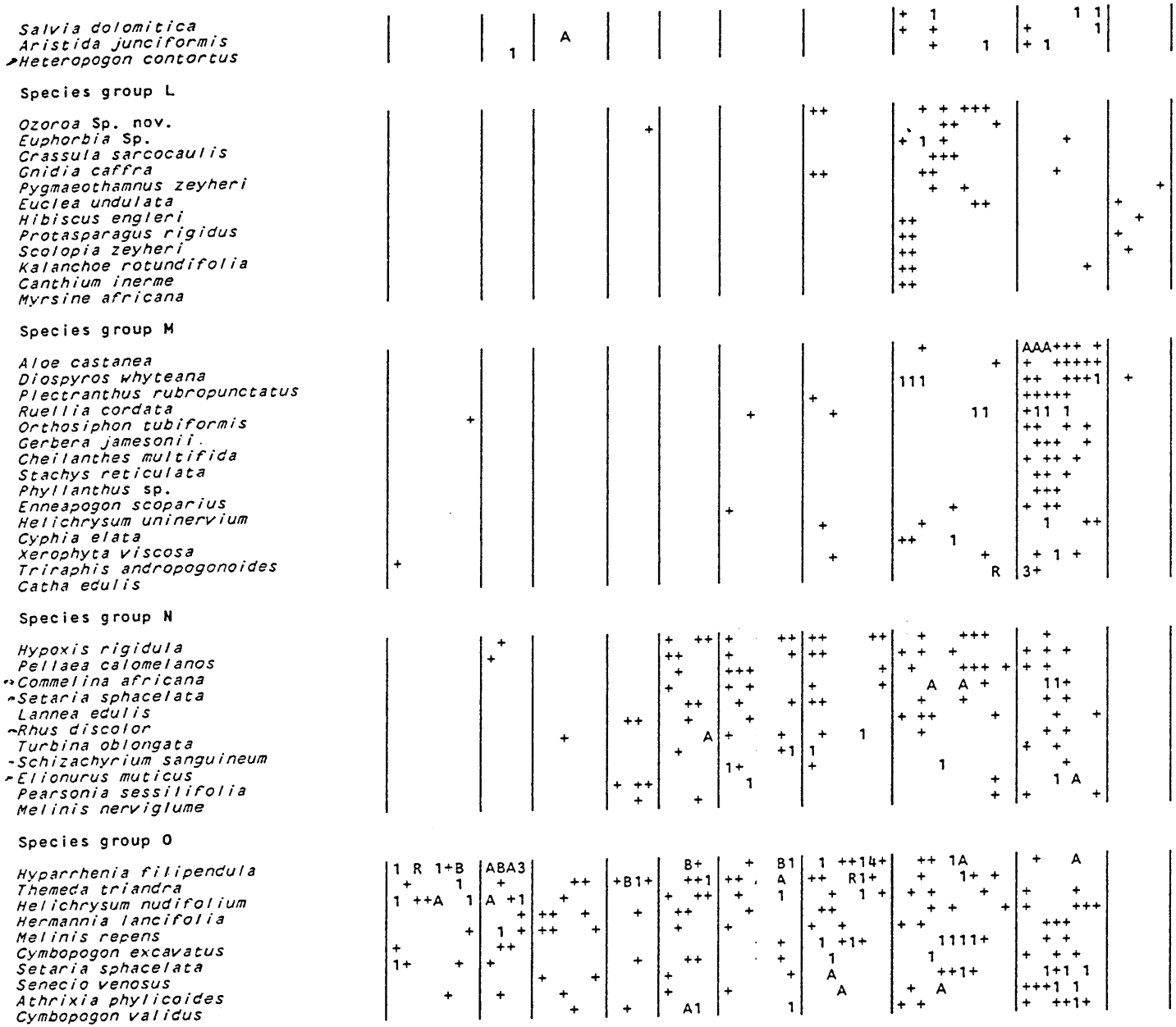
Walker, B.H. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. S. Afr. J. Wildl. Res. 6: 1-32.

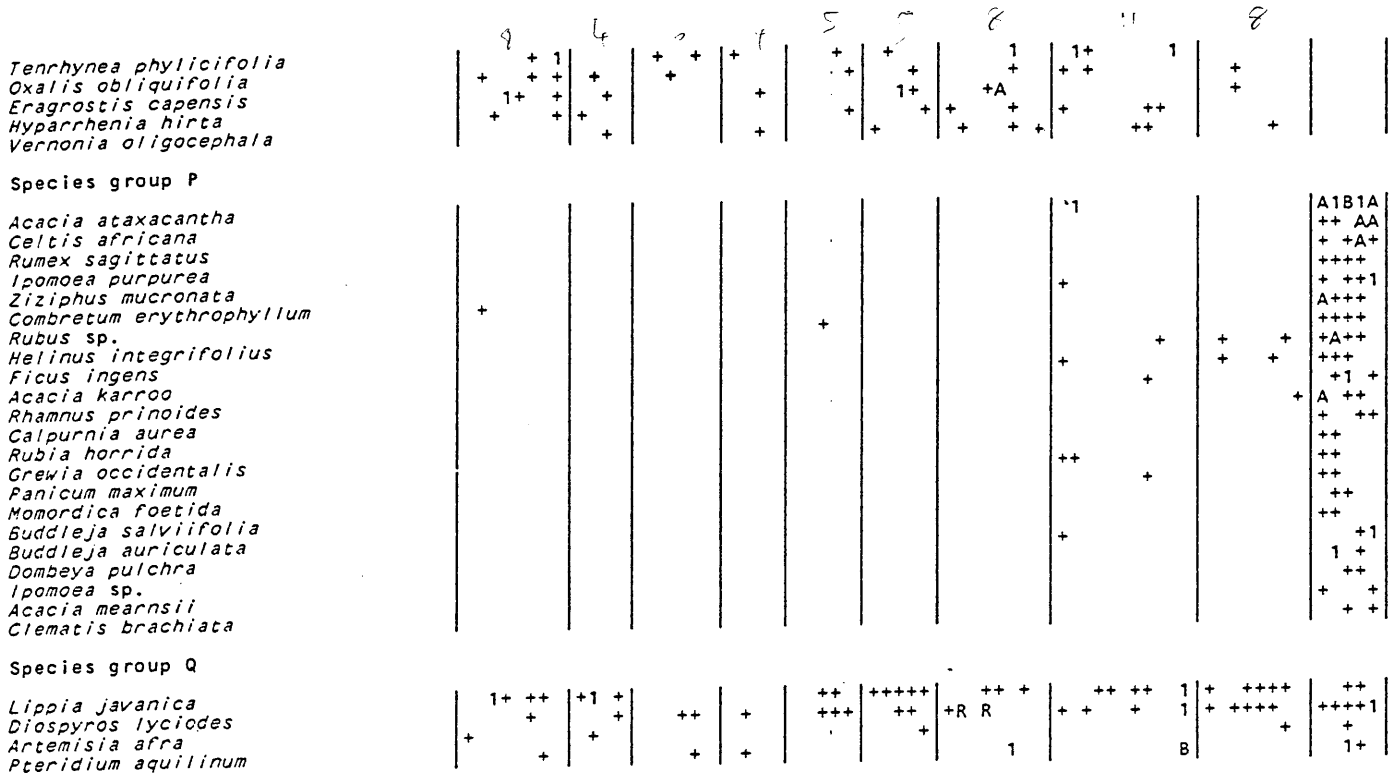
Westfall, R.H. 1981. The plant ecology of the farm Groothoek, Thabazimbi district. M.Sc. Thesis. University of Pretoria, Pretoria.

Table 2. A phytosociological table of the vegetation of the drier dolomitic regions and associated areas of the North-eastern mountain sourveld of the Transvaal. (Species of an occurrence of 1 have been omitted).

Community numbers	1									2
	1.1		1.2				1.3			
	1.1.1	1.1.2	1.2.1			1.2.2	1.3.1		1.3.2	
			1 2 1 1		1 2 1 2					
			a	b						
Relevé number	00000000 65745446 51490688	0010 5507 2840	000000 222265 325195	0000 8458 3742	00000 37307 01959	00001 55670 63656	00011001 78677870 87331673	01001101100 28877754486 70834271217	00000000 44667478 43246520	11111 33334 67890
Species per relevé	11111111 75345528	1221 9119	334323 246495	3232 2737	32232 48806	42333 28311	33221212 55628510	42422223221 86351862755	43322322 13489154	22211 61287
Species group A										
Helichrysum rugulosum	++ ++ +1	+++	+				+			
Conyza bonariensis	+1+++1++	+			R		+			
Eragrostis curvula	+ +BA+ +	+ +					A +		1 +	
Oenothera tetraptera	+++ +	++ +								
Cassia mimosoides	+ + +	+ +	+		+		+			
Species group B										
Hyparrhenia tamba	A33++41								1+	+
Pseudarthia hookeri	+ + +++	1			+		+	+		
Verbena bonariensis	++1+									
Nidorella auriculata	+ 1 +									
Wahlenbergia krebsii	+ ++	+								
Agrimonia odorata	+ +									
Mariscus sumatrensis	++									
Species group C										
Zornia capensis		++++								
Leucas cf. glabrata		++			+	+				
Species group D										
Loudetia simplex	+		1AAB +		1+A2+	+RA+1	1++B1 B	+ 1	1 ++	
Eragrostis racemosa			+ ++ 1	+1+	+ +	1++++	+ + +1	+		
Indigofera atrata			+ + ++	++	+	+++ 1	+++++ +		+	
Diheteropogon amplectens			+++ +		+ +	++++	+ +++ +	+ +		+
Bewsia biflora	B		++		+++R1	1++ +	++ +		+	+ +
Clutia monticola			+++++	++++	+	+ +	++			
Hemizygia transvaalensis			+ +	++	+ +	+ ++	++ +			
Pentanisia angustifolia			++	+++	+ +	++ ++	+	+	+	
Parinari capensis			1+ +	+	1	+11	++			
Fadogia tetraquetra		+	+		++++	++ +	+			
Vernonia natalensis	+	+	A +		+ + +	+ +				
Senecio microglossum	+	R	+	1	1 +	1 A	A+ + +	+	+	
Species group E										
Barleria ovata			++++++	+	++++					
Panicum natalense			++ 1+	1++1	+A +	+				
Aeschynomene nodulosa			+++++	+ +	++	+	+			
Trachypogon spicatus			+1++	1	+1	+	1 +	+		







The phytosociology of the high altitude hygrophilous vegetation regions of the North-eastern Mountain Sourveld of the Transvaal, South Africa.

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Submitted for publication in Phytocoenologia

Abstract

An analysis of the vegetation of the relatively high hygrophilous regions of the Transvaal escarpment is presented. Relevès were compiled in 53 stratified random sample plots. A TWINSPAN - classification, refined by Braun - Blanquet procedures revealed eight plant communities, which can be classified under two major communities. One Class, one order, two alliances, seven associations and one community without syntaxonomic rank are newly described. All syntaxa are related to specific environmental conditions.

Keywords: Braun-Blanquet procedures, classification, Grassland Biome, hygrophilous, drainage line, seepage area

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Introduction

In a syntaxonomic and phytosociological study of the North-eastern mountain sourveld regions (Acocks, 1988), the vegetation of the rocky outcrops of Black Reef Quartzite and associated rock outcrops as well as the dry dolomitic regions was described by Matthews et al. (1991 a&b). To complete this study the syntaxonomy and phytosociology of the high altitude hygrophilous vegetation of the north-eastern mountain sourveld is presented in this paper. This study contributes to the urgently needed syntaxonomical synthesis (Mentis & Huntley, 1982 and Scheepers, 1987) presently being made by the vegetation ecology group of the University of Pretoria in South Africa.

The study area

The location of the study area is shown in Figure 1. This area of Transvaal is very mountainous and much of the area is undeveloped, with those areas which are developed (mainly by forestry) found in a central area, namely around the towns Sabie, Pilgrim's Rest and Graskop. The very nature of this area makes most of it inaccessible to normal vehicles and still many more areas, especially to the north, nearly completely inaccessible except for long excursions on foot or by use of specialized vehicles such as helicopters. The undeveloped nature of these areas has also resulted in a shortage of certain environmental data such as a rainfall and specifically temperature figures (a result of a shortage of weather stations).

A detailed description of the physical environment of the area is given by Matthews et al. (in prep). The main rock types found in the study area are quartzite, dolomite and shales. The area that is of concern here are the relatively high lying moist zones of the study area(above 1 600 m) in the mist belt zones. The mist belt areas are described by Scheepers (1978), Deall (1985), Deall et al. (1989a) and Matthews et al. (in prep). They encompass most of the geological formations. The drainage lines and seepage zones are also included although they may also occur at lower altitudes.

Soils of these areas are varied as a result of the varied geology but are mostly, according to the soil classification of Macvicar et al. (1977), are of the shallow Hutton form (orthic A horizon on a structureless B horizon), found on the plateaux and the valley sides. The rock outcrops, peak areas and many of the valley sides have shallow lithosols, with the dominant soil forms being Mispah (orthic A horizon on rock) and

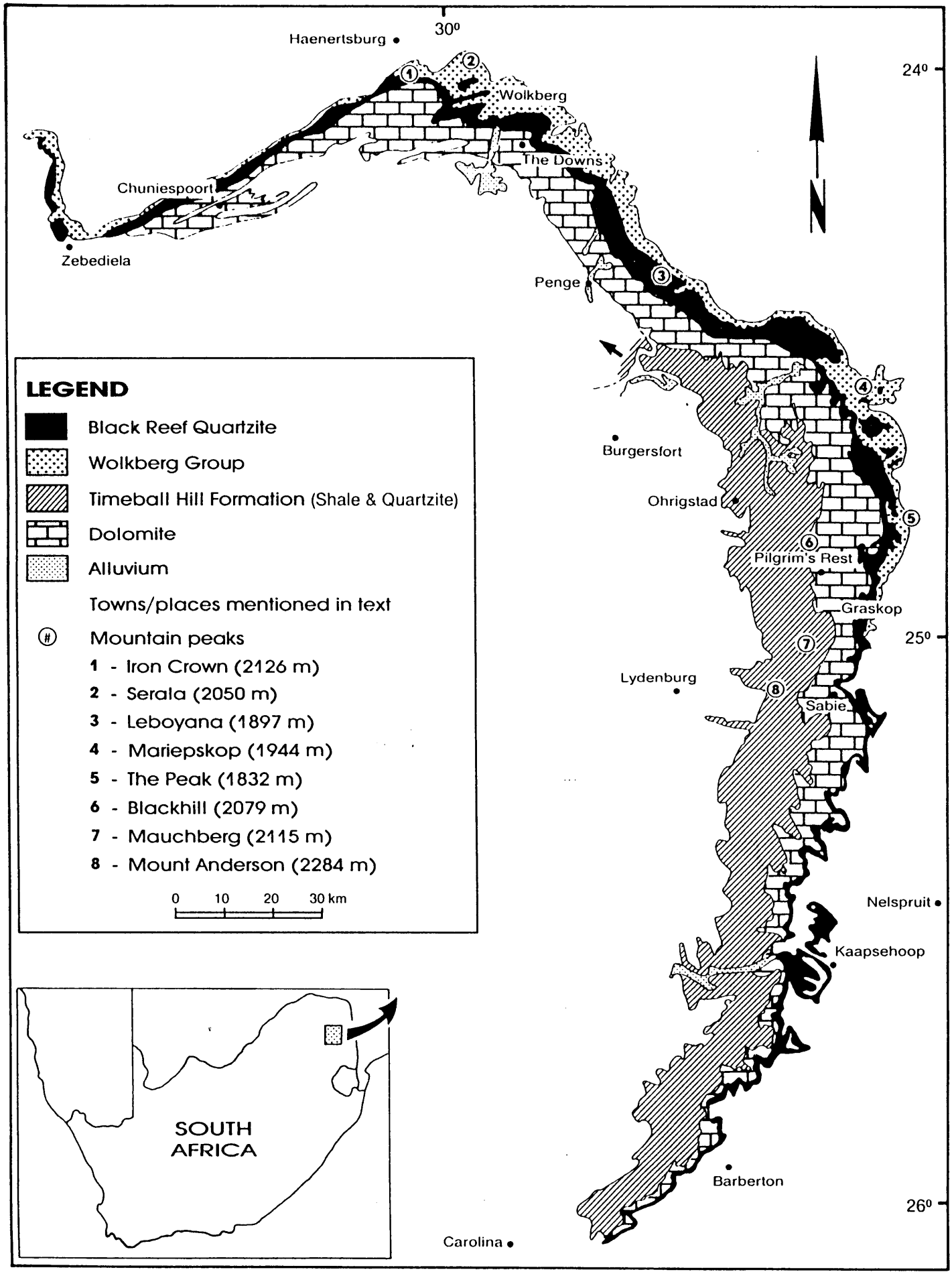


Figure 1. Map showing the locality of the study area, simplified geology and position of major mountain peaks (After the 1:1 000 000 Geological Map of South Africa, 1984, Geological Survey, Dept. of Mineral & Energy Affairs, Pretoria).

Glenrosa (orthic A horizon on lithocutonic B horizon).

The climate of the Eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool dry winters (Fabricius 1969 & 1988). Characteristic of the escarpment is the occurrence of mist in the so called mist belt and in these areas under discussion the mist having a pronounced effect. Rainfall data for specific stations relevant to the habitats discussed in this paper are given in Table 1.

Table 1. Mean annual and absolute maximum and minimum rainfall for relevant weather stations of the Eastern Transvaal Escarpment.*

Stations Grid	Altit. (m)	Period (Yrs)	Annual Rainfall (mm)		
			Min	Max	Mean
1. Lisbon F.S. 24°53'S 30°51'E	1402	21	1000	2354	1579
2. Mac Mac F.S 24°59'S 30°49.'E	1360	59	814	2331	1515
3. Graskop 24°56'S 30°51'E	1487	24	708	1821	1321
4. Mariepskop F.S. 24°35'S 30°52'E	1400	40	683	2601	1308
5.Grootfontienberg 24°57'S 30°43'E	1644	8	988	1400	1178
6. Blyde F.S. 24°50'S 30°50'E	1433	49	314	1931	1130
7. Clewer House 24°54'S 30°41'E	1750	21	543	1379	943
8. Elandshoogte 25°30'S 30°30'E	1905	20	459	1339	862
9. Morgezon F.S. 24°53'S 30°43'E	1630	27	384	1162	800

* Compiled from Rainfall Deciles for Transvaal Region (Erasmus 1987).
F.S. - Forestry Station

Methods

In the broader study two hundred 100 m^2 sample plots (10 m x 10 m) were distributed in a stratified random manner throughout the main study area. The plots

were as far as possible equally distributed in the different physiographical - physiognomically homogenous units, distinguished on the basis of physiognomy, dominant species composition and abundance (See also Matthews et. al. 1991 a&b). This resulted in 53 sample plots being placed in the relatively high altitude hygrophilous vegetation regions, described in this paper. Sampling was carried out from January to May 1990. Taxa names conform to those of Gibbs-Russell et al. (1985, 1987).

The following aspects were recorded for each sample plot:

1. The total floristic composition, as well as a cover-abundance values for each species was recorded by using the Braun-Blanquet cover-abundance scale as described by Mueller-Dombois & Ellenberg (1974).
2. Altitude, read from 1:50 000 topographical maps.
3. Gradient, with use of a clinometer.
4. Aspect, with use of a compass.
5. Rockiness, estimated as a percentage of the ground cover.
6. Size of rocks as follows: Large rock outcrops(>1 000 mm diameter), rocks(300 - 1 000 mm diameter), small rocks(50 - 300 mm diameter) and stones or gravel(<50 mm diameter).
7. Topographical position based on terrain types, according to Land Type Survey Staff (1989) namely (1) crests, (2) scarp, (3) midslope, (4) footslope and (5) valley bottom or floodplain.
8. Geology, according to 1:250 000 geological survey maps (Geological Survey 1986) and locally at a smaller scale, personal observations in the field.
9. Land type according to 1:250 000 landtype map, Land Type Survey Staff (1989).
10. Exposure, as exposed to sun, wind and mist, expressed as sheltered, partly sheltered or exposed.

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

Results

Classification

The results are presented in a phytosociological table (Table 2).

In general the vegetation of this area can be described as grasslands found predominantly at altitudes of above 1 600 m, except for the drainage and seepage areas which may also occur at lower altitudes. The geology is represented by various rock types described by Matthews (in prep.). Most areas are wet with a mean annual rainfall of > 800 mm (compare Table 1). This area represents the high lying areas of the North-eastern mountain sourveld (Acocks 1988), including many of the mountain peaks of the area, the altitude of which ranges from 1 600 m up to over 2 000 m (Photo 1). This vegetation unit is large and heterogeneous and is characterized by species group N (Table 2).The grass species Alloteropsis semialata, Andropogon schirensis, Themeda triandra, the short semi-woody shrub Rabdosiella calycina and the forbs Lobelia flaccida and Acalypha sp. are prominent and conspicuous species of this grassland. The number of species recorded per relevé ranges from a minimum of 11 to a maximum of 42 with an average of 22 species per plot (Table 2).

Photo 1. The habitat of the Alloteropsido semialatae - Rendlietea alterae, Leboyana peak (1 897 m) area.

Due to the complex and heterogenous topography within this grassland, great variation in habitat exists, resulting in the tresence of many different syntaxa.

In the analysis of the vegetation eight plant communities were identified which can be grouped into two major communities. The first major plant community of high altitudes hygrophilous areas, is the Class Alloteropsido semialatae - Rendlietea alterae. The second major community represents relatively dry drainage and seepage areas on dolomite and shale, found scattered throughout the study area. The hierarchical classification of the vegetation reinforces the correlation between habitat and communities (Figure 3).

The plant communities recognized in the study area can be classified as follows:

1 Alloteropsido semialatae - Rendlietea alterae representing relatively high altitude hygrophilous grasslands, excluding relatively dry drainage lines on dolomite and shales (but includes wet drainage lines on shallow soils).

1.1 Helichryso pilosellum - Festucetalia costatae of relatively high altitude hygrophilous grasslands, excluding all drainage lines or seepage areas.

1.1.1 Crassulo vaginatae - Festucion costatae representing relatively high altitude hygrophilous grassland on various geological formations.

1.1.1.1 Festuco costatae - Proteetum gaguedi, representing a short shrubveld of steep rocky south-easterly facing slopes on various geological formations.

1.1.1.2 Eulalio villosae - Festucetum costatae representing grassland of not-rocky flat areas of high altitude peaks.

1.1.1.3 Gnidio kraussianae - Festucetum costatae, a grassland on gentle north-westerly, not-rocky slopes, predominantly on shale.

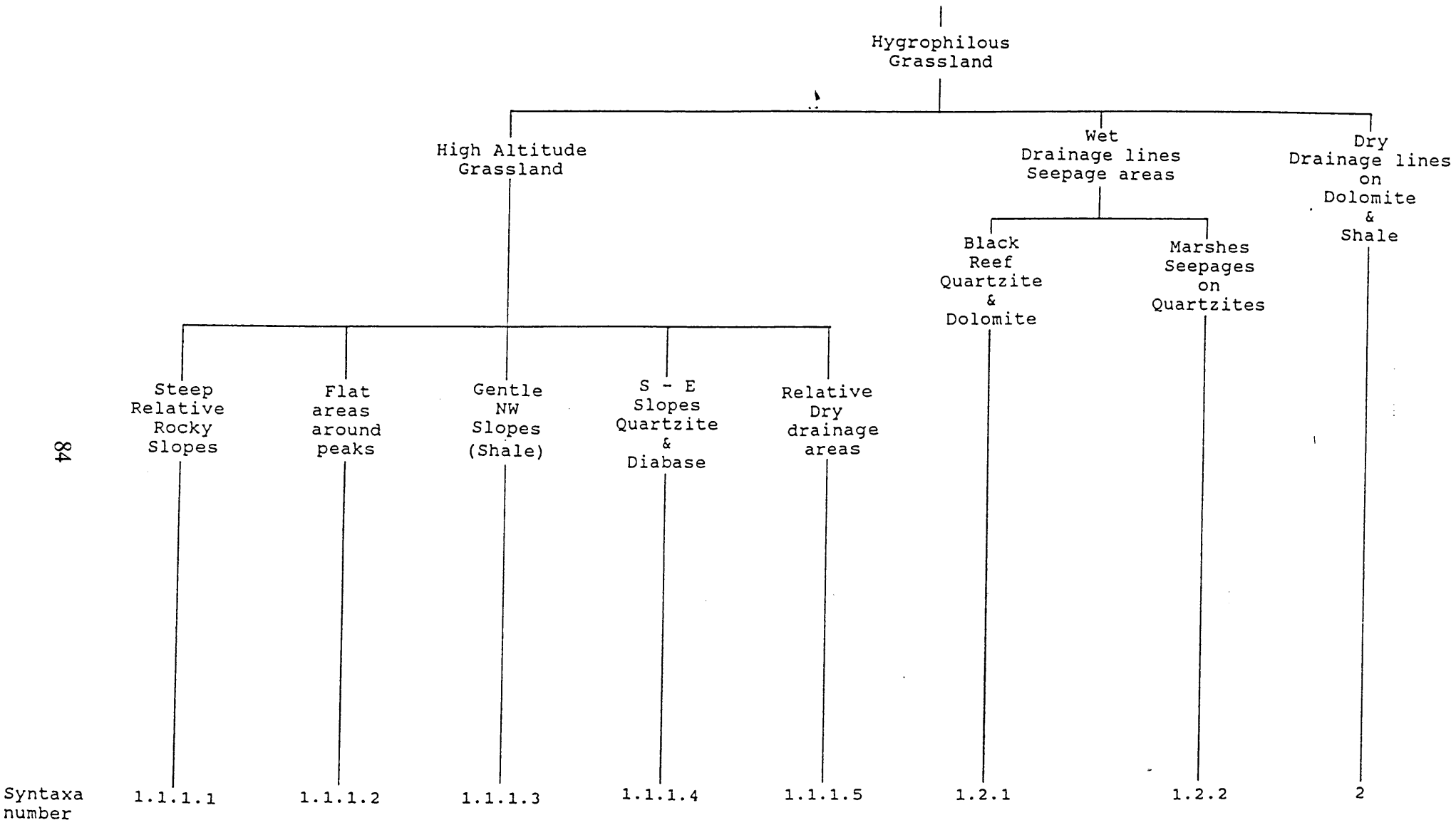


Figure 2. Dendrogram to illustrate the habitat relationships of the syntaxa. (See text for explanation of the syntaxa).

1.1.1.4 Satyrio longicaudae - Festucetum costatae, grassland on high altitude south to easterly facing areas on quartzite and diabase.

1.1.1.5 Aristida junciformis - Festuca costata, grassland of relatively dry drainage lines of high altitude, northerly facing slopes.

1.2 Helichryso aureonitentis - Monopsion decipientis of wet drainage lines on shallow soils.

1.2.1 Helichryso aureonitentis - Sopubietum canae, a marsh of drainage lines and seepage areas on the Black Reef formation as well as on dolomite.

1.2.2 Helichryso aureonitentis - Stiburetum alopecuroidis representing marshes or drainage lines on quartzites.

2 Phymaspermo acerosi - Eragrostidetum curvulae of dry drainage lines on deep soils on dolomite and shale.

Description of the communities.

1 Alloteropsido semialatae - Rendlietea alterae Class nov.

Type relevé : 114

These are moist grasslands found predominantly at altitudes of 1 600 m to over 2 000 m and exclude the drainage and seepage areas with no visible surface water which occur on the dolomite and some areas with shales.

This community is characterized by species group K (Table 2). The diagnostic species are mostly grasses such as the dominant Rendlia altera, characteristic of shallow soils, Eragrostis racemosa, Diheteropogon filifolius, Monocymbium ceresiiforme, Tristachya leucothrix and Panicum ecklonii and the forbs Commelina africana, Selago hyssopifolia, Vernonia hirsuta and Becium obovatum. An average of 22 species was recorded per relevé (Table 2).

1.1 Helichryso pilosellum - Festucetalia costatae Order Nov. (Photo 2)

Type relevé : 114

These are moist grasslands found on plateaux and slopes at the relatively high altitudes of 1 600 m to over 2 000 m, and exclude all the seepage areas and drainage lines. This order is found on various geological formations, although it is scarce on dolomite.

This syntaxon is characterized by species group G (Table 2). The diagnostic species are the grasses Festuca costata, Trachypogon spicatus, Loudetia sp. nov. and the forbs Helichrysum pilosellum, Alepidea gracilis var. major, Vernonia natalensis, Helichrysum cephaloideum, Helichrysum platypterum, Clutia monticola, Aeschynomene nodulosa var. nodulosa and Oxalis obliquifolia. An average of 24 species was recorded per relevé (Table 2).

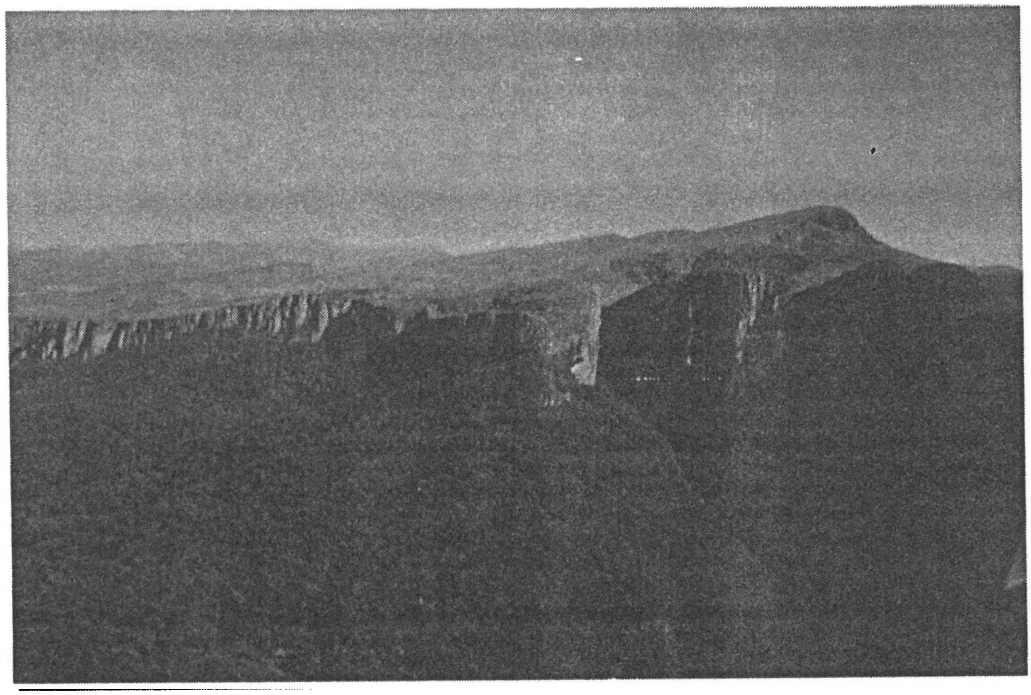


Photo 2. The flat plateaux habitat of the Eulalio villosae - Festucetum costatae, on Serala mountain (2 050 m). Note the natural forest surrounding the mountain.

Within this order two alliances, four associations and one community without syntaxonomic rank, were identified.

1.1.1 Crassulo vaginatae - Festucion costatae Alliance. nov.

Type relevé : 119

These are moist grasslands found at altitudes of 1 600 m to over 2 000 m. This alliance is found on various geological formations.

This alliance is characterized by species group F (Table 2). There are no diagnostic grass species but one sedge species Cyperus obtusiflorus, while the diagnostic forbs species are Wahlenbergia squamifolia, Haplocarpha scaposa, the small succulent Crassula vaginata subsp. vaginata and the geophyte Scilla nervosa. An average of 26 species was recorded per relevé (Table 2).

Within this alliance five associations were identified.

1.1.1.1 Festuco costatae - Proteetum gaguedi Ass. nov.

Type relevé : 147

This is a short shrubveld present on steep, 18 - 40°, southerly to south-easterly facing slopes. The localities are relatively rocky areas (5 - 20% rock cover) found scattered throughout the grasslands. This syntaxon is found on similar topographical positions on various geological formations.

This community is characterized by species group A (Table 2). The diagnostic species include the grass Sporobolus pectinatus, the sedge Tetraria natalensis and the shrubby Protea gaguedi and the semi-woody small shrub Tetraselago wilmsii. The diagnostic forbs are Helichrysum acutatum, Helichrysum adenocarpum subsp. adenocarpum, Helichrysum wilmsii (an endemic to the escarpment areas), Erica woodii, Schistostephium crataegifolium, Pimpinella transvaalensis, and the large fern Blechnum tabulare. An average of 27 species was recorded per relevé (Table 2).

No trees are found in this association. The shrub stratum is about 1.5m tall, with the most prominent species being Protea gaguedi and small semi-woody shrubs of Rabdosiella calycina and Tetraselago wilmsii.

The grass species, which dominate the vegetation include Rendlia altera, Festuca costata, Monocymbium ceresiiforme and Andropogon schirensis. Other prominent forbs are Alepidea gracilis var. major, Wahlenbergia squamifolia and Crassula vaginata subsp. vaginata.

1.1.1.2 Eulalio villosae - Festucetum costatae Ass. nov. (Photo 3)

Type relevé : 127

These moist grasslands are found on flat plateaux or terrace areas at altitudes of 1 600 m to over 2 000 m in association with mountain peaks or escarpment edges. This association is found on Black Reef quartzite as well as on dolomite, diabase and the Timeball Hill formation.

This syntaxon is characterized by species group B (Table 2). The diagnostic species are the grasses Eulalia villosa, Eragrostis sclerantha subsp. sclerantha, the diagnostic forb Senecio coronatus and the succulent Crassula alba var. parvisepala. An average of 23 species was recorded per relevé (Table 2).

No trees or shrubs are found in this association. The herbaceous layer is well developed, the dominant grass species include Rendlia altera, Festuca costata, Monocymbium ceresiiforme, Eragrostis racemosa and Diheteropogon filifolius. Other prominent forbs are Helichrysum pilosellum, Alepidea gracilis var. major and Pentanisia prunelloides which is common in places. The last species coming from species group D (Table 2), indicating that this community has some affinities with community 1.1.1.3.

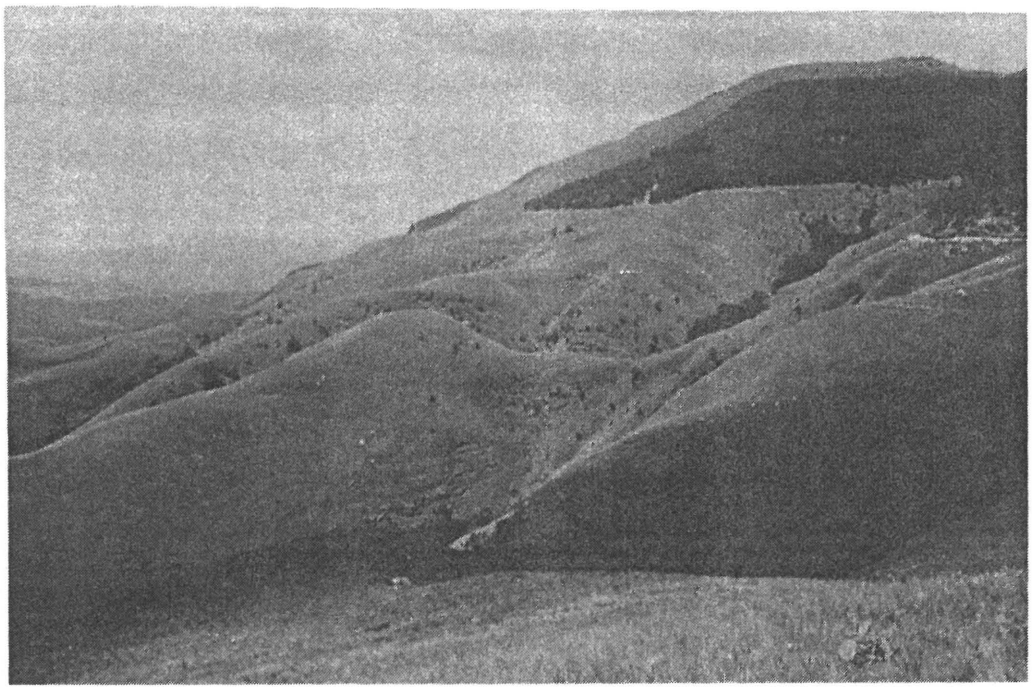


Photo 3. The Phymaspermo acerosi - Eragrostidetum curvulae, in the drainage lines and Helichryso pilosellum - Festucetalia costatae on the surrounding high grassland zones, in the Mauchberg peak area. Note the development of exotic plantations of Pinus sp.

1.1.1.3 Gnidio kraussianae - Festucetum costatae Ass. nov.

Type relevé : 12

These are grasslands found predominantly on northerly to north-westerly facing, gentle (2 - 10°) slopes, at altitudes of 1 600 m to 1 900 m. This association is found on various geological formations, although predominantly on shales, and it was never found to occur on dolomite. The habitat of this syntaxon shows signs of being slightly drier than the other associations of this alliance.

This syntaxon is characterized by species group C (Table 2). The diagnostic species are the grass Schizachyrium sanguineum and the forbs Gnidia kraussiana var. kraussiana, Eriosema angustifolium, Euphorbia striata var striata, Sebaea rehmannii, Stachys simplex, Vernonia natalensis, Helichrysum nudifolium, Indigofera sanguinea, Argyvolobium lancifolium, Polygala hottentotta, Rhynchosia monophylla and the shrub Protea caffra. The grass Alloteropsis semialata is characteristic of the Class Alloteropsido semialatae - Rendlietea alterae, but in this association it has the highest constancy. An average of 28 species was recorded per relevé (Table 2).

No trees or shrubs are found in this association. The herbaceous layer is well developed, with the dominant grass species including Rendlia altera, Festuca costata, Monocymbium ceresiiforme Diheteropogon filifolius, Eragrostis racemosa and Andropogon schirensis with Themeda triandra dominating locally. Other prominent forbs are Helichrysum pilosellum, Commelina africana and Eriosema ellipticifolium. The last species is from species group D (Table 2), showing that this community has affinities with community 1.1.1.2.

1.1.1.4. Satyrio longicaudae - Festucetum costatae Ass. nov.

Type relevé : 114

These are moist grasslands at the highest altitudes and are predominantly found above 1 800 m. This association is found on southerly to easterly facing gentle to steep slopes on quartzite and diabase. These areas may be rocky although the rocks have a low cover (< 10%) value.

This syntaxon is characterized by species group E (Table 2). There are no diagnostic grass species but the sedge species Bulbostylis oritrephes subsp. australis, the orchid Satyrium longicauda, the forbs Monsonia glauca, Helichrysum glomeratum,

Helichrysum spiralepis, Aster lydenburgensis, Pearsonia obovata, Senecio oxyriifolius, Cyanotis speciosa, Sebaea sedoides var. confertiflora and Pearsonia sessilifolia subsp. sessilifolia, the ground creeper Rhynchosia villosa, the geophytes Hypoxis galpinii, Eucomis autumalis and the shrub Protea roupelliae(in areas of rock) are diagnostic taxa. An average of 24 species was recorded per relevé (Table 2).

No trees are found in this association but in rocky areas
1-2 m high shrubs of Protea roupelliae are present. The herbaceous layer is well developed, with the dominant grass species Rendlia altera, Festuca costata, Eragrostis racemosa, Alloteropsis semialata and Tristachya leucothrix. Other prominent forbs are Helichrysum pilosellum and Crassula vaginata subsp. vaginata.

1.1.1.5 Aristida junciformis - Festuca costata grassland community (no syntaxonomical rank).

These are moist grasslands which form seepage lines with no visible surface water, or which borders wetter runoff areas. The community occurs at altitudes of 1 600 m to over 1 800 m and is not found on dolomite.

This community is characterized by the absence of species groups A - F (Table 2). There are no diagnostic species but the grasses Aristida junciformis and Themeda triandra do have high constancy values. An average of 19 species was recorded per relevé (Table 2).

Although this community can clearly be distinguished in the field, it's syntaxonomic status is unclear due to a lack of diagnostic species. However, it is classified under the Crassula vaginatae - Festucion costatae. Further investigation should clarify the syntaxonomic status of this community.

1.2 Helichryso aureonitentis - Monopsion decipientis All. nov.
Type relevé : 90

These are very wet grasslands which occur in drainage lines and seepage areas. This vegetation is found on various geological formations.

This syntaxon is characterized by species group J (Table 2). The diagnostic grass species are Aristida junciformis and Loudetia simplex and the diagnostic forbs Helichrysum aureonitens, Monopsis decipiens, Xyris nivea and Helichrysum

mariepscopicum an endemic species of the escarpment. It must be noted however that the grass species Rendlia altera which is common throughout the associations discussed before, is scarce in this alliance. An average of 17 species was recorded per relevé (Table 2).

Within this alliance two associations were identified.

1.2.1 Helichryso aureonitentis - Sopubietum canae Ass. nov.

Type relevé : 90

This association occurs in wet seepage lines, marsh areas on the Black Reef formation and on dolomite. It is also present at the relatively lower altitudes of 1 600m to 1 300m.

This syntaxon is characterized by species group H (Table 2). The diagnostic grass species is Microchloa caffra and the diagnostic forbs are Sopubia cana, Nidorella auriculata and Cephalaria pungens. An average of 19 species was recorded per relevé (Table 2).

No trees or shrubs are found in this association. The herbaceous layer is well developed, with the dominant grass species including Loudetia simplex, Diheteropogon filifolius and Monocymbium ceresiiforme. Other prominent forbs are Helichrysum aureonitens, Monopsis decipiens and Selago hyssopifolia.

1.2.2 Helichryso aureonitentis - Stiburetum alopecuroidis Ass. nov.

Type relevé : 117

This vegetation is restricted to wet seepage lines, marsh areas on quartzite and occurs on westerly and northerly facing slopes, at relatively high altitudes of 1 450 m to 1 900 m and is not present on dolomite.

This syntaxon is characterized by species group I (Table 2). The diagnostic grass species are Stiburus alopecuroides, Koeleria capensis the sedge Scirpus ficinioides and the forbs such as the insectivorous Drosera madagascariensis and an unidentified bryophyte. An average of 15 species was recorded per relevé (Table 2).

No trees or shrubs are found in this association. The herbaceous layer is well developed, with one grass species Loudetia simplex common in places. Other prominent forbs are Helichrysum aureonitens, Monopsis decipiens, Xyris nivea, Commelina africana

and Lobelia flaccida subsp. flaccida.

2 Phymaspermo acerosi - Eragrostidetum curvulae Ass. nov.

Type relevé : 161

This grassland community occurs on seepage lines with no visible surface water, and is found on the deeper soils derived from dolomite as well as shale. It occurs at altitudes of 1 600 m to 1 750 m.

This community is characterized by species group L (Table 2). The diagnostic grass species are Eragrostis curvula, Cymbopogon validus and the diagnostic forbs Phymaspermum acerosum, Vernonia oligocephala, Helichrysum umbraculigerum and an unidentified Selago sp. (Matthews 495). An average of 18 species was recorded per relevé (Table 2).

No trees are found in this association. The herbaceous layer is well developed, with the dominant grass species Alloteropsis semialata and Themeda triandra. One other prominent forb is Lobelia flaccida. The semi-woody shrub Rabdosiella calycina is also prominent.

Discussion

The aim of this study was to identify, characterize and interpret ecologically, by using habitat properties, the major vegetation units and their variations that occur in the North-eastern mountain sourveld of the Transvaal Escarpment. Since, ecologically interpretable plant communities were distinguished, the general descriptions and proposed classification can be used for further vegetation studies as well as for land-use planning and management.

One class, one order, two alliances, seven associations and one community without syntaxa rank are newly described. This classification contributes to the knowledge of the syntaxonomy of South Africa grassland communities.

Acknowledgements

This research was partially supported by the Foundation for Research Development.

References

Acocks, J.P.H. 1988. Veld Types of South Africa. Mem. bot. Surv. S. Afr. 40: 1-128.

Behr, C.M. & Bredenkamp, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanic Garden. S. Afr. J. Bot. 54: 525-533.

Bredenkamp, G.J., Joubert, A.F. & Bezuidenhout, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. S. Afr. J. Bot. 55: 199-206.

Deall, G.B., Theron, G.K. & Westfall, R.H. 1989. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 2. Floristic classification. Bothalia 19: 69-89.

Deall, G.B., Scheepers, J.C. & Schutz, C.J. 1989. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. Bothalia 19: 53-67.

Deall, G.B. 1985. A plant-ecological study of the Eastern Transvaal Escarpment in the Sabie area. M.Sc. Thesis, University of Pretoria, Pretoria.

Erasmus. J.F. 1987. Rainfall Deciles for Transvaal Region. Department of Agriculture and Water supply.

Fabricius, A.F. 1969. In Schutte, J.M. 1971. Die onttreking van water uit die newellaag en lae wolke by Mariepskop. S.A Department of water Affairs, Division Hydrological Research, Technical note 20: 1-21.

Fabricius, A.F. 1988. Klimageographie-Sudafrika (Moqambique, Swaziland, Republik Sudafrika). Africa-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

Geological Survey. 1986. Geology map 1:250 000 geological series. 2430 Pilgrim's Rest. Government Printer, Pretoria.

Gibbs-Russell, G.E., Welman, W.G., Retief, E.,Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M., Nicoholas, A., De Wet, C., Mogford, J.C. & Mulvena, J. 1987. List of species of southern African plants. 2nd edn, Part 2, Mem. bot. Surv. S. Afr. 56: 1-270.

Gibbs-Russell, G.E., Watson, L.,Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M.P. & Dallwitz, M.J. 1990. Grasses of Southern Africa. Mem. bot. Surv. S. Afr. 58: 1-437.

Gibbs-Russell, G.E., Reid, C., Van Rooy, J & Smook, L. 1985. List of species of southern African plants. 2nd edn, Part 1, Mem. bot. Surv. S. Afr. 51: 1-152.

Hill, M.O. 1979. TWINSPAN. A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University. Ithaca, New York.

Land Type Survey Staff. 1989. Land types of the maps 2330 Tzaneen and 2430 Pilgrim's Rest. Mem. agric. nat. Resour. S. Afr. No. 12.

MacVicar, C.N. & co-workers (1977): Soil classification - A binomial system for South Africa. -Dept. Agriculture-technical services, Pretoria.

Matthews, W.S., Bredenkamp, G.J. & van Rooyen, N. 1991a. The grassland associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the Transvaal Escarpment. S. Afr. J. Bot. (in press).

Matthews, W.S., Bredenkamp, G.J. & van Rooyen, N. 1991b. The vegetation of the dry dolomitic regions of the North-eastern mountain sourveld of the Transvaal Escarpment, South Africa. Phytocoenologia (in press).

Matthews, W.S. (In prep.). The vegetation of the North-eastern mountain sourveld of the Transvaal Escarpment. M.Sc. Thesis, University of Pretoria, Pretoria.

Mentis, M.T. & Huntley, B.J. 1982. A description of the Grassland Biome Project. S. Afr. Nat. Sci. Prog. Report No. 62, CSIR, Pretoria.

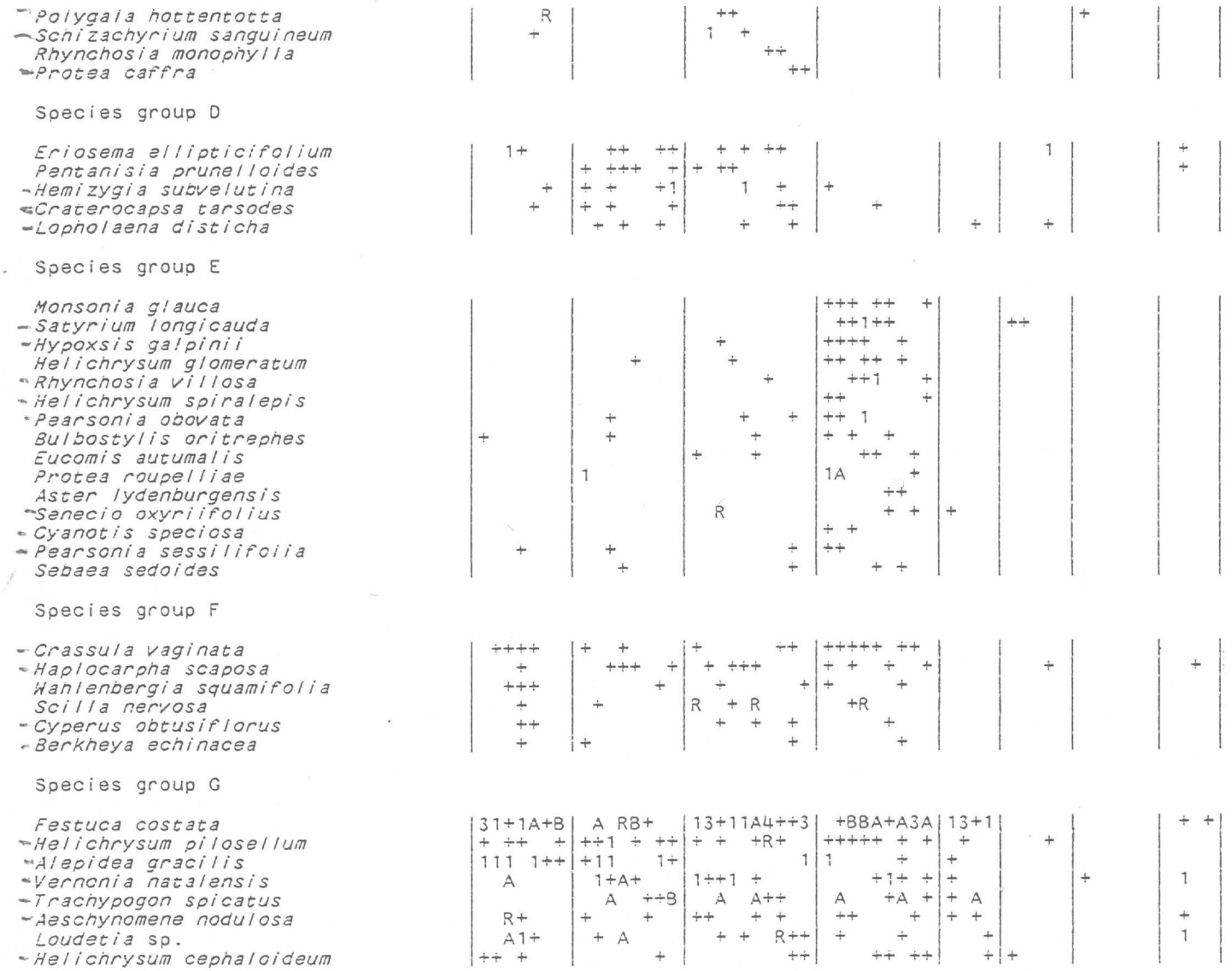
Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation Ecology. John Wiley & Sons, New York.

Scheepers, J.C. 1978. Vegetation of Westfalia Estate on the North-Eastern Transvaal Escarpment. Mem. bot. Surv. S. Afr. 42: 1-230

Scheepers, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR, Pretoria.

Table 2. A phytosociological table of the vegetation of the high altitude hygrophilous regions and associated areas of the North-eastern mountain sourveld of the Transvaal.

Community numbers	1							2
	1.1					1.2		
	1.1.1					1.2.1	1.2.2	
	1.1.1.1	1.1.1.2	1.1.1.3	1.1.1.4	1.1.1.5			
Relevè numbers	1111111 5456459 6780473	11111110 72056672 57094709	1000010000 2115111400 0269993127	111110110 111119073 314289161	1000 2496 1080	00010 99999 02607	011011 111290 576068	1101 6524 1068
Species per relevè	2242221 9515476	22321212 95106184	3232432231 0516204817	222222212 955061584	2111 7596	12121 75474	111211 925032	1228 1308
Species group A								
Helichrysum acutatum	+++++ +	+	+	+ +				++
Protea gaguedi	+1AR	+	+	A				
Helichrysum adenocarpum	++++		R		+	+	+	
Erica woodii	R+ ++		+					
Schistostephium crataegifolium	++ +			+	+	+		+ +
Tetraria natalensis	11+		R+					+
Pimpinella transvaaiensis	+++			+				+
Helichrysum wilmsii	+ A		1					+
Tetraselago wilmsii	+ +	+		+			1	
Blechnum tabulare	+ +							+
Sporobolus pectinatus	+ +		+	+			1	
Species group B								
Eulalia villosa		1+R						
Senecio coronatus	+	++						
Eragrostis sclerantha		+ R					A	
Crassula alba	+	RR					+ +	
Species group C								
Gnidia kraussiana	+		+++ +					
Eriosema angustifolium			+ + + +	+	+			
Euphorbia striata			++ +		+		1	
Sebaea rehmannii			R + +	+				
Stachys simplex		+	+ + +					
Helichrysum nudifolium	+		+ + +					+
Helichrysum sp.		+	++ +			+		
Indigofera sanguinea		1	+ +					
Argyrolobium lancifolium			+ +					



Helichrysum platypterum	++ +	A++	+ + +	+	+			R
Clutia monticola	+ +		++ R +	++	+			
Oxalis obliquifolia	++	+	+ +	++	+		+	
Species Group H								
Sopubia cana	++1 +	+	+	+		+++1	+	
Microchloa caffra	+A A				1	BA+1		
Nidorella auriculata	1				+	+ 1 +		+
Cephalaria pungens		+	+ +	+	+	++	+	
Species group I								
Stiburus alopecuroides		+	+ +		A	+	+1A11	++
Drosera madagascariensis	+		+				+ +	
Bryophyta sp.							+ +	
Scirpus ficinioides					+		1 +	
Koeleria capensis			3				5	
Species group J								
Helichrysum aureonitens	+		1	+ +	+	1+++	++A R+	
Monopsis decipiens			+ +1	+ +	+	+++ +	R B+++	
Loudetia simplex		+	+ +R			11+ +	33	
Aristida junciformis	+		+		+ +A	+ 1	3+	
Xyris nivea	+				+	++	++ +	
Helichrysum mariepscopicum						++	+ +	
Species group K	7	8	10	a	4	5	6	4
Rendlia altera	+ ++ 3	1+ +B1B+	A4BABA3+	1 A++A 1B	4	A1	3	
Eragrostis racemosa	A++ +	A+ A +1+	+++ A+	+1+ +1 +	++	+ 1	+ +	
Monocynbium ceresiiforme	R++R+ 1	++ 3 +	+ ++ A++	++ R	+	AA	++	
Diheteropogon filifolius	+ +	1++ +1A	+ 1++1 +	+1+ +	+	A+ +	+	
Commelina africana	+1	+	++R++ +	++	+ +	+	R+1	
Selago hyssopifolia	+ + +	+ +	+ +	+		++ +		
Tristachya leucothrix	+	+	+	++ + +		+	+	
Becium obovatum			++			+	+	
Vernonia hirsuta	+		++	+	+		R	
Panicum ecklonii	A +	+ +		1		1		
Species group L								
Eragrostis curvula			+		+	+ A	+	AABB
Phymaspermum acerosum		+	+		++	1		3BB+
Selago sp.	+		+					++A
Vernonia oligocephala						+		A+
Cymbopogon validus								A +
Helichrysum umbraculigerum	+							B 1

Species group M

	7	8	10	9	4	5	6	4
Alloteropsis semi-alata	+	1 +1	++++A 1R1+	1 1+ 11	+	+ +	1 +	+++
Andropogon schirensis	+11+A	+ +	+++ +++ 3+	A		+	+ +	+
Lobelia flaccida	+		1+ ++	+++ +	++		+ ++	+++
Themeda triandra	+R	R	+BA+	1A	1 13	B +		++R
Rabdosiella calycina	++ 1	+ ++	+	++	1			+ ++
Acalypha angustata	+ +	+ +	+ + +	+ +1+	+			++
Cyphia stenopetala		+	+R +	++ +				+
Acalypha sp.	++ +		B + +		+		1	+A

The phytosociology and syntaxonomy of the relatively low altitude vegetation regions of the North-eastern mountain sourveld of the Eastern Transvaal Escarpment.

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Submitted for publication in Bothalia

Abstract

An analysis of the vegetation of the relatively low altitude regions of the North-eastern Mountain Sourveld of the Eastern Transvaal Escarpment is presented. Relevés were compiled in 53 stratified random sample plots. A TWINSPAN - classification, refined by Braun - Blanquet procedures revealed seven plant communities, which can be classified under three major vegetatation units, although of different syntaxonomic rank. All communities are related to specific environmental conditions. Formal syntaxonomical descriptions of the communities are given.

Uittreksel

'n Analise van die plantegroei van die relatiewe laagliggende gebiede van die Noord-oostelike Bergsuurveld van die Oos-Transvaalse platorand, word aangebied. Relevés is in 53 gestratifieerd ewekansige monsterpersele saamgestel. 'n TWINSPAN - klassifikasie, verfyn deur die Braun - Blanquet prosedures, toon drie plantegroeitipes', wat in sewe plantgemeenskappe onderverdeel kan word alhoewel verskille in syntaksonomiese rang voorkom. Die geïdentifiseerde plantgemeenskappe kan verklaar word aan die hand van spesifieke omgewingsfaktore. Die plantgemeenskappe word formeel syntaksonomies beskryf.

Keywords: Braun-Blanquet procedure, Grassland Biome, syntaxonomical classification

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Introduction

Land in the Eastern Transvaal Escarpment, represented by Acocks's (1988) North-eastern mountain sourveld (veld type 8), is in great demand for afforestation (cf. photo 1). As stated by Deall et al. (1989a) this is in direct conflict with the need to protect mountain catchments, to conserve natural ecosystems and to preserve scenic landscapes for the tourist industry. Rational land-use planning is required to resolve such conflict (Ferrar et al. 1988). A plant ecological study could contribute to this land-use planning exercise, as the relationship between plant-ecological studies and land-use planning and management has often been demonstrated (Bayer 1970; Walker 1976; Van Rooyen et al. 1981; Moore & Chapman 1986).

Furthermore, Mentis & Huntley (1982) stated the necessity to identify, describe and determine the location of the major vegetation types and subtypes within the Grassland Biome. This was also emphasized by Scheepers (1987). One of the goals of the former vegetation classification and mapping task group of the Botanical Research Institute, (now part of the Grassland Research Centre of the Department of Agricultural Development) is the production of a vegetation classification on a national basis (Scheepers 1986). A vegetation classification of the North-eastern mountain sourveld would contribute to this national goal.

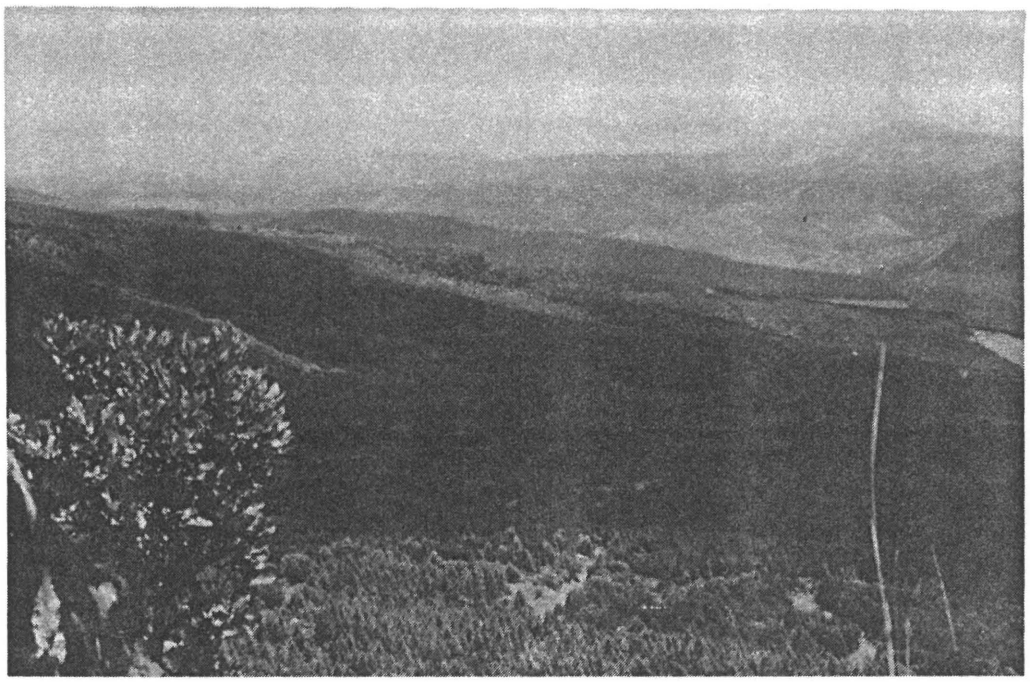


Photo 1. The extent of afforestation in some areas of the Transvaal escarpment, natural grassland all but a relict.

Within this area Deall (1985) and Deall et al. (1989b) described the vegetation of a narrow transect of the escarpment, in the Sabie area, while Matthews et al. (1991 a, b & c) described the communities associated with Black Reef quartzite rock outcrops, the relatively drier dolomitic regions and those of the high altitudes of the escarpment. In this paper the vegetation of the relatively low eltitudes is described. The above studies together with other studies in the Grassland Biome eg. Deall (1985), Bezuidenhout (1988), Bloem (1988), Bredenkamp et al. (1989), Turner (1989), Shackleton (1989), Bezuidenhout & Bredenkamp (1990 & 1991), Kooij (1990) and Du Preez & Bredenkamp (1991) should provide adequate knowledge of the grassland vegetation to compile a formal syntaxonomy of the plant communities identified in this study.

The study area

The location of the study area is shown in Figure 1. This area of Transvaal is very mountainous and much of the area is undeveloped, with those areas which are developed (mainly by forestry) found in a central area namely around Sabie, Pilgrim's Rest and Graskop. The very nature of this area makes most of it inaccessible to ordinary vehicles and many areas can only be reached by long treks on foot or by the use of specialized vehicles. The undeveloped nature of these areas has also resulted in a shortage of certain environmental data such as a rainfall and temperature figures due to the lack of weather stations.

A detailed description of the physical environment of the area is given by Matthews (in prep). The main rock types found in the study area are quartzite, dolomite and shales. The area that is of concern here are the relatively low-lying zones of the study area (below 1 600m). They encompass most of the geological formations.

Soils of these areas are varied as a result of the varied geology and topography, but are mostly of the shallow Hutton form (Land Type Survey Staff 1989), found on the plateaux and the valley sides. The rock outcrops and many of the valley sides have shallow lithosols, with the dominant soil forms being Mispah and Glenrosa.

The climate of the Eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool dry winters (Fabricius 1988). Rainfall data for specific stations relevant to the habitats discussed in this paper are given in

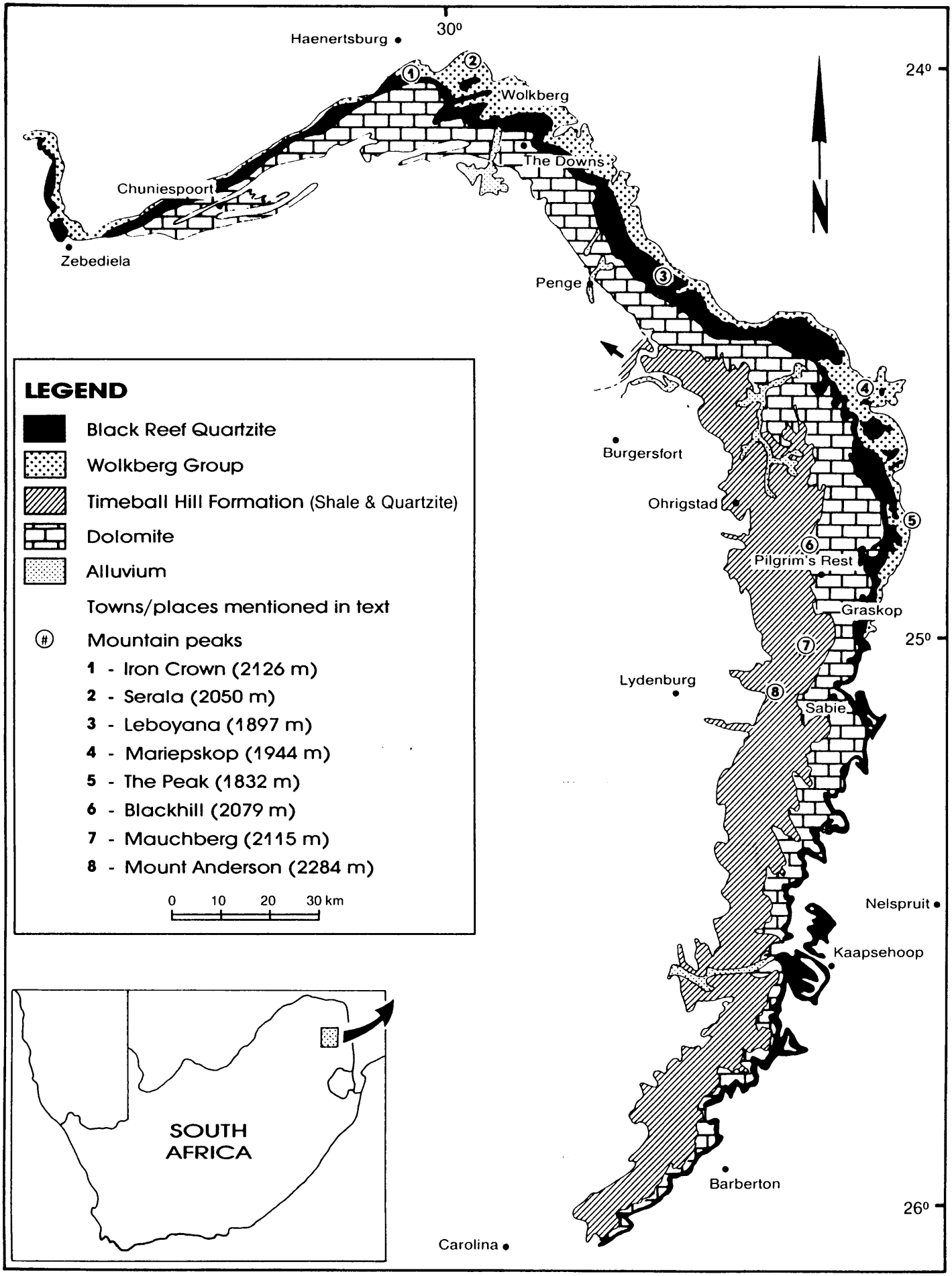


Figure 1. Map showing the locality of the study area, simplified geology and position of major mountain peaks (After the 1:1 000 000 Geological Map of South Africa, 1984, Geological Survey, Dept. of Mineral & Energy Affairs, Pretoria).

Table 1. Characteristic of the escarpment is the occurrence of mist in the so called mist belt and in these areas under discussion the mist having a effect.

Table 1. Mean annual and absolute maximum and minimum rainfall for relevant weather stations of the Eastern Transvaal Escarpment.*

Stations Grid	Altit. (m)	Period (Yrs)	Annual Rainfall (mm)		
			Min	Max	Mean
1. Lisbon F.S 24°53'S 30°51'E	1402	21	1000	2354	1579
2. Mac Mac F.S 24°59'S 30°49'E	1360	59	814	2331	1515
3. Graskop 24°56'S 30°51'E	1487	24	708	1821	1321
4. Blyde F.S 24°50'S 30°50'E	1433	49	314	1931	1130
5. The Downs 24°08'S 30°11'E	1350	56	524	1701	948
6. Clewer House 24°54'S 30°41'E	1750	21	543	1379	943
7.Pilgrim's Rest 24°55'S 30°46'E	1240	56	526	1502	938
8. Morgezon F.S. 24°53'S 30°43'E	1630	27	384	1162	800
9. Frankfort 24°49'S 30°45'E	1300	28	537	1094	777

* Compiled from Rainfall Deciles for Transvaal Region (Erasmus 1987).
F.S. - Forestry Station

Methods

Two hundred 100 m^2 sample plots (10 m x 10 m) were distributed in a stratified random manner throughout the main study area. The plots were as far as possible equally distributed in different physiographical - physiognomically homogenous units, distinguished on the basis of physiognomy, dominant species composition and abundance. This resulted in 53 sample plots being placed in the broad unit described as relatively low altitude vegetation. Sampling was carried out from January to May 1990. Taxa names conform to those of Gibbs-Russell et al. (1985, 1987).

The following were recorded for each sample plot:

1. The total floristic composition, as well as cover-abundance values for each species, was recorded by using the Braun-Blanquet cover-abundance scale as described by Mueller-Dombois & Ellenberg (1974).
2. Altitude, read from 1:50 000 topographical maps.
3. Gradient, with use of a clinometer.
4. Aspect, with use of a compass.
5. Rockiness, estimated as a percentage of the ground cover.
6. Size of rocks as follows: Large rock outcrops (>1 000 mm diameter), rocks (>300 - 1 000 mm diameter), small rocks (>50 - 300 mm diameter) and stones or gravel (≤50 mm diameter).
7. Topographical position based on terrain types, according to Land Type Survey Staff (1989) namely (1) crests, (2) scarp, (3) midslope, (4) footslope and (5) valley bottom or floodplain.
8. Geology, according to 1:250 000 geological survey maps (Geological Survey 1986) and locally at a smaller scale, personal observations in the field.
9. Land type according to 1:250 000 Land Type map, Land Type Survey Staff (1989).
10. Exposure, as exposed to sun, wind and mist, expressed as sheltered, partly sheltered or exposed.

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

Results and Discussion

Classification

The results are presented in a phytosociological table (Table 2). In general the vegetation of this area (see photo 2) can be described as grasslands found predominantly at altitudes of below 1 600 m, except for the hotter northern portions of the study area, where this vegetation type may also occur at relatively cooler, higher altitudes. The

geology is represented by various rock types. Most areas are relatively wet with a mean annual rainfall of > 800 mm (compare Table 1).

The grass species Eragrostis racemosa, Monocymbium ceresiiforme, Rendlia altera, Trachypogon spicatus, Diheteropogon filifolius and the forbs Aeschynomene nodulosa, Commelina africana, Haplocarpha scaposa, Helichrysum oreophilum, Dicoma anomala and Hypoxis galpinii are prominent and conspicuous species throughout this grassland (species group L, Table 2). The number of species recorded per relevé ranges from a minimum of 17 to a maximum of 46 with an average of 26 species per plot (Table 2).

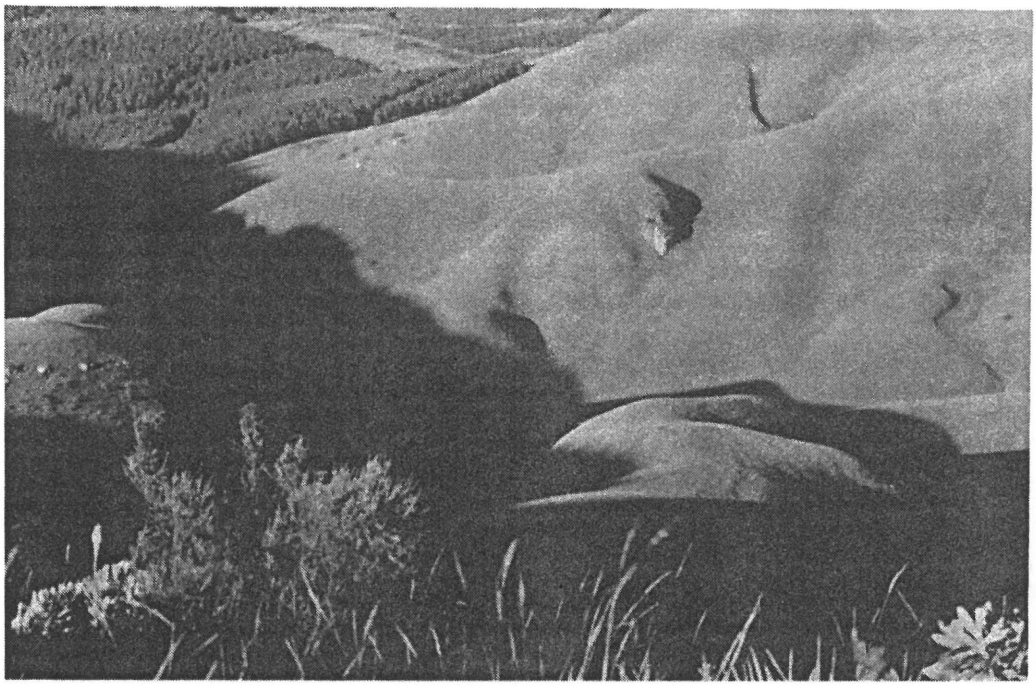


Photo 2. The heterogenous nature of the relatively low altitude grasslands which is described in the text (Note the complex topography).

Due to the complex and heterogeneous topography and the resultant climatic differences within this grassland, great variation in habitat exists, resulting in the presence of many different syntaxa.

The analysis resulted in the identification of seven plant communities. In a

hierarchical classification these communities are arranged into one class, one alliance, four associations, four subassociations and two variants. The first major plant community of the low altitude areas is the Loudetio simplico - Alloteropsidetea semialatae. The hierarchical classification of the vegetation also indicates a broad association between plant communities and habitat (Figure 2).

The plant communities recognized in the study area are classified as follows:

1 Loudetio simplicis - Alloteropsidetea semialatae, the vegetation of the relatively low altitude areas of the north-eastern mountain sourveld, including two syntaxa of somewhat higher altitude.

1.1 Indigofero sanguineae - Panicion natalensis, a grassland of relatively low altitude areas

1.1.1 Diheteropogono amplectentis - Proteetum gaguedi, a grassland community of relatively dry, rocky areas.

1.1.1.1 Diheteropogono amplectentis - Proteetum gaguedi - Hemizygietosum transvaalensis, a grassland of relatively lower altitude areas.

1.1.1.2 Diheteropogono amplectentis - Proteetum gaguedi - Fadogietosum tetraquetra, a grassland of relatively higher altitude areas.

1.1.2 Panico natalensis - Andropogonetum schirensis, a grassland of low altitude relatively wet areas.

1.1.2.1 Panico natalensis - Andropogonetum schirensis - Bulbostyletosum oritrephes, a grassland of wet, predominantly shale areas.

1.1.2.1.a Tetraselago wilmsii variant.

1.1.2.1.b Eriosema ellipticifolium variant.

1.1.2.2 Panico natalensis - Andropogonetum schirensis - Hypoxidetosum filiformis, a grassland of wet, predominantly dolomite areas.

1.2 Eragrostido scleranthae - Monocymbietum ceresiiformis, a grassland community of flat, not rocky, relatively high altitudes on Black Reef Quartzites.

1.3 Diheteropogono filifolii - Scilletum nervosae, a grassland community of relatively high altitudes on Timeball Hill Quartzites.

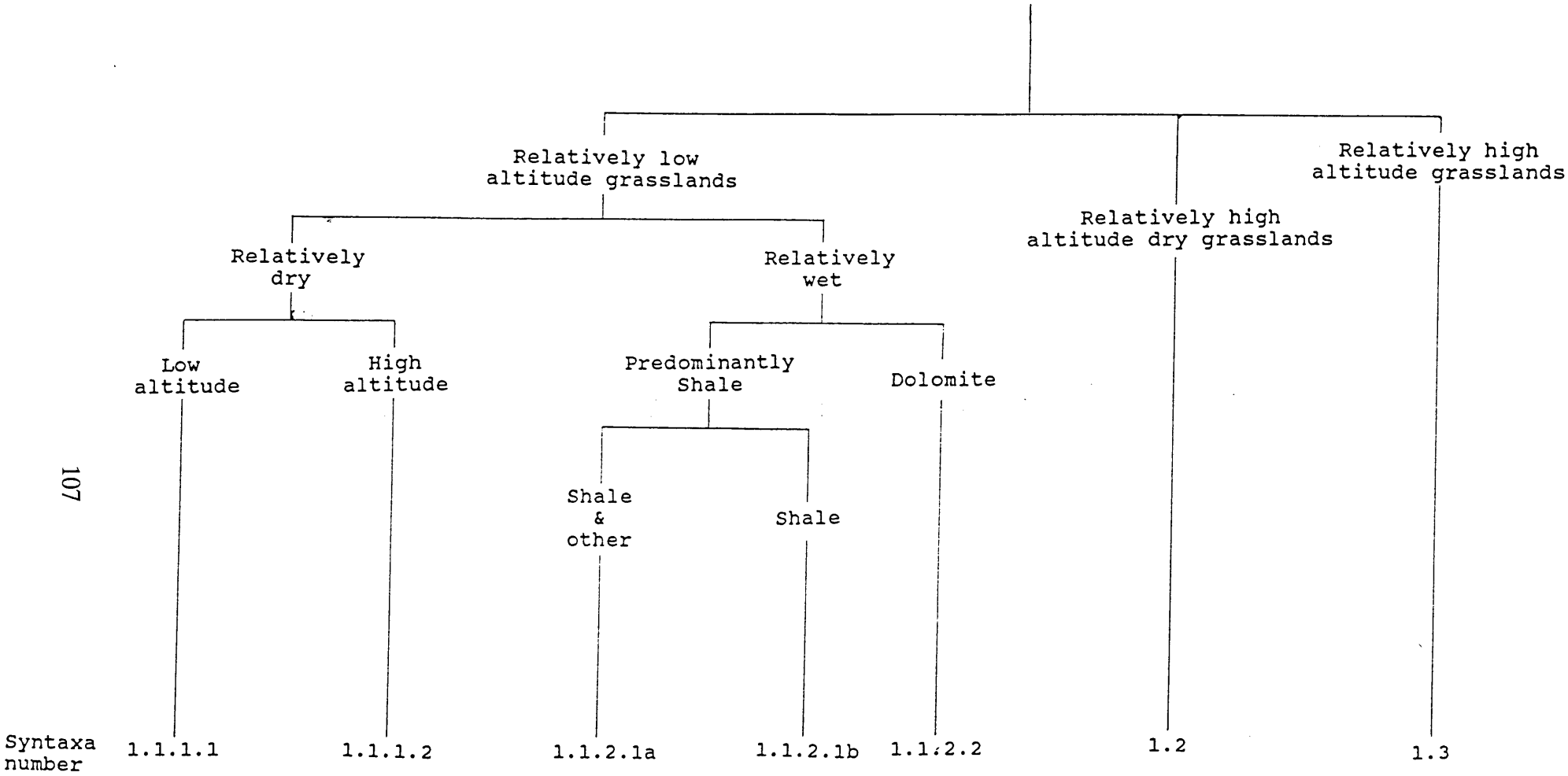


Figure 2. Dendrogram to illustrate the habitat relationships of the syntaxa. (See text for explanation of the syntaxa).

Description of the plant communities.

1. Loudetio simplicis - Alloteropsidetea semialatae Class nov.

Type relevé : 149

These are relatively lower altitude grasslands found predominantly at altitudes between 1 250 m and 1 600 m on various geological formations. Included here are also the higher (predominantly over 1 600 m) altitude relative dry grassland. Mean annual rainfall ranges from 777 to over a 1 000 mm (Table 2).

This vegetation unit is large and heterogeneous and is characterized by species group J (Table 2). The diagnostic species are Loudetia simplex which can be dominant, Alloteropsis semialata and Stiburus alopecuroides, the sedge Bulbostylis burchellii, the forbs Vernonia natalensis, Helichrysum pilosellum, Clutia monticola, Helichrysum aureonitens, Helichrysum acutatum, Acalypha angustata var. glabra and the semi-woody forb Rhus discolor. An average of 27 species was recorded per relevé (Table 2).

1.1 Indigofero sanguineae - Panicion natalensis Alliance Nov.

Type relevé : 149

These are relatively lower altitude grasslands found predominantly at altitudes between 1 250 m and 1 600 m on the various geological formations. Mean annual rainfall ranges from 777 to over a 1 000 mm (Table 2).

This alliance is characterized by species group H (Table 2). The diagnostic species are the grass species Panicum natalensis, Themeda triandra, Eulalia villosa and the forbs Indigofera sanguinea, Inezia integrifolia, Lopholaena disticha, Pearsonia sessilifolia subsp. sessilifolia and Alepidea gracilis var. major. An average of 27 species was recorded per relevé (Table 2).

Within this alliance two associations (1.1.1 and 1.1.2), each with two subassociations, and one subassociation with two variants were identified.

1.1.1 Diheteropogono amplectentis - Proteetum gaguedi Ass. Nov.

Type relevé : 105

This association is restricted to relatively dry areas (Table 1, Frankfort weather station) been found at low altitudes (1 250 m), as well as high altitudes (1 600 m), but

being dry. This association is restricted to relatively rocky (10 - 50% rock cover) slopes on the various geology formations of the study area but not on dolomite.

This assosiation is characterized by species group C (Table 2). The diagnostic species are the grass species Diheteropogon amplectens, Bewsia biflora, Tristachya leucothrix, the dwarf shrub Protea gaguedi and the forbs Pentanisia angustifolia, Helichrysum miconiifolium, Parinari capensis and Berkheya insignis. An average of 28 species was recorded per relevé (Table 2). Two subassociations were identified.

This vegetation unit shows affinities with the drier dolomite communities (Matthews et. al. 1991) of the study area for example the Hemizygio tranvaalensis - Loudetietum simplex, a grassland of valley sides and slopes.

1.1.1.1 Diheteropogono amplectentis - Proteetum gaguedi - Hemizygietosum transvaalensis Subass. Nov.

Type relevé : 105

This is the typical subassociation. These are relatively dry grasslands (Table 1, Frankfort weather station) been found at low altitudes (1 250 m). This vegetation unit is found on relative rocky (10 - 50% rock cover) slopes on the various geology formations of the study area but not on dolomite.

This community is characterized by species group A (Table 2). The diagnostic species are the grass species Cymbopogon validus, Hyparrhenia filipendula var. pilosa, Melinis repens subsp. repens, Setaria sphacelata var. torta and the woody forbs Hemizygia transvaalensis, Hermannia staurostemon, Geigeria elongata, Triumfetta welwitschii var. welwitschii, the forbs Thesium costatum var. costatum, Anthospermum pumilum subsp. pumilum, Zornia capensis, Senecio microglossum, Pygmaeothamnus zeyheri, the ground creeper Turbina oblongata and the geophyte Hypoxis rigidula var. rigidula. An average of 28 species was recorded per relevé (Table 2).

The 2 m high tree Faurea speciosa and 1,5 m high shrubs of Protea gaguedi are found in this subassociation. The herbaceous layer is well developed, the dominant grass species include Loudetia simplex, Diheteropogon amplectens, Bewsia biflora, Themeda triandra, Monocymbium ceresiiforme and Eragrostis racemosa. Other prominent forbs are Pentanisia angustifolia, Indigofera sanguinea and Aeschynomene nodulosa.

1.1.1.2 Diheteropogono amplectentis - Proteetum gaguedi - Fadogietosum tetraquetra Subass. Nov.

Type relevé : 42

These are relatively dry grasslands (Table 1, Morgenzon weather station) been found at relatively higher altitudes (1 600 m) than the Hemizygietosum transvaalensis. Although this community is associated with a relatively higher altitude, this is still predominantly lower as well as being drier than the high altitude communities described by Matthews et al. 1991. This subassociation is found on relative rocky (10 - 35% rock cover) slopes on the various geology formations of the study area but not on dolomite.

This community is characterized by species group B (Table 2).

There are no diagnostic grass species but there is one diagnostic sedge species Cyperus obtusiflorus. The diagnostic species are mostly woody forbs namely Fadogia tetraquetra, Indigofera atrata, Gnidia kraussiana var. kraussiana, Tenrhynea phylicifolia, Athrixia phylicoides, Vernonia centaureoides, Acalypha sp. and the geophyte Raphionacme galpinii. An average of 27 species was recorded per relevé (Table 2).

There are no prominent trees but for the 1,5 m high shrubs of Protea gaguedi to be found in this association. The herbaceous layer is well developed, the dominant grass species include Loudetia simplex, Diheteropogon amplectens, Panicum natalensis, Monocymbium ceresiiforme and Trachypogon spicatus. Other prominent forbs are Pentanisia angustifolia, Indigofera sanguinea and Aeschynomene nodulosa.

1.1.2 Panico natalensis - Andropogonetum schirensis Ass. Nov.

Type relevé : 9

These are relatively wetter grasslands (Table 1, Lisbon weather station) found at various altitudes. This association is found on relatively rocky (1 - 35% rock cover) slopes on the various geology formations of the study area but is scarce on the Timeball Hill Formations quartzites.

This association is characterized by species group G (Table 2). The diagnostic species are the grass species Andropogon schirensis, Ctenium concinnum, Loudetia sp. (Matthews no. 470), the forbs Selago hyssopifolia, Eriosema ellipticifolium, Cephalaria pungens, Sopubia cana and the small semi-woody shrub Phymaspermum acerosum. An average of 27 species was recorded per relevé (Table 2). Two subassociations were

identified:

1.1.2.1 Panico natalensis - Andropogonetum schirensis - Bulbostyletosum oritrephes Subass. Nov.

Type relevé : 9

This subassociation is found on flattish areas on the various geology formations of the study area but found predominantly on shale.

This subassociation is characterized by species group E (Table 2). The diagnostic species being found in this subassociation are the grass species Koeleria capensis, the sedge species Bulbostylis oritrephes subsp. australis and Kyllinga alba, the 1 m high shrubs of Protea caffra, the small scanty shrubs of Erica caffrorum var. caffrorum, the forbs Pentanisia prunelloides, Gnidia capitata, Senecio erubescens and Vernonia hirsuta. An average of 30 species was recorded per relevé (Table 2).

With the exception of Protea caffra there are no prominent trees or shrubs found in this subassociation. The herbaceous layer is well developed, the dominant grass species include Andropogon schirensis, Loudetia sp. (Matthews no. 470), Ctenium concinnum, Loudetia simplex, Monocymbium ceresiiforme, Eragrostis racemosa, Trachypogon spicatus, Rendlia altera, Diheteropogon filifolius and Panicum natalensis has its highest constancy in this subassociation. Other prominent forbs are Eriosema ellipticifolium, Indigofera sanguinea and Aeschynomene nodulosa.

1.1.2.1.a Tetraselago wilmsii variant.

This variant is found on slopes and flattish areas of predominantly shale but also found on Black Reef quartzite and dolomite.

This community is characterized by species group D (Table 2).

The diagnostic species are the grass species Schizachyrium sanguineum, Melinis nerviglume, the small semi-woody shrubs Tetraselago wilmsii, Rhus tumulicola the forbs Acalypha sp., Pearsonia obovata and Wahlenbergia krebsii subsp. krebsii. An average of 34 species was recorded per relevé (Table 2).

1.1.2.1.b Eriosema ellipticifolium variant.

This variant is found on flattish areas of shale. This community is characterized

by the absence of species group D (Table 2). There are no diagnostics species for this variant although Eriosema ellipticifolium has a high constancy in this variant. An average of 25 species was recorded per relevé (Table 2).

1.1.2.2 Panico natalensis - Andropogonetum schirensis - Hypoxidetosum filiformis Subass. Nov.

Type relevé : 149

These are relatively wetter grasslands found at various altitudes. This subassociation is found on slopes and flattish areas with the lowest rock cover (0 - 10% rock cover) on various geology formations but predominantly on dolomite.

This subassociation is characterized by species group F (Table 2). The diagnostic species are the grass species Microchloa caffra, the small woody forb Erica woodii, the forbs Oxalis obliquifolia, Craterocapsa tarsodes and the small geophyte Hypoxis filiformis. An average of 23 species was recorded per relevé (Table 2).

There are no prominent trees or shrubs present in this subassociation. The herbaceous layer is well developed, the dominant grass species include Andropogon schirensis, Loudetia sp., Panicum natalensis, Eulalia villosa, Alloteropsis semialata, Loudetia simplex, Monocymbium ceresiiforme, Eragrostis racemosa, Trachypogon spicatus and Rendlia altera. Other prominent forbs are Selago hyssopifolia, Indigofera sanguinea and Haplocarpha scaposa.

1.2 Eragrostido scleranthae - Monocymbietum ceresiiformis Ass. nov.

Type relevé : 187

These are moderately wet grasslands (Table 1, Graskop weather station) being found at relatively high altitudes (between 1 500 m and 1 850 m). Although this community is associated with a relatively higher altitude, this is still predominantly lower than the high altitude communities described by Matthews et al. (1991). This association is found on relative flat relatively not-rocky (1 - 10% rock cover) areas of the various geology of the study area although predominantly on the Black Reef quartzite formation, but not on the Timeball Hill formation.

This association is characterized by species group I (Table 2). The diagnostic species are the grass species Eragrostis sclerantha, the forbs Berkheya echinacea subsp.

echinacea, Eriosema angustifolium, Schistostephium crataegifolium, Clerodendrum glabrum, Wahlenbergia squamifolia, Euryops pedunculatus and the ground creeper Rhynchosia monophylla. An average of 22 species was recorded per relevé (Table 2).

There are no prominent trees or shrubs present in this association. The herbaceous layer is well developed, the dominant grass species include Loudetia simplex, Alloteropsis semialata, Eragrostis racemosa, Rendlia altera and Monocymbium ceresiiforme, which in this community has high cover values. Another prominent forb is Aeschynomene nodulosa.

1.3 Diheteropogono filifolii - Scilletum nervosae Ass. nov.

Type relevé : 110

These are moderately wet grasslands (Table 1, Clewer House weather station) been found at relatively high altitudes (1 850 m), although in the north are found at lower altitudes. Although this community is associated with a relatively higher altitude, this is still predominantly lower as well as being drier than the high altitude communities described by Matthews et al. (1991). This association is found on relative flat areas which can be rocky (0 - 20% rock cover) of quartzites of the Timeball Hill Formation, although in the northern areas of the study area (see photo 3) it is found on the Wolkberg Group.

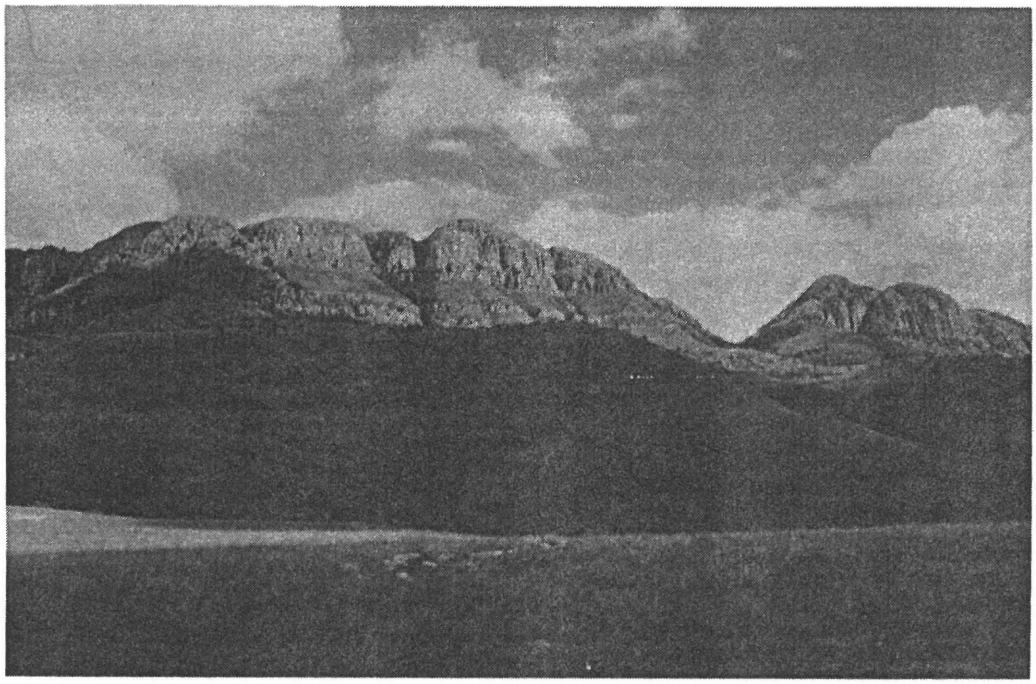


Photo 3. The habitat of the Diheteropogono filifolii - Scilletum nervosae Ass. nov. in the northern areas of the escarpment on the Wolkberg group.

This community is characterized by species group K (Table 2). The diagnostic species are one grass species Sporobolus pectinatus, the fern Pteridium aquilinum, the forbs Senecio venosus, Cyanotis speciosa, Hermannia lancifolia and the geophyte Scilla nervosa. In the northern parts of the study area Gnidia caffra and Helichrysum cephaloideum are diagnostic. An average of 25 species was recorded per relevé (Table 2).

There are no prominent trees or shrubs present in this association. The herbaceous layer is well developed, the dominant grass species include Eragrostis racemosa, Diheteropogon filifolius, Monocymbium ceresiiforme and Trachypogon spicatus. Other prominent forbs are Aeschynomene nodulosa and Commelina africana.

Concluding Remarks

The aim of this study was to identify, characterize and interpret ecologically, by using habitat properties, the major vegetation units and their variations that occur in the North-eastern mountain sourveld of the Eastern Transvaal Escarpment. Since, ecologically interpretable plant communities were distinguished, the general descriptions and proposed classification can be used for land-use planning and management. This is of special interest for the allocation of land for afforestation, due to these areas being the main areas used for afforestation.

One Class, one alliance, four associations, four subassociations and two variants are newly described. This classification contributes to the syntaxonomy of South Africa grassland communities.

Acknowledgements

This research was partially supported by the Foundation for Research Development. The University of Pretoria is thanked for the use of it's facilities.

References

ACOCKS, J.P.H. 1988. Veld Types of South Africa. Mem. bot. Surv. S. Afr. 40: 1-128.

BAYER, A.W. 1970. Plant ecology in the service of man in southern Africa. S. Afr. J. Sci. 66: 71-77.

BEHR, C.M. & BREDENKAMP, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. S. Afr. J. Bot. 54: 525-533.

BEZUIDENHOUT, H. 1988. 'n Plantsosiologiese studie van die Mooirivier opvangs gebied Transvaal. M.Sc. Potchefstroom University for Christian Higher Education. Potchefstroom.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom - Ventersdorp - Randfontein area, South Africa. Phytocoenologia 18: 387-403.

BEZUIDENHOUT, H. & BREDENKAMP, G.J. 1991. The vegetation of the Bc Landtype in the Western Transvaal Grassland, South Africa. Phytocoenologia 19(4): 497-518.

BLOEM, K.J. 1988. 'n Plantsosiologiese studie van die Verlorenvaleinatuurreservaat, Transvaal. M.Sc. thesis. University of Pretoria.

BREDENKAMP, G.J., JOUBERT, A.F. & BEZUIDENHOUT, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. S. Afr. J. Bot. 55: 199-206.

DEALL, G.B. 1985. A plant-ecological study of the Eastern Transvaal Escarpment in the Sabie area. M.Sc. Thesis, University of Pretoria, Pretoria.

DEALL, G.B., SCHEEPERS, J.C. & SCHUTZ, C.J. 1989a. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. Bothalia 19: 53-67.

DEALL, G.B., THERON, G.K. & WESTFALL, R.H. 1989b. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 2. Floristic classification. Bothalia 19: 69-89.

DU PREEZ, P.J. & BREDENKAMP, G.J. 1991. Vegetation classes of the south-eastern Orange Free State. Bloemfontein museum (in press).

ERASMUS. J.F. 1987. Rainfall Deciles for Transvaal Region. Department of Agriculture and Water supply.

FABRICIUS, A.F. 1969. In Schutte, J.M. 1971. Die onttreking van water uit die

newellaag en lae wolke by Mariepskop. S.A Department of water Affairs, Division Hydrological Research, Technical note 20: 1-21.

FABRICIUS, A.F. 1988. Klimageographie-Sudafrika (Moqambique, Swaziland, Republik Sudafrika). Africa-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

FERRAR, A.A., ISAACS, G. & STACEY, J.R. (eds). 1988. Environmental conservation features of the Transvaal Escarpment: an information base for regional planning. Occasional Report No. 31. FRD, CSIR, Pretoria.

GEOLOGICAL SURVEY. 1986. Geology map 1:250 000 geological series. 2430 Pilgrim's Rest. Government Printer, Pretoria.

GIBBS-RUSSELL, G.E., REID, C., VAN ROOY, J & SMOOK, L. 1985. List of species of southern African plants. 2nd edn, Part 1, Mem. bot. Surv. S. Afr. 51: 1-152.

GIBBS-RUSSELL, G.E., WELMAN, W.G., RETIEF, E.,IMMELMAN, K.L., GERMISHUIZEN, G., PIENAAR, B.J., VAN WYK, M., NICOHOLAS, A., DE WET, C., MOGFORD, J.C. & MULVENA, J. 1987. List of species of southern African plants. 2nd edn, Part 2, Mem. bot. Surv. S. Afr. 56: 1-270.

HILL, M.O. 1979. DECORANA. A FORTRAN programme for detrended correspondence analysis and reciprocal averaging. Department of Ecology and Systematics, Cornell University. Ithaca, New York.

HILL, M.O. 1979. TWINSPAN. A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University. Ithaca, New York.

KOOIJ, M.S. 1990. A phytosociological survey of the vegetation of the North Western Orange Free State. M.Sc. Thesis, University of Pretoria, Pretoria.

LAND TYPE SURVEY STAFF. 1989. Land types of the maps 2330 Tzaneen and 2430 Pilgrim's Rest. Mem. agric. nat. Resour. S. Afr. No. 12.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. 1991a. The grassland associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the Transvaal Escarpment. S. Afr. J. Bot. 57(3): 143-150.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. 1991b. The vegetation of the dry dolomitic regions of the North-eastern mountain sourveld of the Transvaal Escarpment, South Africa. Phytocoenologia (in press).

MATTHEWS, W.S. (In prep.). Phytosociology of the North-eastern Mountain Sourveld. M.Sc. Thesis, University of Pretoria, Pretoria.

MATTHEWS, W.S., BREDENKAMP, G.J. & VAN ROOYEN, N. (In prep.). The phytosociology of the high altitude hygrophilous vegetation regions of the North-eastern Mountain Sourveld of the Transvaal, South Africa. Phytocoenologia

MENTIS, M.T. & HUNTLEY, B.J. 1982. A description of the Grassland Biome Project. S. Afr. Nat. Sci. Prog. Report No. 62, CSIR, Pretoria.

MOORE, P.D. & CHAPMAN S.B. (eds). 1986. Methods in Plant Ecology. Blackwell Scientific Publications, London.

MUELLER-DOMBOIS, D. & ELLENBERG, H. 1974. Aims and methods of vegetation Ecology. John Wiley & Sons, New York.

SCHEEPERS, J.C. 1978. Vegetation of Westfalia Estate on the North-Eastern Transvaal Escarpment. Mem. bot. Surv. S. Afr. 42: 1-230

SCHEEPERS, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR, Pretoria.

SHACKLETON, C.M. 1989. An Ecological survey of a selected area of Pondoland Sourveld with emphasis on it's response to the management practices of burning and grazing. M.Sc. thesis. University of Transkei.

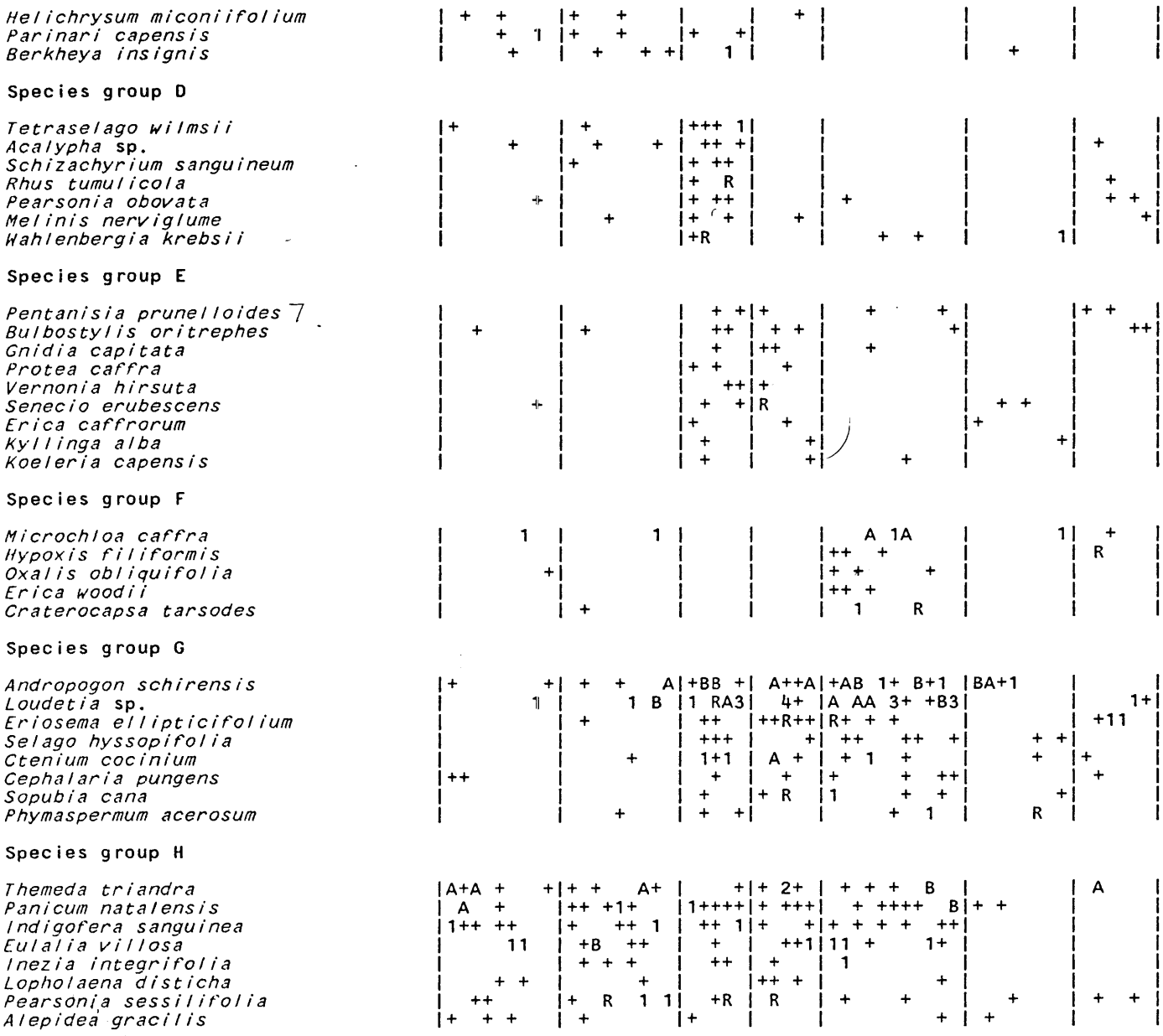
TURNER, B.J. 1989. A Phytosociological study of the South-eastern Transvaal Highveld grasslands. M.Sc. thesis. University of Pretoria, Pretoria

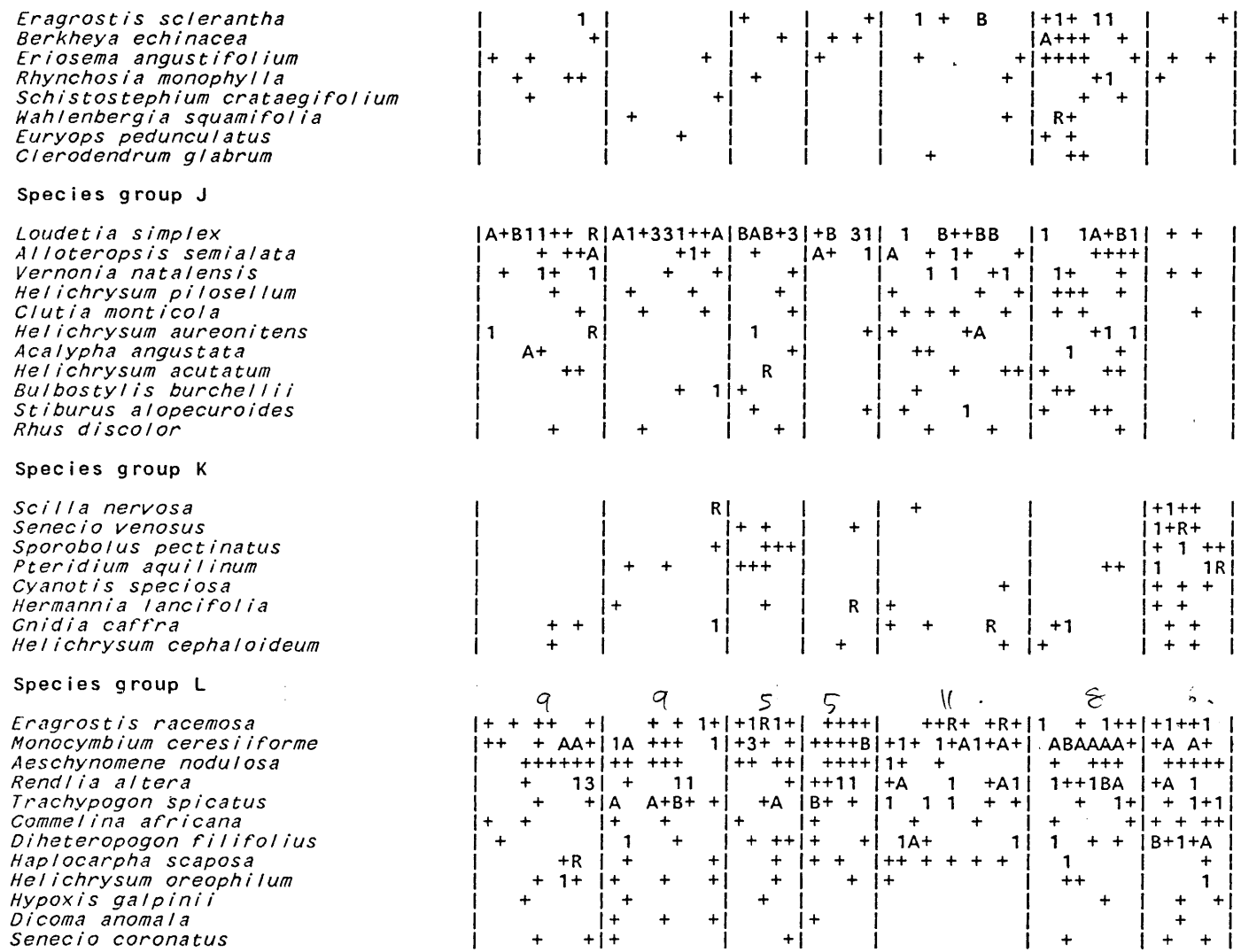
VAN ROOYEN, N., THERON, G.K. & GROBBELAAR, N. 1981. A floristic description and structural analysis of the plant communities of the Tunda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. Jl. S. Afr. Bot. 47: 213-246.

WALKER, B.H. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. S. Afr. J. Wildl. Res. 6: 1-32.

Table 2. A phytosociological table of the vegetation of the relative low altitude vegetation regions of the North-eastern mountain sourveld of the Transvaal escarpment.

Community number	1						
	1.1					1.2	1.3
	1.1.1		1.1.2				
	1.1.1.1	1.1.1.2	1.1.2.1		1.1.2.2		
			a	b			
Releve number	001111110 882402992 954355214	001101101 432535296 256475256	00010 00021 19637	00000 11000 10438	11101101111 34693435256 56244932835	11111210 88888079 26739083	111111 161600 085979
Species per releve	222222223 855897882	342132212 560912676	43333 20531	22122 63987	22221121122 75279937797	22212221 42680159	223222 460270
Species group A							
Hypoxis rigidula	+++ + ++	+ +	+				
Hemizygia transvaalensis	++ ++ +						
Turbina oblongata	+ +1 +	+					
Thesium costatum	++ +					+	+ +
Anthospermum pumilum	+ +A	1				++ +	+ +
Cymbopogon validus	+ A A+						
Zornia capensis	+ R+ +	R	+	+	+		+
Hyparrhenia filipendula	1 ++						
Senecio microglossum	++ +	+					
Melinis repens	++ +		+				
Geigeria elongata	++						
Hermannia staurostemon	++						
Pygmaeothamnus zeyheri	+1	1					+
Triumfetta welwitschii	++						
Faurea speciosa	1R	+	A				
Setaria sphacelata	+ +					R	
Species group B							
Fadogia tetraquetra		++ + + ++	+				
Indigofera atrata	+ +	++++ +		+	+		
Acalypha sp.	+	+ + +	+				
Raphionacme galpinii	+	R ++					+
Gnidia kraussiana		+ +			+		
Tenrhynea phylicifolia		++					
Athrixia phylicoides		+ +		+			
Vernonia centaureoides		+ +					
Cyperus obtusiflorus		++		R	+		+
Species group C							
Diheteropogon amplectens	++1+1++	R ++++1 +	+	+			
Pentanisia angustifolia	++ ++++ +	+++++ ++	++	++	+ +	+ +	+
Bewsia biflora	1++ + +	+ R					
Tristachya leucothrix	+ 1 +	+++ +					
Protea gaguedi	A +A +	A A AA		A	+ R +		A





Endemic flora of the quartzitic and Related Rock Types of the North-eastern Transvaal Escarpment, South Africa.

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Submitted for publication in Biological Conservation

Abstract

This is the first attempt to assess the endemic seed plant flora of the north-eastern Transvaal Escarpment in terms of the region's lithology (mainly rocks of the Transvaal Sequence). A total of 78 species and infraspecific taxa are endemic or near-endemic to the quartzitic and related rock types of the Black Reef Quartzite Formation, Wolkberg Group and Timeball Hill Formation (ca. 3 880 km^2). As a major centre of biodiversity, we propose to call this escarpmental region of Transvaal Sequence the Wolkberg Centre of endemism, with two subunits of endemism, the Blyde Subcentre in the south and Serala Subcentre in the north. Nearly all the endemics are herbaceous, thus conforming to the observation that regional endemism levels in the Afromontane Region are high in grassland, but low among the tree flora of the patches of undifferentiated evergreen forest. The vegetation of the Wolkberg Centre, especially the grasslands, is under considerable pressure, particularly from the timber industry and invasive alien plants. Existing and proposed conservation areas in the Wolkberg centre are listed.

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INTRODUCTION

At a very general scale, the surface of southern Africa is composed of an interior plateau separated from a narrow coastal margin by the Great Escarpment (Partridge & Maud, 1987). Much of the eastern Escarpment in the provinces of Natal and Transvaal comprises the Drakensberg range of mountains and is assigned to White's (1978, 1983) Afromontane Region, an archipelago-like centre of endemism associated with high altitude areas in many parts of Africa. Of the about 23 000 species and infraspecific taxa of seed plants indigenous to the Flora of Southern Africa region, an estimated 6 700 occur in the Transvaal. About one third of the latter taxa has been recorded from the eastern Transvaal Escarpment. Concomitantly the highest concentration of threatened plant species in the Transvaal is found along the Escarpment area (Fourie, 1986; Ferrar et al., 1988). The great diversity of taxa in these areas can be attributed to the wide array of land forms, climatic conditions and rock types which results in an abundance of discrete habitats (Matthews, 1991; Matthews et al., 1991a & b).

The Drakensberg Range forms part of the Great Escarpment at the eastern edge of the interior plateau of southern Africa. This paper ensues from a phytosociological survey of the montane grassland communities of the north-eastern Transvaal Escarpment (Matthews, 1991; Matthews et al., 1991; Matthews et al. a & b, in press). Classified as North-eastern Mountain Sourveld by Acocks (1988), these rolling grasslands and their associated small patches of forest form part of White's (1978, 1983) Afromontane Region, an archipelago-like centre of endemism associated with high altitude areas in many parts of Africa. The Afromontane flora of Africa contains at least 4 000 species of which a remarkably high proportion of around 75% are endemic (White 1983). Although the majority of Afromontane species are widely distributed within the Afromontane Region, many species, especially grassland elements, are local endemics. Moreover, the Afromontane flora probably had a more complex origin and evolutionary history than any other in the world (White 1981). Hence a strong plea for the preservation of the entire Afromontane flora of Africa was made by White (1981).

Though a region's climate sets the limits for a biota, geology enriches local discontinuity and habitat diversity (Kruckeberg, 1986). This was also illustrated for other

southern African grasslands (Bredenkamp & Theron, 1987; 1980; Bezuidenhout & Bredenkamp, 1990). The Afromontane "archipelago" is very diverse in lithology and physiography, but these have been little studied botanically (White, 1983). Recent phytosociological studies on Afromontane vegetation in Southern Africa include the work by Du Preez et al. (1991) and Du Preez & Bredenkamp (1991). Furthermore, the Transvaal Escarpment, and North-eastern Mountain Sourveld in particular, is under considerable pressure, especially from the timber industry. In many areas extensive afforestation has destroyed most of the natural vegetation, and large tracts of land have been severely invaded by alien plants. This is in direct conflict with the need to protect the mountain catchments, conserve natural ecosystems and preserve scenic landscapes for the tourist industry (Deall et al., 1989). Rational land-use planning is required to resolve such conflict (Ferrar et al., 1988).

Knowledge of the biodiversity of a region forms the basis for understanding and managing its plant resources and environment. One of the main problems facing the plant conservationist is the lack of sound information on which to base conservation strategies. Although only one manifestation of rarity, the narrow or local endemic is the one that best fits the colloquial notion of this concept (Kruckeberg & Rabinowitz, 1985). The conservation of narrow endemics that are threatened or endangered has therefore become a major concern shared by governments, conservation organisations, and individuals.

The term "endemic" is used in the botanical sense, namely to refer to a taxon limited in its range to a restricted geographical area, or a particular substrate. When a taxon is predominantly confined to a particular area/substrate, but is also marginally presented elsewhere (sometimes in distant satellite populations), it is referred to as a "near-endemic". Note that in biogeographical literature the term endemic is sometimes also used in a different sense, exactly equivalent to the meaning of the biogeographic term "indigenous" (native) (Stace, 1989).

Our assessment of the endemic element in the flora of the north-eastern Transvaal Escarpment (excluding the geologically different southern portion of the

Escarpment around Barberton) led to the recognition of two groups of narrow endemics, namely those on quartzitic and related rock types, and those on dolomite. The primary objective of this paper is to catalogue the narrow endemics of the quartzitic and related rock types, the distribution of which is mainly within the Afromontane region, thus providing the basis for their conservation. Brief reference will also be made to disjunct and outlier/marginal populations, and the phytogeographical significance of our findings. The dolomitic endemics are dealt with in a separate paper (Matthews et al., 19–).

THE STUDY AREA

Geology

The total area under discussion covers approximately 3 880 km^2 and is shown in Fig. 1. Geologically the principal lithostratigraphic units are the Timeball Hill Formation (ca. 2 240 km^2), Black Reef Quartzite Formation (ca. 950 km^2) and units of the Wolkberg Group (ca. 690 km^2) . These units belong to the Transvaal Sequence, a succession of rocks representing a tectono-sedimentary phase of clastic, volcanic, and chemical sedimentation in a long-lived large sedimentary basin (SACS, 1980).

The Black Reef Formation is a very clean quartzite with, in places, lenses and layers of pebbles and conglomerate. Shale is present, especially near the top of the succession. Although the Timeball Hill Formation includes some quartzite, it comprises predominantly shale, siltstone, ironstone and mudstone.

By their hardness and low westerly dip the quartzites of the Wolkberg Group, and particularly the Black Reef Formation, have in this part of the north-eastern Transvaal come to form the top of the Great Escarpment of the Drakensberg, running north from near Kaapsehoop, incised by the Olifants and Blyde Rivers. From the great ravine of the former, the feature bends north-west, the strata acquiring a higher dip towards the Lowveld and the towering range culminates in the prominences of the Wolkberg and the Iron Crown, whence it is prolonged to the west-south-west in the Strydpoort Range, but it makes a sudden northward inflection at Chuniespoort, passing to the north of Potgietersrust (Du Toit, 1956).

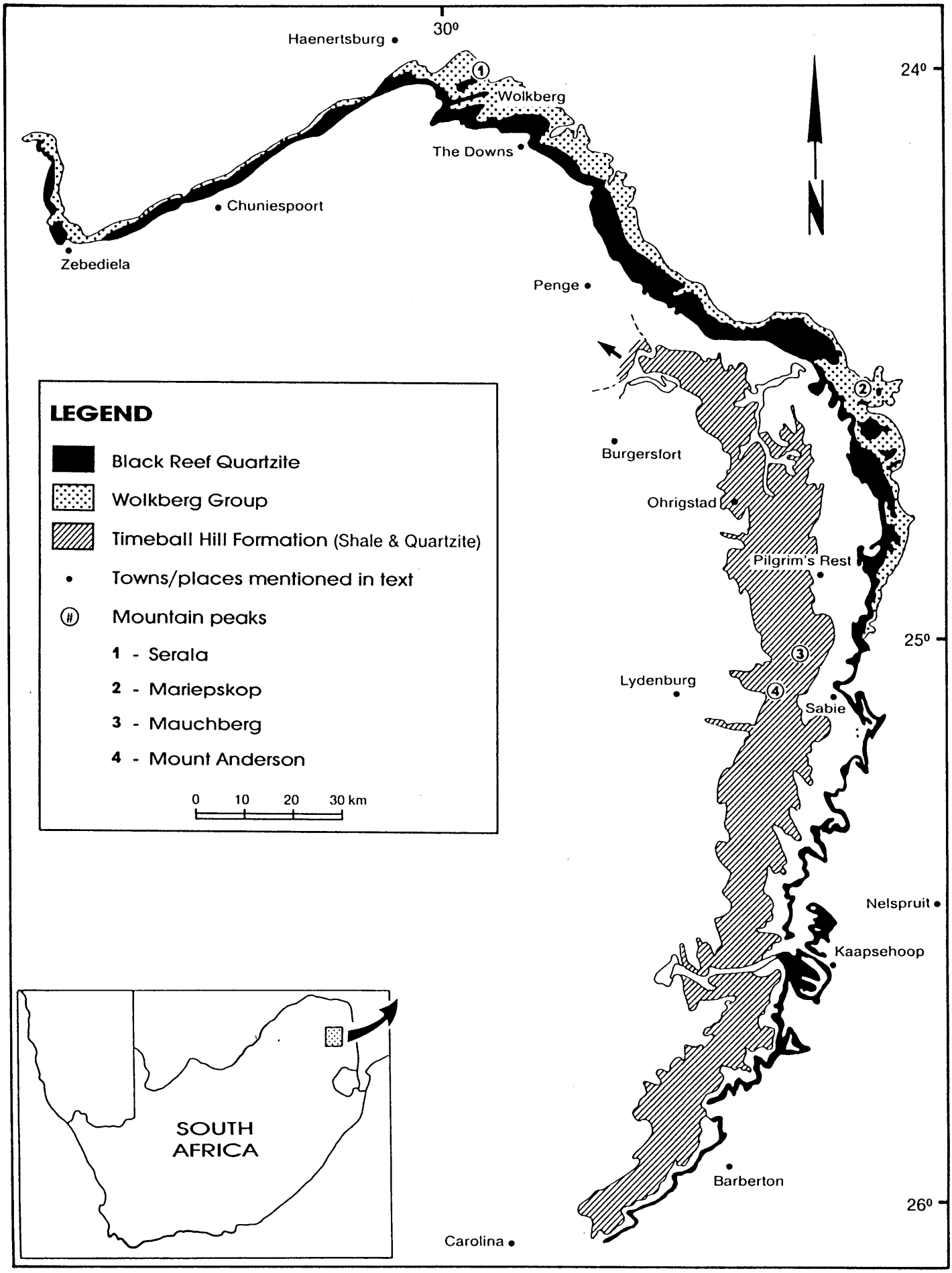


Fig. 1. Map showing the study area, and the distribution of quartzitic and related rocks of the Transvaal Sequence dealt with in this paper. (After the 1:1 000 000 Geological Map of South Africa, 1984, Geological Survey, Dept. of Mineral & Energy Affairs, Pretoria)

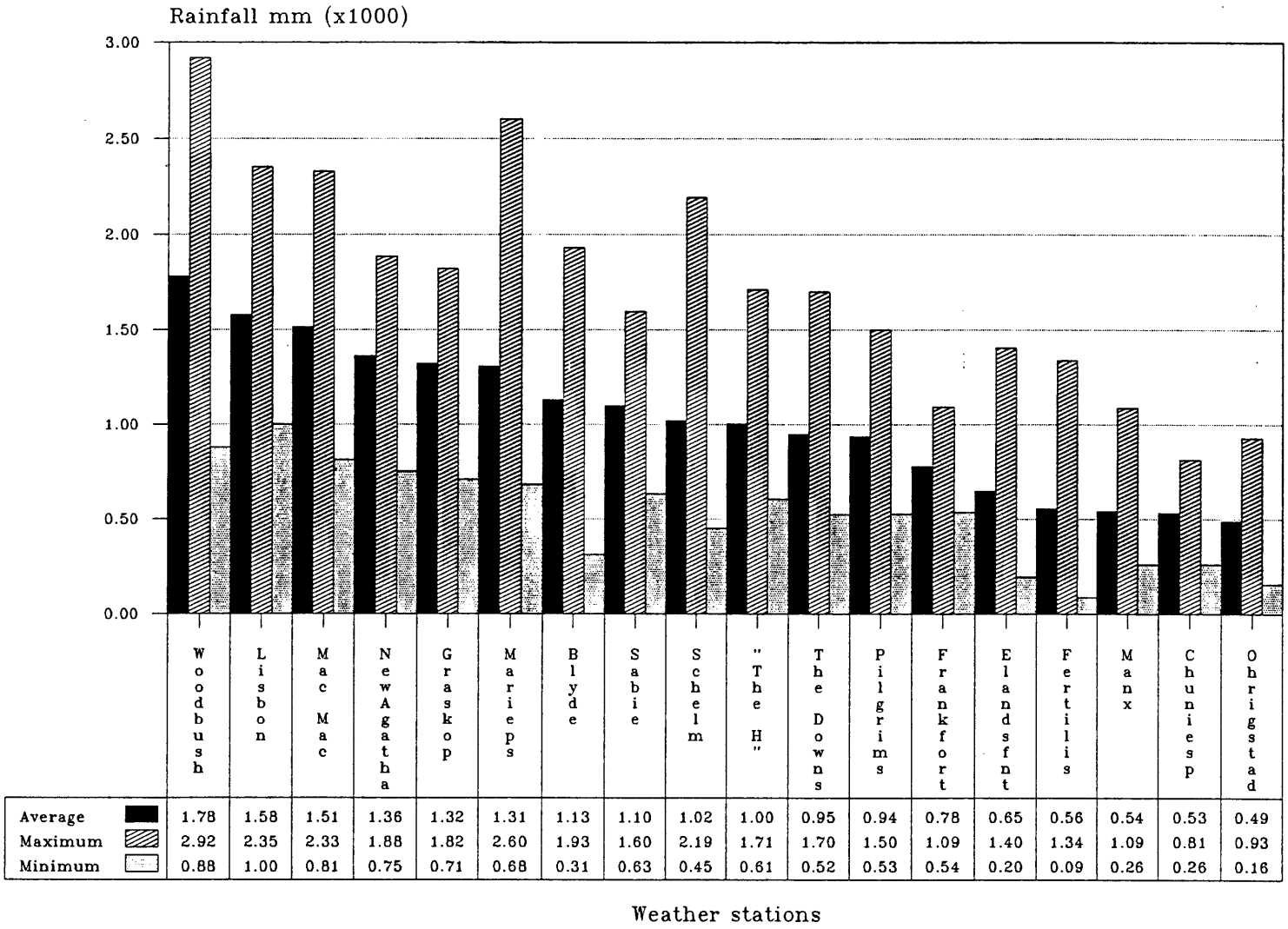
Topography and climate

The study area is very mountainous, with development (mainly by forestry) largely confined to the southern and central areas, particularly in the vicinity of Sabie, Pilgrim's Rest and Graskop. Rugged topography renders many parts difficult to reach by vehicle; some areas, especially to the north, are almost completely inaccessible, except for long excursions on foot or by the use of specialized vehicles and helicopter. The undeveloped nature of these areas has also resulted in a shortage of certain environmental data such as rainfall figures and specifically temperature measurements.

Climatically the north-eastern Transvaal Escarpment can be described as seasonally arid, subtropical, with hot, wet summers and cool, dry winters (Fabricius, 1988). It thus forms a transition between the warm Lowveld to the east and the climatically more extreme Highveld which extends across most of the Transvaal plateau to the west. Characteristic of the escarpment is the occurrence of mist along the so-called mist belt. Rainfall data for specific stations relevant to the study area are given in Fig. 2. Manx and Elandsfontein are examples of weather stations in the drier (rain and mist shadow) of these areas compared to wetter parts with stations such as Lisbon and Mac Mac on the Escarpment.

Soils

Soil patterns are very intricate as a result of the complex topography, geology and variable climate (Schutz in Deall et al., 1989). Soil nomenclature follows MacVicar et al. (1977). Many of the soils show signs of medium (mesotrophic) to high (distrophic) leaching as well as acidity [average pH (water) 4.7]. Soils on Black Reef and Wolkberg Group quartzites are sandy loams (A1 horizon average of 78% sand, B21 horizon 9% clay), with the rocky outcrops characterized by mostly very shallow lithosols, the dominant soil forms being Mispah (orthic A horizon on rock) and Glenrosa (orthic A horizon on lithocutanic B horizon). Under grassland it has given rise to fairly deep soils, with organic, peaty topsoil being common. Other dominant soil forms include Hutton, Clovelly and Champagne (occurring under marshy conditions).



	Woodbush	Lisbon	Mac Mac	NewAgatha	Graskop	Marieps	Blyde	Sabie	Schelm	"The H"	The Downs	Pilgrims	Frankfort	Elandsfnt	Fertilis	Manx	Chuniesp	Ohrigstad
Average	1.78	1.58	1.51	1.36	1.32	1.31	1.13	1.10	1.02	1.00	0.95	0.94	0.78	0.65	0.56	0.54	0.53	0.49
Maximum	2.92	2.35	2.33	1.88	1.82	2.60	1.93	1.60	2.19	1.71	1.70	1.50	1.09	1.40	1.34	1.09	0.81	0.93
Minimum	0.88	1.00	0.81	0.75	0.71	0.68	0.31	0.63	0.45	0.61	0.52	0.53	0.54	0.20	0.09	0.26	0.26	0.16

Fig. 2. Mean annual and absolute maximum and minimum rainfall for selected weather stations along the Eastern Transvaal Escarpment. (From Erasmus, 1987).

Marieps = Mariepskop
Pilgrims = Pilgrims Rest
Elandsfnt = Elandsfontein

The well drained clay loams (A1 horizon average of 36% sand, B21 horizon 43% clay) of the Timeball Hill Formation occur mainly on mountain tops and slopes where it tends to be shallow, except on terraces and in valley bottoms. Subsoils have a high clay content but can become quite sandy in places. A high content of loose or compacted stones on the surface is characteristic of these soils.

METHODS

Data on the distribution of plant taxa were obtained from PRECIS (Pretoria National Herbarium Computerised Information System). This information was verified and supplemented by a study of herbarium specimens in the National Herbarium (PRE), Pretoria, the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria, and the botanical literature. Extensive fieldwork was conducted by the first two authors, and many herbarium specimens were collected. Distributional data were correlated with the 1:250 000 scale geological maps of the Geological Survey, Department of Mineral and Energy Affairs, Pretoria. Scientific names of taxa follow Gibbs Russell et al. (1985, 1987), and subsequent changes and additions published in Bothalia.

RESULTS AND DISCUSSION

The list of endemics is presented with the caution that many areas of the north-eastern Transvaal Escarpment are still ill-explored, and that the number of endemics is likely to increase with a better knowledge of the taxonomy of the region's flora. The number of specimens recorded in Specimen-PRECIS for each quarter-degree grid (about 675 km^2; Edwards & Leistner, 1971) centred in the study area, is shown in Fig. 3. Note the considerable disparity in collecting intensity between grids. This is largely a reflection of the inaccessibility of the different areas to botanists. For example, there are no roads into the mountains between the Olifants River and the road over the mountains at The Downs, some 45 km to the north-west (grids 2430AC, -AD, -BC and -DA).

Of an estimated total of 1 500 seed plant species on quartzitic and related rock types in the study area, at least 78 species and infraspecific taxa are considered to be endemic or near-endemic to these geological substrates (listed in the Appendix), the majority being centred on, or restricted to the Black Reef Quartzite Formation. This comprises a proportion of almost 5.2%. Wild (1964) considers 41 species (4.7%) to be

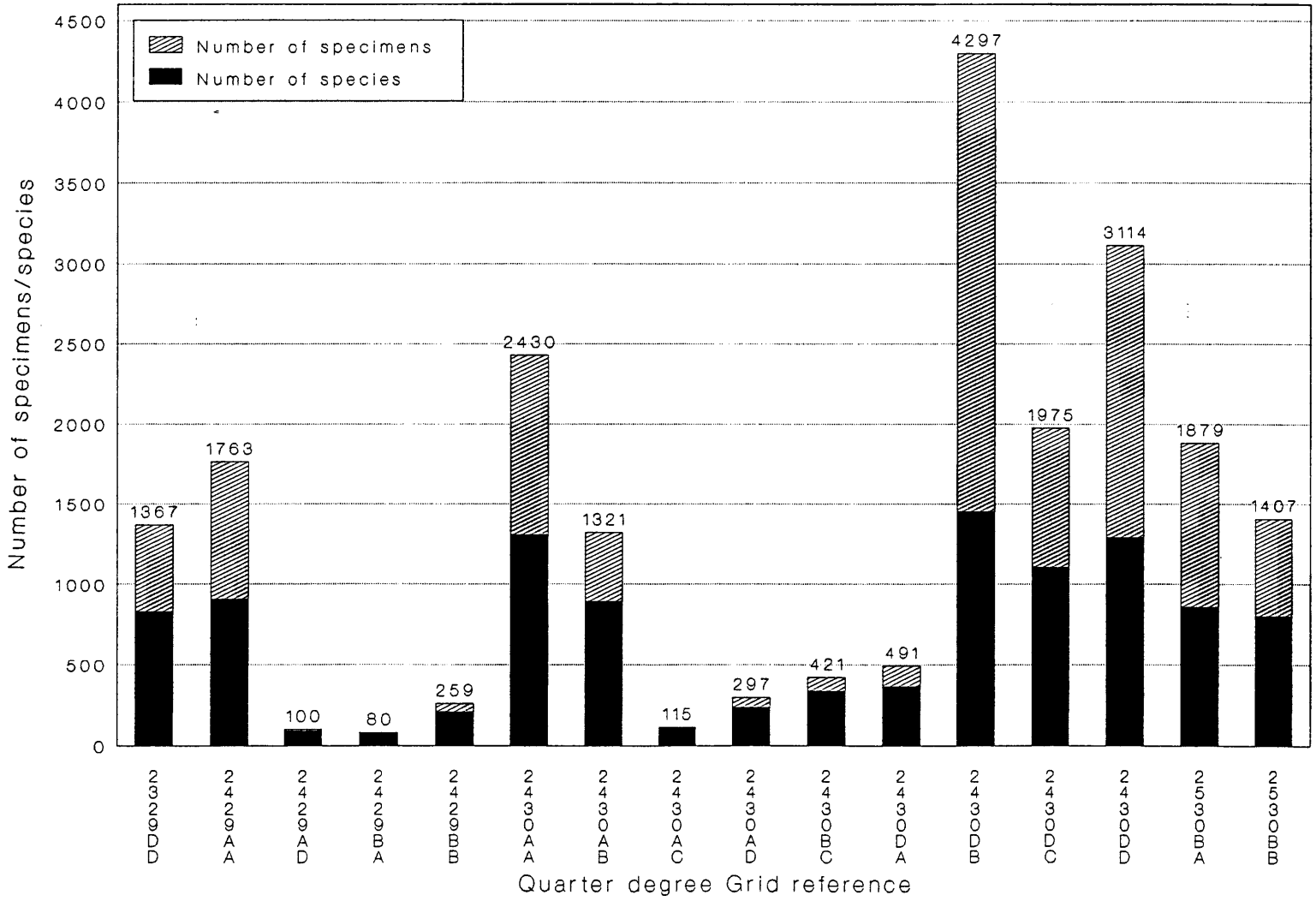


Fig. 3. Plant collecting intensity as reflected by the number of herbarium specimens and species (bryophytes and tracheophytes) recorded for each quarter-degree grid (about 675 km²) centred in the study area. (Based on 1990 data in Specimen-PRECIS, National Botanical Institute, Pretoria.)

endemic to the quartzites of the Chimanimani Mountains in Zimbabwe. Further afield, this compares to about 30 endemics on the granites of Mt. Mulanje in Malawi, South-central Africa's highest mountain (Wild, 1964).

The three families with the largest number of endemics in the study area are the Liliaceae, Iridaceae and Asteraceae, the genus *Helichrysum* with ten species being the most prolific in producing endemics (Table 1). The tendency of many of the families listed in Table 1 to produce endemics is also evident in other parts of the Afromontane Region (Hedberg, 1957; Wild, 1964), and the Drakensberg range in particular (Hilliard & Burtt, 1987). Most significant is the fact that nearly all the endemics are grassland species, a fact which might point to the isolation of the flora for a very long period. A similar preponderance of herbaceous endemics in the Afromontane Region was also reported by other workers (Meadows & Linder, 1989, and references therein). This would seem to contradict White (1983) who holds that most of the grasslands of the Afromontane region comprise a secondary fire-maintained vegetation type, greatly extended relatively recently by man's destructive activity. Consequently, Meadows & Linder (1989) have recently argued that the grasslands, rather than the forest, must have been the long-standing component of the Afromontane vegetation mosaic, in fact, the true "relict" community of the Afromontane Region.

Following a definition in which the Transvaal Escarpment is delineated mainly on topographical grounds, Fourie et al. (1988) listed only 34 plant species as being endemic to the entire mountainous region stretching from around Barberton in the south to the Tzaneen area in the north, a distance of approximately 300 km. In the light of our findings, we consider this figure to be a gross underestimate, and certainly not a true reflection of the floristic richness of the region.

Among the Afromontane endemics, the tree flora of the so-called undifferentiated forest component is widely distributed with very few narrow endemics (White, 1978; 1983). This is also borne out by the present results, with no forest trees endemic to the north-eastern Transvaal Escarpment. The two shrub/small tree endemics, *Combretum petrophilum* and *Dombeya autumnalis*, are only marginally Afromontane, being confined

mainly to the shrub savannah and extensions of Lowveld Sour Bushveld on hot, relatively dry slopes. The remaining larger woody quartzite endemics, *Protea rubromarginata*, *P. laetans* and *Rhus tumilicola*, are clearly associated with Afromontane grasslands, either growing in sparse open woodland, or associated with rocky outcrops and forest margins.

A phytosociological survey has shown that some of the endemics/near-endemics are diagnostic species for certain grassland communities (Matthews et al., 1991). For example, *Helichrysum reflexum*, *H. rudolfii*, *Syncolostemon eriocephalus* and *Protasparagus rigidus* are associated with large quartzitic rocky outcrops along this part of the Escarpment, and *Helichrysum mariepscopicum* is diagnostic for certain high altitude hygrophilous grassland communities (Matthews et al., in press).

Whereas some of the endemics are widely distributed through most of the study area, others are extremely localized. For example, *Thorncroftia media* is known only from the type gathering collected on rocky slopes of the Drakensberg, north-west of Trichardtsdal, *Haemanthus* sp. nov. (aff. *H. albiflos*) from two localities in the Blyderivierspoort Nature Reserve, and *Streptocarpus decipiens* from Mariepskop and Hebronberg. These three species also display the curious phenomenon so common among many plants, endemics in particular: despite the abundant presence of what appears to be suitable habitats, they are, for no obvious reason, absent from most. As Kruckeberg & Rabinowitz (1985, p. 462) so aptly remarked: "organisms do not occur where they cannot, but often they do not occur where they might".

Within the study area, two main subareas of endemism are evident, namely south of the Olifants River (Graskop, Sabie, Pilgrim's Rest, Blyde River) and to the north of it (Wolkberg, Serala, The Downs). Species endemic to the southern sector include *Schoenoxiphium schweickerdtii*, *Aloe nubigena*, *Euclea dewinterii*, *Protea laetans*, *Tulbaghia coddii*, *Erica revoluta*, *Helichrysum homilochrysum* and *Watsonia wilmsii*. Among the northern endemics are species such as *Thesium gracilentum*, *Aster nubimontes*, *Aloe thompsoniae*, *Thorncroftia media*, *Brachystelma pachypodium* and *Helichrysum junodii*.

The place of the Drakensberg in African phytogeography has recently been

reviewed by Hilliard & Burtt (1987). Results of their floristic analysis of the high southern Drakensberg in Natal emphasize the high percentage of endemics in the Drakensberg flora, and also the strong affinity (especially at the generic level) to the Cape flora. They also pointed out the profound floristic differences between the northern Drakensberg (Royal Natal National Park to Giant's Castle) and the southern Drakensberg (Giant's Castle to Bushman's Nek). For the northern Berg they listed 34 species as being endemic above 1 800 m altitude. About 70 species (including two genera) are endemic to the southern Berg and its outliers. Unfortunately no expressed analysis of the distribution of the endemics in relation to the geology was made.

White (1978) has grouped the islands of the Afromontane archipelago into seven regional mountain systems. The southernmost is the Drakensberg System (or Drakensberg Domain sensu Denys, 1980), stretching from the Soutpansberg to Knysna; but geographically the Drakensberg is the escarpment extending from the north-eastern Transvaal to the Barkly East district of the eastern Cape. Hilliard & Burtt (1987) justifiably plead for some degree of precision in the use of the name Drakensberg range. They propose that the Eastern Mountain Region of Phillips (1917) be recognized in the broader African context as the South-eastern Mountain Regional Mosaic (p.94).

It is evident that the area of the Transvaal Escarpment under consideration represents a marked centre of endemism. If the about 28 species endemic to the dolomitic areas of the Chuniespoort Group rocks (Matthews et al., 19–) are added to the 78 of the present study, this part of the Escarpment contains at least 106 endemic or near-endemic species and infraspecific taxa. To this total could be added several more widespread Escarp endemics (e.g. *Argyrolobium muddii*, *Helichrysum aureolum*, *H. chrysargyrum*, *H. galpinii*, *H. molestum*, *H. transmontanum*, *H. wilmsii*, *Stachys arachnoidea*) or marginal ones that are centred outside the study area (e.g. *Cyrtanthus thorncroftii*, *Hemizygia albiflora*, *H. petiolata*, *Watsonia bella*, *W. transvaalensis*) and tropical African Afromontane disjuncts such as *Aeollanthus suaveolens*, *Helichrysum edwardsii*, *H. swynnertonii* and *Leucospermum saxosum*.

Because of its high degree of endemism, and for ease of reference, we propose that the

outcrops of the Transvaal Sequence along the north-eastern Transvaal Escarpment, encompassing rocks of the Black Reef Quartzite Formation, Wolkberg Group, Timeball Hill Formation and Chuniespoort Group, be recognized as the **Wolkberg Centre**. As subcentres within the Wolkberg Centre we propose the **Blyde Subcentre** south of the Olifants River, and the **Serala Subcentre** to the north of it.

Not only is the Wolkberg Centre rich in plant endemics, but it also harbours a number of endemic animals, including one fish (*Barbus treurensis*), four reptiles (*Acontophiops lineatus*, two subspecies of *Afroedura pondolia* and an undescribed species of *Lygodactylis*), one mammal (*Amblysomnus gunningi*) and seven butterflies (*Alaena margaritacea*, *Aloeides nubilus*, *Appias sabina phoebe*, *Charaxes marieps*, *Dira jansei*, *Lepidochrysops irvingi*, *Pseudonympha swanepoeli*) (Henning, 1989). *Tetradactylus breyeri*, a small snake-like plated lizard, has not been rediscovered since its original description in 1913 from the Woodbush forest just north of the Wolkberg Centre (Branch, 1988). The habitat in the vicinity of its original locality has since been destroyed by pine plantations. There is, however, the possibility that it might still survive in the Serala Subcentre.

From a conservation point of view, it is ironic that efforts to conserve the flora of the Wolkberg Centre have hitherto focused mainly on the protection of the patches of floristically poor Afromontane forest, with the endemic-rich grasslands being allowed to be destroyed at an alarming rate, particularly by the timber industry. The amount of grassland conserved is estimated to be less than one percent (Ferrar et al. 1988). With so little grassland left, particularly in the Blyde Subcentre, conservationists should make every effort to check the present indiscriminate destruction of Afromontane grasslands in this part of southern Africa. Existing conservation areas in the Wolkberg Centre are listed in Table 2, and areas of high priority deserving protection, proposed in Table 3.

From unpublished results at our disposal, at least two other centres of endemism are evident along the Eastern Transvaal Escarpment. The one is just north of our study area in the Tzaneen/Woodbush area (mainly granite), and the other, floristically a much richer one, further south in the vicinity of Barberton/Swaziland (a geologically complex

area). The latter centre also harbours several serpentine endemics (Balkwill & Balkwill, 1988; Morrey et al., 1989). A floristic analysis of these regions in which patterns of endemism are assessed in relation to geology, along the lines of the present study, is likely to provide informative results.

ACKNOWLEDGEMENTS

The Director (Research) of the National Botanical Institute is thanked for the use of plant collecting and distributional data produced by the Pretoria National Herbarium Computerised Information System (PRECIS). The plant collecting permits provided by the Transvaal Division of Nature Conservation are acknowledged with thanks. Our appreciation to Mr Jerry Theron, Nature Conservation Officer at Swadini, for support during the field work. Mrs E. du Plessis critically read and improved the manuscript. This study was financed in part by the Foundation for Research Development and the University of Pretoria.

REFERENCES

Acocks, J.P.H. (1988). Veld Types of South Africa, 3rd ed. *Memoirs of the Botanical Survey of South Africa* **57**, 1–146.

Balkwill, K. & Balkwill, M-J. (1988). Studies on serpentine flora: A new species of Brachystelma (Asclepiadaceae). *S. Afr. J. Bot.* **54**, 60–2.

Bezuidenhout, H. & Bredenkamp, G.J. (1990). A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom- Ventersdorp-Randfontein area, South Africa. *Phytocoenologia* **18**, 387–403.

Branch, B. (1988). Field Guide to the Snakes and other Reptiles of Southern Africa. Struik Publishers, Cape Town.

Bredenkamp, G.J. & Theron, G.K. (1978). A synecological account of the Suikerbosrand Nature Reserve I. The phytosiciology of the Witwatersrand geological system. *Bothalia* **12**, 513–29.

Bredenkamp, G.J. & Theron, G.K. (1980). Die Plantegroei van die Manyeleti Wildtuin. KION, Departement Samewerking & Ontwikkeling, Pretoria.

Deall, G.B., Scheepers, J.C. & Schutz, C.J. (1989). The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. I. Physical environment. *Bothalia* **19**, 53–67.

Denys, E. (1980). A tentative phytogeographical division of tropical Africa based on a mathematical analysis of distribution maps. *Bull. Jard. Bot. Nat. Belg.* **50**, 465–504.

Du Preez, P.J., Bredenkamp, G.J. & Venter, H.J.T. (1991). The syntaxonomy and synecology of the dry forests in the south-eastern Orange Free State, I. the Podocarpetalia latifolii. *S. Afr. J. Bot.* **57**, 189-206.

Du Preez, P.J. & Bredenkamp, G.J. (1991). The taxonomy and synecology of the forests in the south-eastern Orange Free State, II. the Pittosporetalia viridiflorii. *S. Afr. J. Bot.* **57**, 207-212.

Du Toit, A.L. (1956). The Geology of Southern Africa. 3rd ed. Oliver & Boyd, Edinburgh.

Edwards, D. & Leistner, O.A. (1971). A degree reference system for citing biological records in southern Africa. *Mitt. Bot. Staatssamml.* München **10**, 501–9.

Erasmus, J.F. (1987). Rainfall Deciles for Transvaal Region. Dept. of Agriculture & Water Supply, Pretoria.

Ferrar, A.A., Isaacs, G. & Stacey, J.R. (eds). (1988). Environmental Conservation

Features of the Transvaal Escarpment: an Information Base for Regional Planning. Ecosystem Programmes Occasional Report **31**. Foundation for Research Development, Pretoria.

Fabricius, A.F. (1988). Klimageographie - Südafrica (Moçambique, Swaziland, Republik Südafrika). Afrika-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

Fourie, S.P., Jacobsen, N.H.G., Kleynhans, C.J. & Tarboton, W. (1988). Biogeographical importance and species/areas warranting particular conservation attention, In *Environmental Conservation Features of the Transvaal Escarpment*, eds A.A. Ferrar, G. Isaacs, & J.R. Stacey. Ecosystem Programmes Occasional Report **31**, 46–70. Foundation for Research Development, Pretoria.

Gibbs Russell, G.E., Reid, C., Van Rooy, J. & Smook, L. (1985). List of species of southern African plants, ed. 2, Part 1: Cryptogams, gymnosperms and monocotyledons. *Memoirs of the Botanical Survey of South Africa* **51**, 1–152.

Gibbs Russell, G.E., Welman, W.G., Retief, E., Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M. & Nicholas, A. (1987). List of species of southern African plants, ed. 2, Part 2: Dicotyledons. *Memoirs of the Botanical Survey of South Africa* **56**, 1–270.

Hedberg, O. (1957). Afroalpine vascular plants. *Symb. Bot. Ups.* **15**, 1–411.

Henning, S.F. (1989). South African red data book: Butterflies. S.A. National Scientific Programmes Report **158**, 1–175.

Hilliard, O.M. & Burtt, B.L. (1987). The Botany of the Southern Natal Drakensberg. Annals of Kirstenbosch Botanic Gardens Vol. 15. National Botanic Gardens, Cape Town.

Kruckeberg, A.R. (1986). An essay: The stimulus of unusual geologies for plant speciation. *Systematic Botany* **11**, 455–63.

Kruckeberg, A.R. & Rabinowitz, A.R. (1985). Biological aspects of endemism in higher plants. *Ann. Rev. Ecol. Syst.* **16**, 447–79.

MacVicar, C.N., De Villiers, J.M., Loxton, R.F., Verster, E., Lambrechts, J.J.N., Merryweather, F.R., Le Roux, J., Van Rooyen, T.H. & Harmse, H.J. von M. (1977). Soil Classification. A Binomial System for South Africa. Scientific Bulletin 390. Department of Agricultural Technical Services, Pretoria.

Matthews, W.S. (1991). The Vegetation of the North-eastern Mountain Sourveld of the Transvaal Escarpment. M.Sc. thesis, University of Pretoria.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. (1991). The grassland-associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the

north-eastern mountain sourveld of the Transvaal escarpment. *S. Afr. J. Bot.* **57**, 143–50.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. [(a) in press]. The phytosociology of the high altitude hygrophilous vegetation regions of the north-eastern mountain sourveld of the Transvaal, South Africa. *Phytocoenologia*.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. [(b) in press]. The vegetation of the dry dolomitic regions of the North-eastern Mountain Sourveld of the Transvaal Escarpment, South Africa. *Phytocoenologia*.

Matthews, W.S., Van Wyk, A.E. & Bredenkamp (19–). Endemic flora of the dolomitic areas of the North-eastern Transvaal Escarpment, South Africa. *Biol. Conserv.* (submitted).

Meadows, M.E. & Linder, H.P. (1989). A reassessment of the biogeography and vegetation history of the southern Afromontane Region, In Biogeography of the Mixed Evergreen Forests of Southern Africa, ed. C.J. Geldenhuys. Ecosystem Programmes Occasional Report **45**, 15–29. Foundation for Research Development, Pretoria.

Morrey, D.R., Balkwill, K. & Balkwill, M-J. (1989). Studies on serpentine flora: Preliminary analysis of soils and vegetation associated with serpentine rock formations in the south-eastern Transvaal. *S. Afr. J. Bot.* **55**, 171–7.

Phillips, E.P. (1917). A contribution to the flora of the Leribe plateau and environs. *Ann. S. Afr. Mus.* **16**, 1–379.

South African Committee for Stratigraphy [SACS] (1980). Stratigraphy of South Africa. Part 1 (Compiled by L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda [also Errata compiled by F. Walraven & M.R. Johnson]: Handbook of the Geological Survey of South Africa **8**. Government Printer, Pretoria.

Stace, C.A. (1989). Plant Taxonomy and Biosystematics, 2nd ed. Edward Arnold, London.

White, F. (1978). The Afromontane Region, In Biogeography and Ecology of Southern Africa, ed. M.J.A. Werger. Junk, The Hague, pp. 463–513.

White, F. (1981). The history of the Afromontane archipelago and the scientific need for its conservation. *Afr. J. Ecol.* **19**, 33–54.

White, F. (1983). The Vegetation of Africa. Unesco, Paris.

Wild, H. (1964). The endemic flora of the Chimanimani Mountains and their significance. *Kirkia* **4**, 125–157.

APPENDIX

Seed plant species endemic or near-endemic to the quartzites and related rock types of the Wolkberg Group and Timeball Hill Formation in the north-eastern Transvaal Escarpment. Near-endemics occasionally also found on dolomite are marked with an asterisk.

GYMNOSPERMS

ZAMIACEAE

Encephalartos cupidus

MONOCOTYLEDONS

AMARYLLIDACEAE

Cyrtanthus huttonii
C. junodii
Haemanthus sp. nov.

COMMELINACEAE

Cyanotis pachyrrhiza

CYPERACEAE

Schoenoxiphium schweickerdtii

IRIDACEAE

Babiana hypogea var. longituba
Crocosmia mathewsiana
Dierama adelphicum
G. calcaratus
G. exiguus
G. macneilii
G. rufomarginatus
Gladiolus varius var. micranthus
G. varius var. varius
G. vernus
Watsonia occulta
W. strubeniae
W. wilmsii

LILIACEAE

Agapanthus inapertus subsp. hollandii
A. inapertus subsp. inapertus
Aloe nubigena
A. thompsoniae
Kniphofia crassifolia
Ledebouria petiolata
Protasparagus clareae
P. intricatus
P. lynettae
*P. rigidus
Tulbaghia coddii
T. simmlerii
T. transvaalensis

ORCHIDACEAE

Disa alticola
D. amoena
D. aristata
D. extinctoria
Schizochilus cecilii subsp. transvaalensis
S. crenulatus
S. lilacinus

DICOTYLEDONS

ANACARDIACEAE

Rhus tumulicola var. meeuseana

forma meeuseana

ASCLEPIADACEAE

Brachystelma pachypodium

B. stellatum

ASTERACEAE

Aster nubimontes

Helichrysum albilanatum

H. homilochrysum

H. junodii

H. mariepscopicum

H. milleri

H. mimetes

H. reflexum

H. rudolfii

H. summo-montanum

H. truncatum

Inezia speciosa

COMBRETACEAE

Combretum petrophilum

DIPSACACEAE

*Scabiosa transvaalensis

EBENACEAE

Euclea dewinterii

ERICACEAE

Erica revoluta

E. subverticillaris

FABACEAE

Lotononis pariflora

GERANIACEAE

Monsonia lanuginosa

M. transvaalense

GESNERIACEAE

Streptocarpus decipiens

S. micranthus

S. pogonites

LAMIACEAE

Hemizygia parvifolia

H. rehmannii

H. rugosifolia

H. subvelutina

Stachys reticulata

Syncolostemon eriocephalus

Thorncroftia media

LOBELIACEAE

Monopsis kowynensis

PASSIFLORACEAE

Adenia wilmsii

PROTEACEAE

Protea laetans

P. rubropilosa

SANTALACEAE

Thesium gracilentum

STERCULIACEAE

*Dombeya autumnalis

TABLE 1

Family Statistics of the Plant Taxa Endemic to the Quartzites and Related Rock Types of the Wolkberg Group, Black Reef Quartzite and Timeball Hill Formation, North-eastern Transvaal Escarpment (see Appendix for details)

Family	Genera	Specific/infraspecific Taxa
Liliaceae	6	13
Iridaceae	5	13
Asteraceae	3	12
Lamiaceae	4	7
Orchidaceae	2	7
Amaryllidaceae	2	3
Gesneriaceae	1	3
Asclepiadaceae	1	2
Ericaceae	1	2
Geraniaceae	1	2
Proteaceae	1	2
Anacardiaceae	1	1
Combretaceae	1	1
Commelinaceae	1	1
Cyperaceae	1	1
Dipsacaceae	1	1
Ebenaceae	1	1
Fabaceae	1	1
Lobeliaceae	1	1
Passifloraceae	1	1
Santalaceae	1	1
Sterculiaceae	1	1
Zamiaceae	1	1
TOTAL	39	78

TABLE 2

Existing Conservation Areas for the Flora of the North-eastern Transvaal Escarpment
(Based on Ferrar et al., 1988)

Conservation area	Size (ha)	Ownership
Blyderivierspoort Nature Reserve	22 664	Transvaal Prov. Adm.
Lekgalameetze Nature Reserve	22 000	Lebowa Government
Wolkberg Wilderness Area	19 270	Transvaal Prov. Adm.
Ohrigstad Dam Nature Reserve	2 563	Transvaal Prov. Adm.
Hartebeesvlakte (Mt. Anderson Area)	±2 000	Dept. of Forestry, Ceylon State Forest
Pilgrim's Rest Nature Reserve	1 840	Transvaal Prov. Adm.
Oribi Nature Reserve	1 827	Private
Mount Sheba Nature Reserve	1 508	Private
London Nature Reserve	1 500	Private (Mondi)
Wolkberg Caves Nature Reserve	1 488	Transvaal Prov. Adm.
Blyfstaanhoogte	450	Private (Mondi)
In-de-Diepte	437	Private (Mondi)
Grootfontein	200	Private (Mondi)
Klein Spitskop	60	Private (Mondi)
Vertroosting Nature Reserve	27	Transvaal Prov. Adm.
Rooywal	2	Private (Mondi)
TOTAL AREA	±77 836	

TABLE 3

Proposed High Priority Areas for the Conservation of the Flora of the North-eastern Transvaal Escarpment

Area	Ownership
Blue Swallow Plains (Kaapsehoop)	Dept. of Forestry, Berlin State Forest
Graskop Bluff (Proposed Nature Reserve)	Graskop Municipality
Mac Mac Bluff	Dept. of Forestry, Mac Mac State Forest
Mauchsberg Peak Area	Private (Mondi)
Mariepskop Complex	Lebowa Government
Olifants River Area	Lebowa Government
Ribbokkop Area (near Wolkberg)	Lebowa Government
Sacramento Creek Area; farms Eldorado, Doornhoek & Sacramento	Dept. of Forestry, Morgenzon State Forest
Stanley Bush Hill	Dept. of Forestry
Thabakgolo Area (Strydomtunnel to The Downs)	Lebowa Government
Upper Blyde River Valley	Private (Rand Mine Estates, TGME)

Endemic flora of the dolomitic areas of the North-eastern Transvaal Escarpment, South Africa.

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Submitted for publication in Biological Conservation

Abstract

The endemic seed plant flora of the north-eastern Transvaal Escarpment (part of the Afromontane Region) was analysed with respect to substrate. Distribution patterns of endemics were strongly correlated with the varied lithology of the region, and a total of 31 species were recorded as endemic or near-endemic to the dolomitic Chuniespoort Formation (ca. 2 100 km^2). Many of these narrow endemics are rare and call for the creation of more conservation areas in the region. The Chuniespoort Formation, together with the associated quartzites and related rock types of the Black Reef Quartzite Formation, Wolkberg Group and Timeball Hill Formation, delineates the Wolkberg Centre, a regional centre of endemism comprising the core of the north-eastern Transvaal Escarpment. A total of about 106 seed plant taxa are considered to be endemic or near-endemic to the Wolkberg Centre. Although the number of endemics on dolomite is less than half the number of endemic plant species on quartzite-derived substrates, the degree of endemicity is higher on the former. The majority of dolomite endemics are confined to the drier areas and are not of such strong Afromontane affinity as the quartzitic ones.

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INTRODUCTION

The African flora is presently divided into 18 mutually exclusive regional centres of endemism and transition zones, of which five are either confined to, or well represented in southern Africa (White, 1983). Mainly on the basis of the richness (or otherwise) of their endemic floras at the species level, these so-called phytochoria are particularly useful as broad geographical units for assessing centres of biodiversity. For nature conservation purposes, however, the recognition of more specific core sites of high species-richness and/or endemism is important for developing strategies for the protection of the greatest number of plant species.

The Afromontane Region is very diverse in lithology and physiography, but hitherto these aspects have been little studied floristically (White, 1983). Since edaphic factors are most commonly involved to show the link between environments and endemic taxa (Kruckeberg & Rabinowitz, 1985; Kruckeberg, 1986), the complex and contrasting lithology of the eastern Transvaal Escarpment provides an opportunity to assess the influence of geology on regional specific endemism and near endemics in this part of the Afromontane Region.

This is the second paper in which the endemic flora of the north-eastern Transvaal Escarpment is analysed in terms of the complex geology of the region. In the first (Matthews et al., 19–), 78 species and infraspecific taxa were shown to be endemic or near-endemic to the quartzitic and related rock types of the Black Reef and Timeball Hill Formation as well as the Wolkberg Group, all being lithostratigraphic units of the Transvaal Sequence. A marked centre of biodiversity, the escarpmental region delineated by these geological units, will henceforth in this paper be referred to as the Wolkberg Centre.

This paper deals with the endemic flora of the mainly dolomitic Chuniespoort Formation, a lithostratigraphic subdivision of the Transvaal Sequence also outcropping within the boundaries of the Wolkberg Centre. No such analysis has previously been attempted. The primary objective of this contribution is to compile an inventory of the plant species endemic to this geologic substrate, thus providing the basis for their

conservation. This knowledge is essential for pin-pointing areas vulnerable to species loss, and is presented so as to facilitate its use in planning activities and ultimately in land management.

THE STUDY AREA

Geology

The distribution of the main outcrop of dolomite relevant to the present study is shown in Fig. 1. It covers a total area of approximately 2 100 km^2. Classified as the Chuniespoort Formation, this stratigraphical unit forms part of the Transvaal Sequence, a succession of rock types representing a tectono-sedimentary phase of clastic, volcanic and chemical sedimentation (SACS, 1980).

The Chuniespoort Formation outcrops in a narrow belt running roughly north and south, flanked by the quartzites, shales and mudstones of the Timeball Hill Formation to the west, and the mainly quartzitic Black Reef Formation (which it overlies) and Wolkberg Group to the east (for the distribution of the last mentioned three units, see Matthews et al., 19–). Predominantly chemical in origin, the Chuniespoort Formation is made up mainly of light-coloured dolomite containing abundant chert. In places it also contains an appreciable proportion of limestone and banded iron formations. Layers of carbonaceous shale and quartzite occur near contact areas with the Black Reef Quartzite (Oaktree Formation).

Dolomite rock outcrops are usually absent from the high-rainfall areas, owing to the high solubility of the limestone. Tufas are found along some of the streams flowing over or near the dolomite. Tufa (limestone tufa) or Travertine is a hard, concretionary, cavernous material deposited from streams draining dolomitic areas under certain conditions (Martini 1987). Where dolomite outcrops do occur, mostly in the drier areas, the typically wrinkled/corrugated texture of the exposed rock surfaces is very characteristic, hence the common name "olifantsklip" (= "elephant rock") because of the resemblance to an elephant's hide.

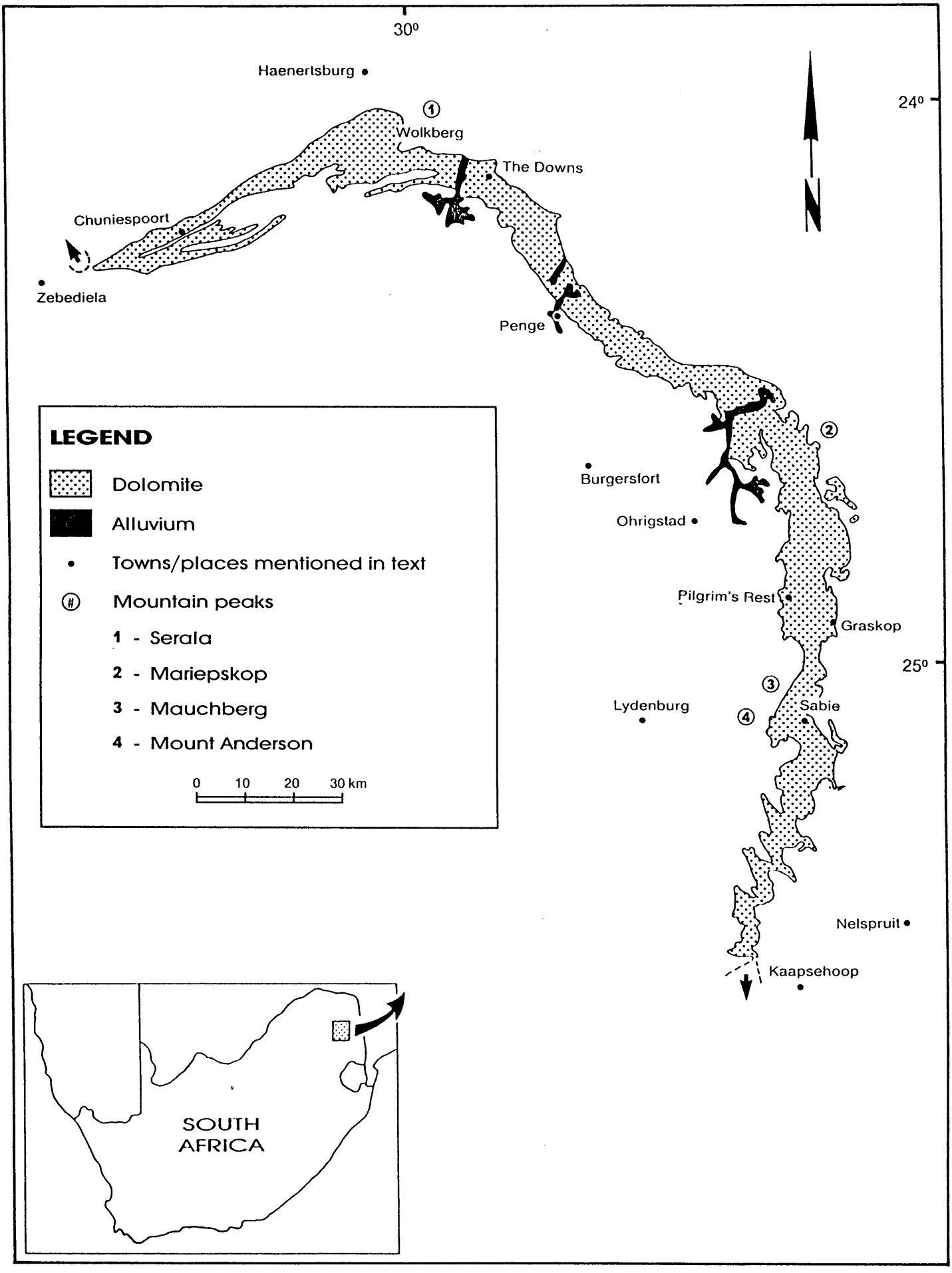

Fig. 1. Map showing the study area, and the distribution of dolomitic rocks of the Chuniespoort Formation (Transvaal Sequence) dealt with in this paper. (After the 1:1 000 000 Geological Map of South Africa, 1984, Geological Survey, Dept. of Mineral & Energy Affairs, Pretoria).

Topography and climate

The study area is very broken and mountainous, resulting in a wealth of different habitats created by the varied combinations of ruggedness of the terrain, changes in aspect, edaphic and climatic factors. Climatically the Transvaal Escarpment area occurs in a seasonally arid, subtropical region, dominated throughout the year by anticyclonic circulation (Gamble, 1988). Mean annual precipitation exceeds 1 000 mm over most of the southern half of the area, and may reach 2 000 mm along the Escarpment crests. More specific rainfall figures for a number of weather stations are supplied in Matthews et al. (19–). In addition to thunderstorms, orographic rain, drizzle and mist are common against the mountains. There is a very pronounced and rapid decrease in rainfall away from the crests on both windward and leeward slopes (490–534 mm). Most of the northern part of the dolomite outcrop area falls within the rain and mist shadow of the main escarpmental crest and is therefore relatively arid compared to the associated quartzitic outcrops of the Black Reef Formation and Wolkberg Group.

Soils

On the basis of the composition of the Chuniespoort Formation, at least two main types of soil are distinguished, namely those found on carbonaceous shale and quartzite (Oaktree Formation) and those on dolomite (Schutz, in Deall et al., 1989). Soils on the former are usually clay loams, distinguished from the sandy Black Reef Quartzite soils by an increased clay content of the subsoil.

The prevalent dolomitic-derived soils are deep and well drained. Only on ridges and steep slopes do the unweathered rocks come to the surface. Of all the soils in the area, these are the least acidic [average pH (water) 5.0 under relatively high rainfall, probably higher in drier areas]. Despite having the lowest mean level of phosphorus (3.9 mg/kg), other important cations are high (e.g. Ca: 132 mg/kg, Mg: 37 mg/kg, K: 46 mg/kg), making these soils the most fertile in the region. According to the soil nomenclature of MacVicar et al. (1977), the dominant forms are Hutton and Griffin.

METHODS

Data on the distribution of plant taxa were obtained from PRECIS (Pretoria National Herbarium Computerised Information System). This information was verified and supplemented by a study of herbarium specimens in the National Herbarium (PRE), Pretoria, the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria, and the botanical literature. Extensive fieldwork was conducted by the first two authors, and many herbarium specimens were collected. However, owing to the rugged topography of the study area, many parts remain botanically poorly explored. Statistics on the considerable inequality in collecting intensity between quarter-degree grids are supplied by Matthews et al. (19–). Distributional data were correlated with the 1:250 000 scale geological maps of the Geological Survey, Department of Mineral and Energy Affairs, Pretoria. Scientific names of taxa follow Gibbs Russell et al. (1985, 1987), and subsequent changes and additions published in Bothalia.

The following formula was used to calculate a quantitative index of endemicity: $I_e = E_f/E_n$, where I_e is the Index of Endemicity, E_f is the factual percentage endemism and E_n is the normal percentage endemism. E_n was read off the nomogram provided by Bykov (1979), as published in Major (1988).

The term "endemic" is used in the botanical sense, namely to refer to a taxon limited in its range to a stated area/substrate. A taxon whose range is centred in a defined area, but also extends feebly beyond its boundaries (sometimes in distant satellite populations), is referred to as a "near-endemic". Note that in biogeographical literature the term endemic is sometimes also used in a different sense, exactly equivalent to the meaning of the biogeographic term "indigenous" (native) (Stace, 1989).

RESULTS AND DISCUSSION

The flora of the Chuniespoort dolomites in the north-eastern Transvaal has an endemic/near-endemic component of at least 31 species and infraspecific taxa (listed in the Appendix), a figure estimated to represent roughly 2,5% of the total number of species (1 200) in the area. Some of these taxa have not yet been formally described, and the total number of endemics is likely to increase as the flora of the more

inaccessible parts becomes better known. The number of endemics on the dolomites is markedly lower than the total of about 78 endemic species and infraspecific taxa (percentage endemism 5.2%) recorded from the associated quartzitic and related substrates (Matthews et al., 19–). The total number of endemics plant species in the Wolkberg Centre is therefore much higher than the mere 34 species listed as endemic to the entire eastern Transvaal Escarpment (admittedly, defined on topographical rather than geological grounds) by Fourie et al. (1988). We are not aware of studies reporting levels of endemism on dolomites in other parts of the Afromontane Region, but our figure compares to the about 30 endemics on the granites of Mt. Mulanje, Malawi (Wild, 1964) an area of approximately 640 km^2.

Endemism could also be expressed in the light of the relationship that exists between percentage endemism and surface area (Major, 1988). Unfortunately, the total number of plant species for each of the various geological units in the Wolkberg Centre is not known precisely. Calculations on the degree of endemism in the latter area are therefore based on estimates derived from the PRECIS date base, and should be viewed as provisional. It should also be noted that the surface area for the regions is very approximate; most of the terrain is so dissected by steep-sided valleys that the actual surface area must be greatly in excess of our map-derived calculations. The Index of Endemicity (I_e) for the Chuniespoort Formation is 3.57 (I_e = 2.5/0.7), for the quartzitic and related rocks 2.60 (I_e = 5.2/2.0) and for the Wolkberg Centre as a whole 2.85 (total number of species 1 600; area 5 980 km^2; I_e = 6.56/2.3). An index value of 1 indicates that an area has the normal, expected degree of endemicity; a value of above 1 indicates greater than normal and below 1 less than normal endemicity (Bykov, 1979; Major, 1988). Therefore, although there are more endemics on the quartzite-derived substrates, the degree of endemicity on dolomite is higher than on quartzite. These figures can be compared with an index value of 3.57 (total number of species 1 400; area 1 115 km^2; I_e = 5.0/1.4) for the southern Drakensberg in Natal/Lesotho (statistics from Hilliard & Burtt, 1987).

The Liliaceae s.l. is the family with the largest number of endemics in the study area, followed by the Euphorbiaceae, Lamiaceae and Acanthaceae (Table 1). Both

Liliaceae and Lamiaceae also have several quartzitic endemics. Noticeable, however, is the lack of dolomite endemics among the Iridaceae (no species) and Asteraceae (one species), two families that are among the three most prolific endemic producers on the surrounding quartzitic substrates (Matthews et al., 19–). Even though large parts of the southern portion of the dolomitic region fall within the Afromontane Region, the genus *Helichrysum*, notorious for its capacity to produce regional endemics throughout this phytochorion (Hedberg, 1957; Wild, 1964; Hilliard & Burtt, 1987), does not have any dolomite endemics. At least ten species of *Helichrysum* are endemic to the quartzitic parts of the Wolkberg Centre, with several others more widespread along the rest of the eastern Transvaal Escarpment.

Prominent is also the large number of succulent *Euphorbia* species (five) endemic to the dolomite. No Euphorbiaceae were recorded among the region's quartzitic endemics. This could, perhaps in part, be attributed to the more arid climatic conditions of particularly the northern and north-western parts of the dolomitic region. The latter areas are also mostly at lower altitudes with high summer temperatures. The preponderance of succulent members of the Euphorbiaceae in the so-called Valley Bushveld vegetation of hot, arid valleys is well known in many other parts of southern Africa (White et al., 1941; Acocks, 1988).

Most dolomite endemics tend to be confined to the more arid parts of the Chuniespoort Formation. Among the few high-rainfall (and proper Afromontane) dolomite endemics are *Aloe alooides*, *A. minima* var. *blyderivierensis*, *Ozoroa* sp. nov. (a grassland suffrutex), *Salvia dolomitica*, *Scabiosa transvaalensis*, and *Pelargonium albiflora*. Again, as in the case of the quartzites (Matthews et al., 19–), there are no forest trees among the dolomite endemics. This further supports the observation that regional specific endemism in the Afromontane Region is restricted mainly to the grassland flora (Meadows & Linder, 1989, and references therein).

A phytosociological survey has shown that some of the dolomite endemics/near-endemics are diagnostic species for certain plant communities (Matthews, 1991; Matthews et al., 1991b). For example, *Orthosiphon tubiformis*, *Ozoroa* sp. nov.,

Protasparagus rigidus and *Salvia dolomitica*, all of which are associated with rocky outcrops.

Quartzitic and dolomitic endemics are nearly always mutually exclusive as to substrate preference. Only in a very few cases were Wolkberg Centre endemics recorded on both types of substrate, examples of such transgressors being *Dombeya autumnalis*, *Protasparagus rigidus* and *Scabiosa transvaalensis*.

Factors supposedly determining endemism on dolomite- and quartzite-derived soils are strongly hypothetical. The primary difference in the soils of dolomite and quartzite endemics (calcicoles and calcifuges respectively) is the high levels of calcium and magnesium in the former. It is possible that so-called calcifuge species on quartzite are more efficient in their uptake of calcium and magnesium, or that they have a lower requirement for these two elements (Larcher, 1983). Quartzite-derived soils are usually sandy, acidic, of low fertility and, especially, low in phoshorus content. From an ecological point of view, these soils would seem to constitute a very unfavourable habitat. Yet, in southern Africa, at least, such regions generally seem to have a higher degree of endemism than adjacent nutrient-rich substrates. Notable examples are the Cape flora (a remarkable example of a "geological" floristic kingdom) and the Pondoland Centre (Van Wyk, 1990). In considering the quartzitic endemics of the Chimanimani Range in Zimbabwe, Wild (1964) suggested that these adverse conditions could have contributed to the evolution of local endemics through ecological stresses resulting in intensified natural selection and perhaps an increase in mutation rate. Aluminium is generally considered to be the most growth-limiting factor associated with soil pH levels of 5.0 or below (Adams, 1981). In this regard Van Wyk (1990) has pointed out that the generally high levels of exchangeable and ionic aluminium (which is not considered an essential plant nutrient) in highly leached acidic soils could be just as important in explaining patterns of plant endemism. In order to survive on such soils, plants must either be able to tolerate the presence of aluminium in their tissues, or have developed some mechanism for excluding it. On the other hand, it has been suggested that many distributional restrictions may be related to competition rather than physico-chemical requirements (Gankin & Major, 1964; Major, 1988). For example, any substrate

different from the typical regional one may so weaken competitive dominance by the regional vegetation, that endemics find a place.

Whereas some of the dolomite endemics are relatively widespread (e.g. *Salvia dolomitica*), the distribution of others also reflects the two subcentra previously recognised among the quartzitic endemics (Matthews et al., 19–). Most of the dolomite endemics are confined to the more arid parts of the Serala Subcentre in the north, e.g. *Dicliptera fionae*, *D. fruticosa*, *Ozoroa albicans*, *Phymaspermum argenteum*, *Encephalartos dolomiticus* and *Melhania integra*. The southern Blyde Subcentre is only weakly defined by dolomite endemics, e.g. *Aloe alooides* and *Pelargonium albiflorum*.

Because the Afromontane Region is like an archipelago, many of its species, other than intruders from the lowlands and local endemics, show disjunctions (White 1981). The quartzitic and related substrates of the Wolkberg Centre harbour a number of tropical African Afromontane disjuncts, particularly species also present on comparable substrates in the eastern highlands of Zimbabwe (Matthews et al., 19–). Such disjuncts are notably absent from the dolomitic Chuniespoort Formation, most probably because this specialised type of substrate is not found in Afromontane "islands" to the immediate north and south of the Wolkberg Centre.

Although in numbers the Chuniespoort Formation is not as rich in endemics as the quartzitic and related substrates, several of its endemics are extremely rare. At least two species, *Plectranthus dolomiticus* and *Brachystelma parvulum*, are known only from the type collections. Illegal plant-collecting has almost exterminated the cycads, *Encephalartos dolomiticus* and *E. inopinus*, from the wild. These two species must therefore be considered endangered, as are the succulents *Aloe monotropa* and *Euphorbia restricta* (Fourie, 1986). That author also classified *Euphorbia barnardii* as vulnerable, and *E. grandialata* and *E. sekukuniensis* as rare.

With a combined total of about 106 endemic and near-endemic plant taxa, the Wolkberg Centre represents one of the major centres of endemism in the Transvaal. Yet, large areas of particularly the southern portion have already been destroyed, mainly

by afforestation, and invasion by alien plants. There is an urgent need for more nature reserves in the area, particularly to conserve what little is left of the grasslands. Moreover, a strong plea for the preservation of the entire Afromontane flora was made by White (1981). The Afromontane Region has complex biogeographical and evolutionary relationships. The complexity of the Afromontane flora and its outstanding scientific interest call for the conservation of the area as a whole. Existing and proposed conservation areas in the Wolkberg Centre are listed in Matthews et al. (19–). From a conservation point of view, our analysis of the region's flora has clearly emphasised the importance of taking into account the geology of the region to ensure the protection of the full biodiversity of the eastern Transvaal Escarpment.

A number of plant species are endemic to the Barberton area of the eastern Transvaal Escarpment. It has already been shown that several of these are endemic to serpentine (Balkwill & Balkwill, 1988; Morrey et al., 1989). A full assessment of the latter endemics in terms of the region's complex geology is likely to provide useful information for planners and conservationists.

ACKNOWLEDGEMENTS

The Director (Research) of the National Botanical Institute is thanked for the use of plant collecting and distributional data produced by the Pretoria National Herbarium Computerised Information System (PRECIS). The plant collecting permits provided by the Transvaal Division of Nature Conservation are acknowledged with thanks. Our appreciation to Mr Jerry Theron, Nature Conservation Officer at Swadini, for support during the field work. Mrs E. du Plessis critically read and improved the manuscript. This study was financed in part by the Foundation for Research Development and the University of Pretoria.

REFERENCES

Acocks, J.P.H. (1988). Veld Types of South Africa, 3rd ed. *Memoirs of the Botanical Survey of South Africa* **57**, 1–146.

Adams, F. (1981). Nutritional imbalances and constraints to plant growth on acid soils. *J. Plant Nutr.* **4**, 81–7.

Balkwill, K. & Balkwill, M-J. (1988). Studies on serpentine flora: A new species of Brachystelma (Asclepiadaceae). *S. Afr. J. Bot.* **54**, 60–2.

Bykov, B.A. (1979). On a quantitative estimate of endemism. *Botan. Mater. Gerb. Inst. Botan. Akad. Nauk Kazakh. SSR.* **11**, 3–8.

Deall, G.B., Scheepers, J.C. & Schutz, C.J. (1989). The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. I. Physical environment. *Bothalia* **19**, 53–67.

Ferrar, A.A., Isaacs, G. & Stacey, J.R. (eds). (1988). Environmental Conservation Features of the Transvaal Escarpment: an Information Base for Regional Planning. Ecosystem Programmes Occasional Report **31**. Foundation for Research Development, Pretoria.

Fourie, S.P. (1986). The Transvaal, South Africa, threatened plants programme. *Biol. Conserv.* **37**, 23–42.

Fourie, S.P., Jacobsen, N.H.G., Kleynhans, C.J. & Tarboton, W. (1988). Biogeographical importance and species/areas warranting particular conservation attention, In *Environmental Conservation Features of the Transvaal Escarpment*, eds A.A. Ferrar, G. Isaacs, & J.R. Stacey. Ecosystem Programmes Occasional Report **31**, 46–70. Foundation for Research Development, Pretoria.

Gamble, F. (1988). Climate of the Transvaal Escarpment, In *Environmental Conservation Features of the Transvaal Escarpment*, eds A.A. Ferrar, G. Isaacs, & J.R. Stacey. Ecosystem Programmes Occasional Report **31**, 1–4. Foundation for Research Development, Pretoria.

Gankin, R. & Major, J. (1964). Arctostaphylos myrtifolia, its biology and relationship to the problem of endemism. *Ecology* **45**, 793–808.

Gibbs Russell, G.E., Reid, C., Van Rooy, J. & Smook, L. (1985). List of species of southern African plants, ed. 2, Part 1: Cryptogams, gymnosperms and monocotyledons. *Memoirs of the Botanical Survey of South Africa* **51**, 1–152.

Gibbs Russell, G.E., Welman, W.G., Retief, E., Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M. & Nicholas, A. (1987). List of species of southern African plants, ed. 2, Part 2: Dicotyledons. *Memoirs of the Botanical Survey of*

South Africa **56**, 1–270.

Hedberg, O. (1957). Afroalpine vascular plants. *Symb. Bot. Ups.* **15**, 1–411.

Hilliard, O.M. & Burtt, B.L. (1987). The Botany of the Southern Natal Drakensberg. Annals of Kirstenbosch Botanic Gardens Vol. 15. National Botanic Gardens, Cape Town.

Kruckeberg, A.R. (1986). An essay: The stimulus of unusual geologies for plant speciation. *Systematic Botany* **11**, 455–63.

Kruckeberg, A.R. & Rabinowitz, A.R. (1985). Biological aspects of endemism in higher plants. *Ann. Rev. Ecol. Syst.* **16**, 447–79.

Larcher, W. 1983. Physiological Plant Ecology. Second edition. Springer-Verlag, Berlyn.

MacVicar, C.N., De Villiers, J.M., Loxton, R.F., Verster, E., Lambrechts, J.J.N., Merryweather, F.R., Le Roux, J., Van Rooyen, T.H. & Harmse, H.J. von M. (1977). Soil Classification. A Binomial System for South Africa. Scientific Bulletin 390. Department of Agricultural Technical Services, Pretoria.

Major, J. (1988). Endemism: a botanical perspective. In Analytical Biogeography, eds A.A. Myers & P.S. Giller. Chapman & Hall, London, pp. 117–146.

Martini, J.E.J. 1987. Limestone and Dolomite resources of the Republics of South Africa, Bophuthatswana, Ciskei, Transkei and Venda: Handbook of the Geological Survey of South Africa 9. Government Printer, Pretoria.

Matthews, W.S. (1991). The Vegetation of the North-eastern Mountain Sourveld of the Transvaal Escarpment. M.Sc. thesis, University of Pretoria.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. (1991a). The grassland-associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the north-eastern mountain sourveld of the Transvaal escarpment. *S. Afr. J. Bot.* **57**, 143–50.

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. (1991b). The vegetation of the dry dolomitic regions of the North-eastern Mountain Sourveld of the Transvaal Escarpment, South Africa. *Phytocoenologia* (in press).

Matthews, W.S., Van Wyk, A.E. & Bredenkamp, G.J. (19–). Endemic flora of the quartzitic and related rock types of the north-eastern Transvaal Escarpment, South Africa. *Biol. Conserv.* (submitted).

Meadows, M.E. & Linder, H.P. (1989). A reassessment of the biogeography and vegetation history of the southern Afromontane Region. In *Biogeography of the Mixed Evergreen Forests of Southern Africa*, ed. C.J. Geldenhuys. Ecosystem

Programmes Occasional Report **45**, 15–29. Foundation for Research Development, Pretoria.

Morrey, D.R., Balkwill, K. & Balkwill, M-J. (1989). Studies on serpentine flora: Preliminary analysis of soils and vegetation associated with serpentine rock formations in the south-eastern Transvaal. *S. Afr. J. Bot.* **55**, 171–7.

Partridge, T.C. & Maud, R.R. (1987). Geomorphic evolution of southern Africa since the Mesozoic. *S. Afr. J. Geol.* 90, 179–209.

South African Committee for Stratigraphy [SACS] (1980). Stratigraphy of South Africa. Part 1 (Compiled by L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda [also Errata compiled by F. Walraven & M.R. Johnson]: Handbook of the Geological Survey of South Africa **8**. Government Printer, Pretoria.

Stace, C.A. (1989). Plant Taxonomy and Biosystematics, 2nd ed. Edward Arnold, London.

Van Wyk, A.E. (1990). The sandstone regions of Natal and Pondoland: remarkable centres of endemism, in *Palaeoecology of Africa*, ed. K. Heine, vol. **21**. A.A. Balkema, Rotterdam, pp. 243–57.

White, A.C., Dyer, R.A. & Sloane, B.L. (1941). The Succulent Euphorbiae (Southern Africa), 2 vols. Abbey Garden Press, Pasadena.

White, F. (1978). The Afromontane Region, In Biogeography and Ecology of Southern Africa, ed. M.J.A. Werger. Junk, The Hague, pp. 463–513.

White, F. (1981). The history of the Afromontane archipelago and the scientific need for its conservation. *Afr. J. Ecol.* **19**, 33–54.

White, F. (1983). The Vegetation of Africa. Unesco, Paris.

Wild, H. (1964). The endemic flora of the Chimanimani Mountains and their significance. *Kirkia* **4**, 125–157.

TABLE 1

Family Statistics of the Plant Taxa Endemic or Near-endemic to the Dolomites of the Wolkberg Group, eastern Transvaal Escarpment (see Appendix for details)

Family	Genera	Species/subspecies
Liliaceae	3	8
Euphorbiaceae	1	5
Lamiaceae	3	4
Acanthaceae	2	3
Sterculiaceae	2	2
Anacardiaceae	1	2
Asclepiadaceae	1	2
Zamiaceae	1	2
Asteraceae	1	1
Dipsacaceae	1	1
Geraniaceae	1	1
TOTAL	17	31

APPENDIX

Seed plants endemic or near-endemic to the dolomites of the Chuniespoort Group in the Transvaal Escarpment. Near-endemics occasionally also found on quartzites and related substrates are marked with an asterisk.

GYMNOSPERMS

ZAMIACEAE

- Encephalartos dolomiticus
- E. inopinus

MONOCOTYLEDONS

LILIACEAE

- Aloe alooides
- A. dolomitica
- A. fouriei
- A. minima var. blyderivierensis
- A. monotropa
- Ledebouria sp. nov.
- Protasparagus fouriei ms.
- *P. rigidus

DICOTYLEDONS

ACANTHACEAE

- Chaetacanthus sp. nov.
- Dicliptera fionae
- D. fruticosa

ANACARDIACEAE

- Ozoroa albicans
- Ozoroa sp. nov.

ASCLEPIADACEAE

- Brachystelma minor
- B. parvulum

ASTERACEAE

- Phymaspermum argenteum

DIPSACACEAE

- *Scabiosa transvaalensis

EUPHORBIACEAE

- Euphorbia barnardii
- E. exelsa
- E. grandialata
- E. restricta
- E. sekukuniensis

GERANIACEAE

- Pelargonium albiflora

LAMIACEAE

- Orthosiphon tubiformis
- Plectranthus dolomiticus
- P. xerophilus
- Salvia dolomitica

STERCULIACEAE

- *Dombeya autumnalis
- Melhania integra

CHAPTER 5

GENERAL DISCUSSION

Synthesis

Four major vegetation groups representing the major grassland types were distinguished (Table 5.1 and Figure 5.1). This confirms that the earlier subdivisions of the total data set into four sub data sets (the four separate phytosociological tables), was adept and justifiable. Each of these, sub-data sets were then processed (refined) separately by Braun-Blanquet procedures to attain the completed phytosociological table for each of the major vegetation types. The splitting of the tables helped to distinguish communities on a sub-table, which otherwise would have remained obscured by the main data set. The splitting of the table into the four major groups is considered successful, as an ecological meaningful classification resulted.

The two other groups distinguished in Figure 5.1, namely forest (F) and woodland (W) areas, are also unique grassland associated communities. Although sufficient data was collected to distinguish and describe the communities, the data is considered inadequate to present them in separate phytosociological tables.

Vegetation group 1

Vegetation group 1 (Table 5.1) represents the vegetation of the large rock outcrops of Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the study area. This vegetation group is represented by group R in Figure 5.1. Some of the species found in this vegetation group are also found in vegetation group 2 (forest)(group F in Figure 5.1). This shows that there are affinities between the two vegetation groups although this vegetation group showing more similarities with that of grassland to that of forest (see vegetation group 11) and the forest community is therefore presented together with rock outcrop vegetation in a single table (see chapter 4, the vegetation of the Black Reef Quartzite and associated large rocky outcrops areas, Matthews et al. 1991a).

Vegetation group 2

Vegetation group 2 represents a unique community, namely the forests of the study area. These forests can be in the form of small clumps, forested kloofs found

throughout most of the study area and the large areas of forest associated with the Transvaal Escarpment. Species of the forests are rarely found in the other plant communities.

Vegetation group 3

Vegetation group 3 represents the high altitude hygrophilous grassland regions of the North-eastern Mountain Sourveld of the study area. These communities are presented in a separate phytosociological Table (Chapter 4, the vegetation of the high altitude hygrophilous grassland areas, Table 2). The sporadic occurrence through mostly the low country, of the species of this vegetation group, indicates a floristic relationship between the high and low altitude vegetation types.

Vegetation group 4

Vegetation group 4 represents the vegetation of the relatively low altitude grassland of the North-eastern Mountain Sourveld of the study area. These communities are presented in a separate phytosociological Table (Chapter 4, the vegetation of the relatively low altitude grassland areas, Table 2). Some communities from this vegetation group show floristic affinities with the vegetation of the dry dolomitic grasslands (vegetation group 6).

Vegetation group 5

Vegetation group 5 represents the species common to the high altitude hygrophilous grasslands and to the relatively low altitude grassland regions, thereby showing that these two vegetation types are floristically closely related. These two grassland types cover the greatest part of the study area.

Vegetation group 6

Vegetation group 6 represents the vegetation of the dry dolomitic regions of the North-eastern Mountain Sourveld of the study area. These communities are presented in a separate phytosociological Table (Chapter 4, the vegetation of the dry dolomitic grassland areas, Table 2.; Matthews et al. 1991b). This vegetation group displays a great variety of plant communities with unique species combinations. Some of the species

found in this vegetation group are also found in vegetation group 7 (woodland areas). This shows that there are affinities between the two vegetation groups, these the drier vegetation types of the study area.

Vegetation group 7

Vegetation group 7 represents a unique community, namely the woodland areas. These woodland areas are mostly in the form of small clumps or wooded kloofs, found spread through the dry dolomitic regions of the study area. As the emphasis of this study is on grassland vegetation, these woodlands have been sampled inadequately to be presented in a separate phytosociological table, and is therefore included in the table of the dry dolomitic regions, to which it is associated.

Vegetation group 8

Vegetation group 8 represents the species common to the woodland areas (vegetation group 7) as well as to the dry dolomitic vegetation regions, thereby confirming that these two vegetation types are floristically related, these the drier vegetation types of the study area.

Vegetation group 9

Vegetation group 9 represents the species common to the relatively low altitude vegetation as well as to the dry dolomitic vegetation regions, thereby showing that these two vegetation types are floristically related. It is also can be concluded that the relatively low altitude vegetation regions are warmer and dryer than the high altitude hygrophilous vegetation regions, the last mentioned having very few species common to dry dolomitic vegetation regions.

Vegetation group 10

Vegetation group 10 represents the species common to high altitude hygrophilous vegetation, to relatively low altitude vegetation regions and to the dry dolomitic vegetation regions, thereby showing that these three vegetation types are closer associated to each other than to the vegetation of the large rock outcrops of Black Reef Quartzite and other large rocky outcrops.

Vegetation group 11

Vegetation group 11 represents the species common to all four major vegetation groups, thereby showing that all four these vegetation types are associated with each other, collectively representing Acocks' (1988) North-eastern Mountain Sourveld. Many of Acocks' (1988) North-eastern Mountain Sourveld character species are found in the general species group (this vegetation group) as well as in the general species of the four different major grassland types. Although the vegetation is comparable, the areas mapped by Acocks are not always North-eastern Mountain Sourveld vegetation areas.

Other work done on similar grassland types or in the case of Deall (1985), on the North-eastern Mountain Sourveld, was found. The work of Bloem (1988) showing similarities, but his general species are not the general species of this grassland type. The grassland, part of Acocks' (1988) Pondoland Coastal Plateau Sourveld, described by Shackleton (1989) interestingly showing similarities to this grassland type, specifically his *Tristachya leucothrix* - *Loudetia simplex* short grassland community, the dominant grassland of Mkambati Game Reserve.

It is also interesting to note that Bloem's (1988) area falls under one of Acocks'(1988) Pure Grassland types whereas Shackleton's (1989) area and this study area falls under one of the tropical forest types. Shackleton's (1989) study area represents the Coastal Tropical Forest type, and this work, the Inland Tropical Forest type. This confirms Acocks', major separation between the pure grassland and tropical forest types. Further research on these two possibly related grassland types could result in interesting findings.

Discussion

The purpose of this study was to classify the vegetation of the North-eastern Mountain Sourveld of the Eastern Transvaal Escarpment. The objectives were:

1. to determine homogeneous vegetation units/habitat units for use in conservation, management and landuse planning programmes. Included was the recognition of scarce and endemic plant species and their localities, that these areas may receive special attention with planners and managers; and
2. to compile a syntaxonomic classification of the grassland of this region as part of the envisaged syntaxonomic classification of grasslands of South Africa.

Sampling

This region of the Transvaal is quite mountainous and many of the areas undeveloped, many areas are inaccessible by road. Also many of the roads which are present, are rough and use of specialized vehicles is necessary in many parts. In wet weather these roads become impassable to even the specialized vehicles. Many areas, specifically to the north, have no access roads and survey work can only be done by long treks on foot or by other more extravagant means, helicopters.

The subjective stratified sampling method was found to be an effective and efficient method to use under these conditions, as samples placed randomly could be positioned in inaccessible places which could be very difficult to reach. Secondly the area being a topographically complex mosaic, a great number of sample plots would have to randomly be placed to attain adequate samples in each recognized stratification units, therefore less samples need be used. The successful classification of the vegetation and meaningful ecological interpretation of the plant communities, proved that this sampling method, as discussed, was successful in this study.

The use of land types for stratification as well as interpretation, which could ensure efficient and effective sampling of the major variations in the vegetation and environment (Bezuidenhout, 1988; Kooij, 1990) did not prove to be such a useful criteria, due to the extreme complex mosaic distribution pattern of the land types in this area.

The size and nature of the study area, as well as the variation of the vegetation connected to the scale of the study and number of sample plots, resulted in some plant communities described and classified by using only a few relevés. It must be stress, however, that each of these communities can ecologically be interpreted.

Floristic survey

The Braun-Blanquet survey method, recording all recognizable species present in the sample plots is considered successful. This does not only result in a meaningful classification, but provides valuable information on the distribution of many rare, endangered or endemic species (Matthews et al. 19- b&c), while acceptable ecological interpretation of the communities recognized, could be made from the data obtained from habitat survey.

Habitat survey

Significant ecological interpretation of each plant community was made, due to adequate habitat data for each sample plot. The importance of a comprehensive habitat survey so as to interpret the plant communities obtained is also emphasized by Bredenkamp (1982). Habitat factors found to be of importance with regard to plant community distributions in this study area include rainfall, exposure to mist, altitude, geology, rockiness, soil, latitude distribution and biotic factors such as fire and grazing. Temperature could also be a factor but no comparative data was available to substantiate this. This list is not to be taken as all habitat factors or the order of importance of factors, as this may vary throughout the study area according to the interaction of the habitat factors (Bredenkamp, 1982).

Data processing

The process of first using the TWINSPAN classification algorithm (Hill 1979b) to identify the preliminary groups and communities and thereafter to refine the data table by means of Braun-Blanquet procedures proved to be very efficient (as for the results obtained are concerned).

This study also emphasizes the findings of Bredenkamp (1982), Bezuidenhout (1988) and Kooij (1990) in that it is difficult to demonstrate meaningful and ecologically justifiable variation in heterogeneous but related vegetation in a single large, phytosociological table. Comprehensive, major vegetation types, with many diagnostic species can easily be recognized in a single table. However, plant communities of lower ranks are often characterized by differential species which may also occur in other floristically and environmentally related communities. The identification of these plant communities of lower rank can be difficult in a single large table as they can be obscured by the large total data sets arrangement of relevés and species.

The necessity to compare the different communities from separate phytosociological tables is stressed by Werger (1973) and Bredenkamp (1975 & 1982). Bredenkamp (1982) stresses the use of an synoptic table so as to highlight floristic characteristics as well as the interrelationships between all the plant communities distinguished in the separate tables. The two-step classification principle (Van der Maarel et al. 1987) was applied successfully to create a synoptic table which included all

the phytosociological data sets. The results attained by the synoptic table were successfully interpreted, relationships found, and therefore the synthesis is deemed successful.

General

The plant communities distinguished and classified in this study are ecological entities and as such can form the basis of vegetation management units (fundamental prerequisite for ecological based rational land-use planning (Pentz 1938; Bayer 1970; Walker 1976; Van Rooyen et al. 1981; Moore & Chapman 1986; Ferrar et al. 1988)) in the North-eastern Mountain Sourveld of the Transvaal Escarpment.

The species identified as endemics, their possible localities (distribution) and relationships with other floras can help to recognize and emphasize important areas for the preservation and conservation of the flora of the North-eastern Mountain Sourveld of the Transvaal Escarpment as well as for the flora of Afromontane regions of Africa.

The identification of homogeneous units, identification and description of habitats, identification and distribution of endemics would facilitate management and land-use planning on a regional or local level. Thereby understanding the environment, problem areas or areas of importance would be recognized and receive the necessary attention. Areas recognized as sensitive or important for flora conservation could be declared or managed as nature reserves, or those areas not deemed sensitive or important left for habitat destructive developments such as a monocultures (forestry plantations).

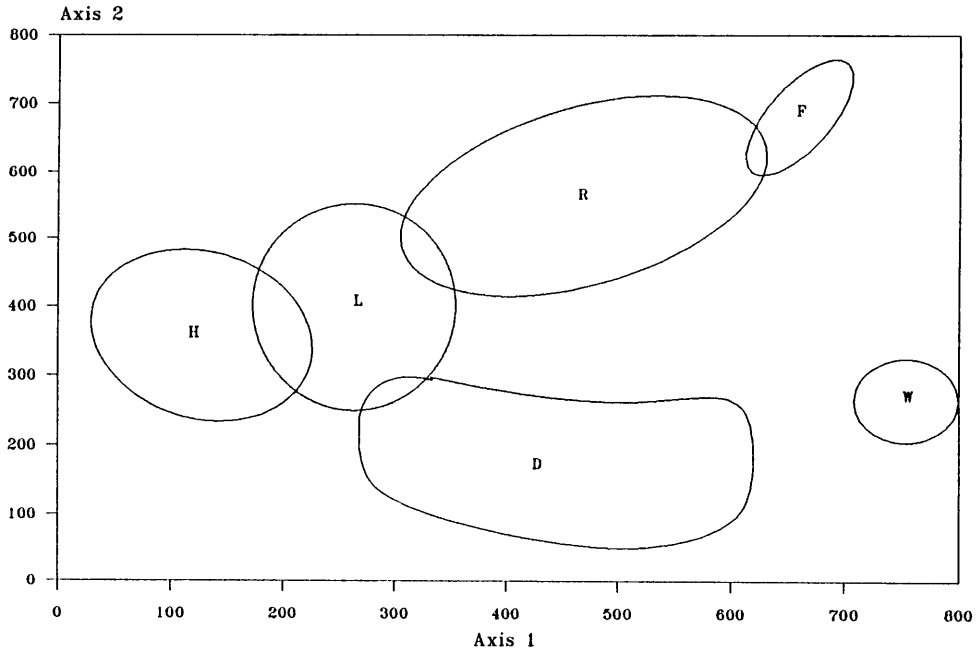

Figure 5.1. A DECORANA of the vegetation of the North-eastern Mountain Sourveld of the Transvaal Escarpment in the study area.

R- Vegetation of the Black Reef Quartzite and associated large rocky outcrops areas

H- Vegetation of the high altitude hygrophilous areas

D- Vegetation of the dry dolomitic areas

L- Vegetation of the relatively low altitude vegetation areas

F- Forested areas

W- Woodland areas

TABLE 5.1. A Synoptic Table of the North-eastern Mountain Sourveld of the Eastern Transvaal Escarpment.

	I	II	III	IV
Synoptic community number	00000 11222 89012	00000000 22222223 34567890	0000000 0000000 1234567	0000000000 0011111111 8901234567
Vegetation group 1				
Myrsine africana	41 5			1
Asplenium friesiorum	4			
Pterocelastrus echinatus	4 2			
Stachys reticulata	3			3
Helichrysum polycladum	3 21			1
Vaccinium exul	21			
Cliffortia serpyllifolia	21			
Lycopodium cernuum	2		1	
Anthospermum welwitschii	21		11	
Canthium inerme	21			11
Bryophyta sp	2	2		1
Cheilanthes inaequalis	2			
Hebenstretia dura	2			
Indigofera melanadenia	1442		1 11	2
Helichrysum reflexum	33		1	
Pentaschistis natalensis	23			
Syncolostemon eriocephalus	13		1	
Protea roupelliae	3	1 2	11	1
Eragrostis acraea	12			
Senecio oxyriifolius	12 1	122	11 1	1
Rhynchosia thorncroftii	12 1			
Rumohra adiantiformis	4			
Cheilanthes viridis	41			1 1
Aloe arborescens	5451			1
Rhus tumulicola	535		2 1	1
Senecio junodii	445		1	
Plectranthus rubropunctatus	355		11	241
Scleria transvaalensis	345		1	
Passerina montana	424			
Otiophora cupheoides	334			
Cheilanthes multifida	322			
Ekebergia pterophylla	234			1
Protasparagus rigidus	222			21
Crassula sarcocaulis	122			
Erica cafforum	212		11 1	22
Trichopteryx dregeana	3 4			
Helichrysum rudolfii	44 2		21	
Melinis nerviglume	2 41		121 1	21 12
Bequaertiodendron magalismontanum	11 4			
Bulboststylis burchellii	11 4		21 12	1
Schizachyrium sanguineum	1 23	1 1	13	121 2
Helichrysum kraussii	4		11	
Landolphia capensis	2		1	1 1

Aristida aequiglumis	2			1
Dicoma anomala	2		2 1 1	2
Smilax kraussiana	23433			
Rapanea melanophloeos	33213		1	1
Cyperus pseudoleptocladus	4122			
Myrica pilulifera	432 5		11 1	
Ochna sp.	2 213		1	11 1
Psychotria capensis	2 2 5			

Vegetation group 2

Maytenus acuminata	5			
Psychotria zombamontana	5			
Xymalos monospora	5			
Schrebera alata	5			
Schefflera umbellifera	2 5			
Podocarpus latifolius	11 5			
Zanthoxylum davii	3			
Trimeria grandifolia	3			
Strophanthus speciosus	3			
Streptocarpus sp.	3			
Pavetta kotzei	3			
Oplismenus hirtellus	3			
Ilex mitis	3			
Halleria lucida	3			
Ficus craterostigma	3			
Bersama swinnyi	3			
Clivia sp.	3			
Maytenus mossambicensis	3			
Plectranthus grallatus	3			
Mackaya bella	3			
Peddiea africana	3			
Rhus chirindensis	1 3			
Maesa lanceolata	1 3			

Vegetation group 3

Helichrysum adenocarpum	2	3 1 211	1 1	
Tetraria natalensis		3 1 2		
Pimpinella transvaalensis		3 1 2	1	
Erica woodii	1	3 1	2	
Panicum ecklonii		22 1 1	11	
Hemizygia subvelutina		1311	1	
Sebaea rehmannii		21	1	
Stachys simplex		12	1	
Monsonia glauca		4	11	
Satyrium longicauda		3 2	1	
Senecio coronatus		13	1 1	
Helichrysum glomeratum		113	1 111	12
Helichrysum spiralepis		2		
Eucomus autumalis	2	12	1	1 1
Aster lydenburgensis		2	1 1	2
Sebaea sedoides		112	11	
Crassula vaginata	11	3224	1111	1
Wahlenbergia squamifolia		3112	1 12	1
Craterocapsa tarsodes		1211	1 1	
Scilla nervosa		1122	1 1 4	

Drosera madagascariensis		1 1 2	1		
Scirpus ficinioides		2 2			
Helichrysum mariepscopicum		22			
Xyris nivea	1	1 223	11		
Eragrostis curvula		1 2215	1 1	43 21	
Selago hyssopifolia		1 1 4			
Helichrysum umbraculigerum		1 3	1		
Festuca costata	2	53555 3	1		
Helichrysum platypterum	2	32212 2	1 1		
Rabdosiella calycina	144	32122 4	1 11	1	
Lobelia flaccida		1 233 34	1 1		
Monopsis decipiens		22245	1 2		
Clutia sp.		2 2 1	11		

Vegetation group 4

Faurea speciosa			211		
Acalypha sp.	2		123 1	1	
Helichrysum miconiifolium			2	1	
Gnidia kraussiana		1 2	2 1	2	
Protea caffra		1	21	11	
Gnidia capitata			121	1	
Monsonia attenuata			21	1	
Koeleria capensis		1 1	111		
Hypoxis Filiformis			2 1		
Euryops pendunculatus			1 2		
Cyanotis speciosa	1	2	1 3	1 2	
Sebaea grandis			1 112		
Panicum natalensis	21 2		235432	4531	
Helichrysum oreophilum	1 2		2211121	52	
Zornia capensis			31111 1	5	
Ctenium concinnum			132211		
Gnidia caffra			21 222	2	
Eulalia villosa	2	2	23133	44 22	
Indigofera sanguinea		11	33323	23 5	
Inezia integrifolia			2211		
Rhynchosia monophylla	21	1	2 1 121	1	
Senecio erubescens	1		1 21 2	4	
Kallinga alba			11 1		
Cyphia stenopetala			1 111		
Lotononis eriantha			111 1		

Vegetation group 5

Alloteropsis semialata		12532224	321333	221	
Rendlia altera		3544221	2214343	43	
Haplocarpha scaposa		1323 1 2	2212311	1 22	
Sopubia cana		3111 41	1221		
Phymaspermum acerosum	2	11 31 5	12 11	1 1	
Alepidea gracilis		54122	211 11	2	
Schistostephium crataegifolium	1	3 121 3	11 2	2	
Helichrysum aureonitens		1 12245	2 1122	1	
Stiburus alopecuroides	1	11 2153	1112		
Helichrysum cephaloideum	1	311321	1 1112		
Eriosema ellipticifolium		232 1 2	1252 3	4	
Helichryum acutatum		5112 3	2 1 22	15	
Helichrysum pilosellum	1	343421	121 23	14	

Cephalaria pungens		111221	2 112 1	14	
Bulbostylis oritrephes	1	1112	11221 2	12	
Nidorella auriculata		1 23 2	1 11	2	
Cyperus obtusiflorus		2 21	2 11 1	1	
Pentanisia prunelloides		42 2	211 2		
Andropogon schirensis	1223	4241 122	224443	1 1	
Tetraselago wilmsii	2122	21 1 1	114	4 1	
Monocymbium ceresiiforme	1 2	5332222	4445554	4 2	
Eragrostis sclerantha	1 2	2 1	1 11241		

Vegetation group 6

Conyza bonariensis				52 1 1	
Pseudarthia hookeri				42 1 11	
Oenothera tetraptera				34	
Wahlenbergia krebsii			2 11	22	
Helichrysum rugulosum			1	441 1	
Cassia mimosoides			1	231 1 1	
Hyparrhenia tamba				5 11	
Verbena bonariensis				3	
Mariscus sumatrensis				2	
Agrimonia odorata				2	
Andropogon eucomis				2 1	
Leucas glabrata			1	2	
Hypericum aethiopicum			11 11	1 2 2	
Pearsonia obovata		112	1 3 1 2	4	
Becium obovatum		1 11	2 1	4	
Dicoma anomala			1	2	
Argyrolobium lancifolium		1	1	3 1 1	
Inulanthera calva				3	
Aristida congesta				2 1	
Cassia italica			1	2	
Crabbea hirsuta			1 1	1 2 1	
Helichrysum herbaceum			21	22	
Barleria ovata				524	
Scabiosa columbaria			11	31	
Triumfetta welwitschii			2	2 121	
Euphorbia sp.				2 2	
Ozoroa sp. nov.			1	23	
Pygmaeothamnus zeyheri			21 1	211	
Aloe castanea				15	
Diospyros whyteana				14	
Ruellia cordata				1 4	
Orthosiphon tubiformis				1 1113	
Gerbera jamesonii				3	
Phyllanthus sp.			1	2	
Enneapogon scoparis				2	
Euclea crispa				121	
Cheilanthes multifida				12	
Helichrysum uninervium				1 12	
Cyphia elata			1	112	
Xerophyta viscosa				11	
Triraphis andropogonoides				1 112	
Catha edulis				12	
Rhynchosia nitens				1 34	
Maytenus tenuispina			1	1 1134	
Xerophyta retinervis				2 23	

Dombeya rotundifolia				22
Seemannaralia gerrardii				22
Sutera accrescens				2 2 22
Heteropogon contortus			1	2 12
Lannea edulis				22212
Turbina oblongata			31	1 12212
Elionurus muticus				2111
Hyparrhenia filipendula			2	45 23422
Helichryum nudifolium		1 2 2	2 1	441 32222
Senecio microglossum			21	12 222211
Setaria sphacelata			1 1	22 221112
Melinis repens	2 2		2 1	133 11212
Athrixia phylicoides			2 1	121 11114
Tenrhynea phylicifolia			2	2 221112
Eragrostis capensis			1	22 2 22 1
Hyparrhenia hirta			1	22 1122
Vernonia oligocephala		1 3	1	2 2 1211
Cymbopogon excavatus				13 1332
Cymbopogon validus		3	3	1221 14
Bewsia biflora			32	1 354212
Pellaea calomelanos	11 4		1	2 22222
Hermannia staurostemon			2	231 124
Hemizygia transvaalensis			3	23232
Geigeria elongata			2	4 3331

Vegetation group 7

Acacia ataxacantha				1 5
Celtis africana				4
Rumex sagittatus				4
Ipomoea purpurea				4
Ziziphus mucronata				1 4
Combretum erythrophyllum				1 4
Rubus sp.				1 4
Helinus integrifoius				124
Ficus ingens				123
Acacia karroo				1 3
Calpurnia aurea				3
Rhamnus prinoides				13
Grewia occidentalis				1 2
Panicum maximum				1 2
Momordica foetida				2
Buddleja salviifolia				2
Buddleja auriculata				1 2
Dombeya pulchra				2
Ipomoea sp.				2
Acacia mearnsii				2

Vegetation group 8

Rhoicissus tridentata				1342
Rhus dentata				1 1 1343
Lippia javanica				34 252342
Diospyros lycioides			1	1222322245

Vegetation group 9

171

Pentanisia angustifolia			441 121	242411
Anthospermum pumilum	2		21 22	14122531
Hermannia lancifolia			1111 2	23221223
Diheteropogon amplectens	2		4411	3224411
Fadogia tetraquetra	1 4		41	21 431
Indigofera atrata			23 11	431441
Senecio venosus	3		21 4	2 11123
Hypoxis galpinii			111 12	2224
Thesium costatum			2 12	2 2 321
Raphionacme galpinii	2		12 1	2 2 1
Berkheya insignis	2		121 1	2 2
Hypoxis rigidula	2		421	2 33321
Rhus discolor			111 11	311 22
Acalypha angustata			2 1 12	3 23311

Vegetation group 10

Themeda triandra		212242 4	33132 1	22253342
Vernonia natalensis		13332 12	321 222	21332
Oxalis obliquifolia		21122 1	1 2	221 11111
Clutia monticola		2 222	121 221	55122
Tristachya leucothrix		1113 11	23	1 121
Aristida junciformis		1 1 422	1 1	1 12
Lopholaena disticha		21 21	21 31	221
Protea gaguedi		3111	33 12 1	3 111
Polygala hottentotta		1 1 1	11	2 4

Vegetation group 11

Aeschynomene nodulosa	5323	22223 2	4344235	53211
Loudetia simplex	1225	12 42	5554342	1 4255412
Commelina africana	32 3	2132313	2211124	13132
Trachypogon spicatus	222	3233	2423324	422121
Eriosema angustifolium	121	212	21 1142	2 2211
Diheteropogon filifolius	22	2433231	1232225	421
Eragrostis racemosa	1 2	3434322	3354445	442531
Loudetia sp.	22	32322 2	12424 2	35 11
Pteridium aquilinum	2243		23 23	1 12 11 2
Microchloa caffra	1	3 24	11 211	2 1 1
Berkheya echinacea	1	1111	1 12 4	3 21
Pearsonia sessilifolia	1 3	1112	2321112	4 1 12
Crassula alba	1121	12 2	12	11
Vernonia centaureoides	1 3		2	2
Parinari capensis	3		222	32132
Helichrysum wilmsii	2 2	2 1 2	11	12
Sporobolus pectinatus	2	2 11 1	13 4	1 1

I Vegetation of the Black Reef Quartzite and associated large rocky outcrops

II Vegetation of the high altitude hygrophilous areas

III Vegetation of the relatively low altitude areas

IV Vegetation of the dry dolomitic areas

CHAPTER 6.

CHECK LIST

A checklist of all the species collected or recorded during the survey is presented. The aim of the checklist is to provide an overview of the flora of the region and provide information on voucher species names or the distribution of the taxa. The families and species are arranged alphabetically, making the locating of species simple. In the list taxon names are followed by author names, and in the case of Genera, also by a number (without parenthesis) according to De Dalla Torre & Harms (1958) except for the ferns which is according to Gibbs-Russell et al. (1985). Exotic taxa are marked with a asterisks.

The list was compiled by including all species collected and recorded by W.S. Matthews as well as some species collected by A.E. van Wyk while preparing this thesis. Species taken up in the H.G.W.J. Schweickerdt Herbarium (PRU) collection, which were collected by W.S. Matthews, are followed by a number (voucher number) in parenthesis. Those collected by A.E. van Wyk, the voucher number are preceded by the letters AEW. The species were identified by the Pretoria National Herbarium (PRE), Pretoria and the H.G.W.J. Schweickerdt Herbarium (PRU), University of Pretoria. Scientific names of taxa conform to those of Gibbs-Russell et al. (1985, 1987, 1990), and subsequent changes and additions published in many different issues of Bothalia.

The flora of the region is represented by 823 species, including infra - specific taxa. The relationship between the number of families, genera and species (including infra - specific taxa) of the Pteridophyta, Gymnospermae, Monocotyledonae and Dicotyledonae is given in Table 1. The most prominent families (families represented by more than 7 different species) is given in Table 2.

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

	Families		Genera		Species	
	No.	%	No.	%	No.	%
Pteridophyta	12	10.0	13	3.0	24	2.9
Gymnospermae	2	1.7	2	0.5	3	0.4
Monocotyledonae	14	11.7	124	28.7	223	27.1
Dicotyledonae	91	76.4	293	67.8	573	69.6
TOTAL	119		432		823	

Table 2. Most Prominent Families (families represented by more than 7 species).

Asteraceae	118
Poaceae	93
Fabaceae	74
Liliacaeae	44
Rubiaceae	30
Lamiaceae	24
Scrophulariaceae	23
Orchidaceae	21
Iridaceae	20
Cyperaceae	18
Anacardiaceae	14
Celastraceae	14
Crassulaceae	10
Acanthaceae	9
Euphorbiaceae	9
Proteaceae	9
Thymelaeaceae	9
Amaryllidaceae	8
Asclepiadaceae	8
Ericaceae	8
Polygalaceae	8
Selaginaceae	8
Total species	579

Table 3. Most Prominent Genera (genera represented by six or more species).

Helichrysum	38
Senecio	14
Indigofera	14
Aloe	12
Rhus	11
Eragrostis	10
Maytenus	9
Vernonia	8
Crassula	8
Habenaria	7
Erica	7
Gnidia	7
Rhynchosia	7
Aristida	7
Andropogon	6
Hyparrhenia	6
Hypoxis	6
Berkheya	6
Protea	6
Polygala	6

PTERIDOPHYTA

Adiantaceae
- *Cheilanthes* Swartz 340
- *Cheilanthes eckloniana* (Kunze) Mett. (555)
- *Cheilanthes inaequalis* (Kunze) Mett. var. *inaequalis* (506)
- *Cheilanthes multifida* (Swartz) Swartz subsp. *lacerata* N.C. Anthony & Schelpe (560)
- *Cheilanthes viridis* (Forssk.) Swartz var. *viridis* (485)

- *Pellaea* Link 360
- *Pellaea calomelanos* (Swartz) Link (566)
- *Pellaea pectiniformis* Bak. (510)

Aspidiaceae
- *Rumohra* Raddi 660
- *Rumohra adiantiformis* (G. Forst.) Ching (912)

Aspleniaceae
- *Asplenium* L. 520
- *Asplenium aethiopicum* (Burm. f.) Becherer (508, 591)
- *Asplenium friesiorum* C. Chr. (507)

Blechnaceae
- *Blechnum* L. 690
- *Blechnum capense* (L.) Schlecht.
- *Blechnum tabulare* (Thunb.) Kuhn

Cyatheaceae
- *Cyathea* J.E. Sm. 180
- *Cyathea dregei* Kunze

Davalliaceae
- *Oleandra* Cay. 510
- *Oleandra distenta* Kunze (509)

Dennstaedtiaceae
- *Pteridium* Scop. 260
- *Pteridium aquilinum* (L.) Kuhn

Equisetaceae
- *Equisetum* L. 50
- *Equisetum ramosissimum* Desf.

Lomariopsidaceae
- *Elaphoglossum* Schott 580
- *Elaphoglossum acrostichoides* (Hook. & Grev.) Schelpe (559)

Lycopodiaceae
Lycopodium L. 20
Lycopodium carolinianum L. var. *grandifolium* Spring (805)
Lycopodium cernuum L. (580)
Lycopodium gnidioides L. f. (461)

Osmundaceae
Osmunda L. 80
Osmunda regalis L.

Schizaeaceae
Mohria Swartz 120
Mohria caffrorum (L.) Desv. (484)
Mohria caffrorum (L.) Desv. var. *caffrorum* (484)

Selaginellaceae
Selaginella Beauv. 30
Selaginella dregei (Presl) Hieron. (498)
Selaginella kraussiana (Kunze) A. Braun

GYMNOSPERMAE

Cupressaceae
Widdringtonia Endl. 38
Widdringtonia nodiflora (L.) Powrie (AEW 10534)

Podocarpaceae
Podocarpus L' Herit. 13
Podocarpus falcatus (Thunb.) R. Br. ex Mirb.
Podocarpus latifolius (Thunb.) R. Br. ex Mirb. (AEW 10543)

MONOCOTYLEDONAE

Amaryllidaceae
Apodolirion Bak. 1187
Apodolirion buchananii Bak.

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

Brunsvigia Heist. 1177
Brunsvigia cf. natalensis Bak.

Clivia Lind. 1170
Clivia caulescens R. A. Dyer
Clivia miniata Regel

Cyrtanthus L. F. 1191
Cyrtanthus tuckii Bak.

Nerine Herb 1175
Nerine filifolia Bak.

Scadoxus Raf. 1167a
Scadoxus puniceus (L.) Friis & Nordal

Commelinaceae
Commelina L. 896
Commelina africana L. (309)
Commelina cf. modesta Oberm.

Cyanotis D. Don 904
Cyanotis lapidosa Phill. (460)
Cyanotis speciosa (L. f.) Hassk.

Cyperaceae
Bulbostylis Kunth 471a
Bulbostylis burchellii (Fical. & Hiern) C.B. Cl. (295)
Bulbostylis contexta (Nees) Bodard (452)
Bulbostylis oritrephes (Ridley) C.B. Cl. subsp. *australis* B.L. Burtt (354)

Carex L. 525
Carex mossii Nelmes (689)
Carex spicato-paniculata C.B. Cl. (554)

Cyperus L. 459
Cyperus leptocladus Kunth (296)
Cyperus obtusiflorus Vahl
Cyperus pseudoleptocladus Kuekenth. (500)
Cyperus schlechteri C.B. Cl. (699)

Isolepis R. Br. 468
Isolepis fluitans (L.) R. Br. (463)

Kyllinga Rottb. 462
Kyllinga alba Nees (436)

Mariscus Gaertn. 459c
Mariscus congestus (Vahl) C.B. Cl. (877)
Mariscus sumatrensis (Retz.) J. Raynal (743)

Rhynchospora Vahl 492
Rhynchospora brownii Roem. & Schult. (823)

Scirpus L. 468
cf. *Scirpus ficinioides* Kunth (517)

Scleria Berg. 515
Scleria sp. (804)
Scleria transvaalensis E.F. Franklin (446)

Tetraria Beauv. 494
Tetraria natalensis (C.B. Cl.) Koyama (344)

Dioscoreaceae
Dioscorea L. 1252
Dioscorea sylvatica (Kunth) Eckl. var. *sylvatica* (AEW 10539)

Eriocaulaceae
Eriocaulon L. 828
Eriocaulon abyssinicum Hochst. (890)
Eriocaulon dregei Hochst. var. *sonderianum* (Koern.) Oberm. (803)

Hypoxidaceae
Hypoxis L. 1230
Hypoxis angustifolia Lam. var. *angustifolia* (337)
Hypoxis filiformis Bak. (719)
Hypoxis galpinii Bak. (717)
Hypoxis cf. kraussiana Buchinger (718)
Hypoxis obtusa Burch. ex Edwards
Hypoxis rigidula Bak. var. *rigidula* (645,716)

Iridaceae
Anomatheca Ker 1316a
Anomatheca grandiflora Bak.

Aristea Ait. 1295
Aristea ecklonii Bak. (693)

Crocosmia Planch. 1306
Crocosmia aurea Planch.
Crocosmia paniculata (Klatt) Goldbl.

Dierama K. Koch 1303
Dierama sp. (444,633)
Dierama medium N.E. Br.

Dietes Salisb. ex Klatt
Dietes grandiflora N.E. Br.

Gladiolus L. 1311

Gladiolus ecklonii Lehm. subsp. *ecklonii* (340)
Gladiolus exiguus G.J. Lewis (307,341,907)
Gladiolus longicollis Bak. var. *platypetalus* (Bak.) Oberm. (759)
Gladiolus sp. (800)
Gladiolus varius f. Bol. var. *micranthus* (Bak.) Oberm. (526)

Hesperantha Ker-Gawl. 1301
Hesperantha baurii Bak.

Moraea Mill. 1265
Moraea elliotii Bak. (569,636)
Moraea cf. spathulata (L. f.) Klatt

Romulea Maratti 1261
Romulea campanuloides Harms var. *campanuloides* (833)

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

Watsonia Mill. 1315
Watsonia transvaalensis Bak. (AEW 10525)
Watsonia densiflora Bak.
Watsonia wilmsii L. Bol. (342)

Juncaceae

Juncus L. 936
Juncus effusus L. (691)

Liliaceae

Agapanthus L. Herit. 1046
Agapanthus inapertus Beauv.

Albuca L. 1079
Albuca sp.

Aloe L. 1026
Aloe alooides (L. Bol.) V. Druten
Aloe arborescens Mill.
Aloe dolomitica Groenewald
Aloe greatheadii Schonl. var. *greatheadii* (909)
Aloe integra Reynolds
Aloe marlothii Berger
Aloe minima Bak. var. *blyderivierensis* (Groenewald) Reynolds
Aloe modesta Reynolds (331)
Aloe nubigena Groenewald
Aloe parvibracteata Schonl. (920)
Aloe sessiliflora Pole Evans

Aloe thompsoniae Groenewald (AEW 10526)

Androcymbium Willd. 969
Androcymbium melanthioides Willd. var. *striatum* (Hochst.) Bak. (831)
Androcymbium sp.

Anthericum L. 989
Anthericum angulicaule Bak. (703)
Anthericum longistylum Bak. (652)

Behnia Didr. 1147
Behnia reticulata (Thunb.) Didr.

Bowiea Harv. ex Hook. f. 1011
Bowiea volubilis Harv. ex Hook. f.

Bulbine Willd. 985
Bulbine sp.

Chlorophytum Ker-Gawl. 990
Chlorophytum bowkeri Bak. (483,798)

Dipcadi Medik. 1084
Dipcadi gracillimum Bak. (697)

Dracaena Vand. ex L. 1109
Dracaena hookerana K. Koch

Drimia Jacq. ex Willd. 1082
Drimia sphaerocephala Bak. (694)

Eriospermum Jacq. ex Willd. 1012
Eriospermum abyssinicum Bak. (665)

Eucomis L'Herit. 1088
Eucomis sp.

Kniphofia Moench 1024
Kniphofia linearifolia Bak. (486)

Ledebouria Roth. 1090a
Ledebouria cooperi (Hook. f.) Jessop (696)

Litttonia Hook. 964
Litttonia modesta Hook.

Lilium L. 1072

Lilium formosanum (Bak.) Wallace *

Myrsiphyllum Willd. 1113a
Myrsiphyllum asparagoides (L.) Willd. (867)
Myrsiphyllum ramosissimum (Bak.) Oberm. (AEW 10537)

Ornithogalum L. 1089
Ornithogalum tenuifolium Delaroche subsp. *tenuifolium* (676)

Protasparagus Oberm. 1113
Protasparagus rigidus (Jessop) Oberm. (558)
Protasparagus virgatus (Bak.) Oberm. (408)

Sansevieria Thunb. 1110
Sansevieria hyacinthoides (L.) Druce

Scilla L. 1086
Scilla natalensis Planch.
Scilla nervosa (Burch.) Jessop (667)

Smilax L. 1151
Smilax kraussiana Meisn.

Trachyandra Kunth 985a
Trachyandra reflexipilosa (Kuntze) Oberm. (475)

Tulbaghia L. 1047
Tulbaghia acutiloba Harv.
Tulbaghia coddii Vosa & Burbidge (730)
Tulbaghia ludwigiana Harv. (683)

Urginea Steinh. 1080
Urginea kniphofioides Bak. (684)

Orchidaceae

Brownleea Harv. ex Lindl. 1433
Brownleea galpinii H. Bol. subsp. *galpinii* (881)

Corycium Swartz 1440
Corycium dracomontanum Parkman & Schelpe (492)

Cynorkis Thouars 1421
Cynorkis kassneriana Kraenzl. (432)

Disa Berg. 1434
Disa saxicola Schltr. (374)
Disa stachyoides Reichb. f.

Eulophia R. Br. ex Lindl. 1648
Eulophia streptopetala Lindl.

Habenaria Willd. 1422
Habenaria chlorotica Reichb. f. (874)
Habenaria dives Reichb. f.
Habenaria dregeana Lindl. (352)
Habenaria falcicornis (Burch. ex Lindl.) H. Bol.
Habenaria galpinii H. Bol. (441)
Habenaria lithophila Schltr.
Habenaria pseudociliosa Schelpe ex J.C. Manning (518)

Herschelia Lindl. 1435
Herschelia cf. *baurii* (H. Bol.) Kraenzl.

Holothrix L.C. Rich. ex Hook. 1408
Holothrix orthoceras (Harv.) Reichb. f. (538)

Satyrium Swartz 1430
Satyrium cristatum Sond. var. *cristatum* (880)
Satyrium cristatum Sond. var. *longilabiatum* A.V. Hall (351)
Satyrium longicauda Lindl. var. *longicauda* (345)
Satyrium neglectum Schltr.

Schizochilus Sond. 1431
Schizochilus cecilii Rolfe subsp. *transvaalensis* (Rolfe) Linder (801)

Stenoglottis Lindl. 1407
Stenoglottis fimbriata Lindl. (431)

Poaceae
Alloteropsis J.S. Presl K94
Alloteropsis semialata (R. Br.) Hitchc. subsp. *semialata* (469)

Andropogon L. K71
Andropogon appendiculatus Nees (808)
Andropogon eucomus Nees
Andropogon huillensis Rendle (399)
Andropogon lacunosus J.G. Anders. (809)
Andropogon mannii Hook. f. (AEW10245)
Andropogon schirensis A. Rich. (292, 447)

Aristida L. K262
Aristida aequiglumis Hack. (587)
Aristida canescens Henr. subsp. *canescens* (902)
Aristida congesta Roem. & Schult. subsp. *barbicollis* (Trin. & Rupr.) De Winter
Aristida junciformis Trin. & Rupr. subsp. *junciformis* (411,837)

Aristida sp. (617)
Aristida sp. (777)
Aristida transvaalensis Henr. (875)

Bewsia Goosens K344
Bewsia biflora (Hack.) Goossens (356)

Bothriochloa Kuntze K63
Bothriochloa bladhii (Retz.) S.T. Blake (780)

Brachiaria Griseb. K104
Brachiaria bovonei (Chiov.) Robyns (766)
Brachiaria serrata (Thunb.) Stapf

Brachypodium Beauv. K432
Brachypodium flexum Nees (403)

Chloris Swartz K301
Chloris gayana Kunth (878)

Ctenium Panz. K299
Ctenium concinnum Nees

Cymbopogon Spreng. K72
Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy
Cymbopogon plurinodis(Stapf) Stapf ex Burtt Davy (601)
Cymbopogon validus (Stapf) Stapf ex Burtt Davy (404)

Cynodon Rich. ex Pers. K296
Cynodon dactylon (L.) Pers.

Digitaria Haller K89
Digitaria eriantha Steud.
Digitaria monodactyla (Nees) Stapf (767,836)
Digitaria setifolia Stapf (701)

Diheteropogon Stapf K81
Diheteropogon amplectens (Nees) Clayton
Diheteropogon filifolius (Nees) Clayton (448)

Elionurus Kunth ex Willd. K28
Elionurus muticus (Spreng.) Kunth (661)

Enneapogon Desv. ex Beauv. K357
Enneapogon cenchroides (Roem. & Schult.) C.E. Hubb.
Enneapogon scoparius Stapf (603,765)

Eragrostis Beauv. K286
Eragrostis acraea De Winter (747,807)
Eragrostis caesia Stapf (567)
Eragrostis capensis (Thunb.) Trin. (698,709)
Eragrostis chloromelas Steud. (782,900)
Eragrostis curvula (Schrad.) Nees (412, 547)
Eragrostis gummiflua Nees
Eragrostis plana Nees (413)
Eragrostis racemosa (Thunb.) Steud. (288, 400)
Eragrostis sclerantha Nees subsp. *sclerantha* (284)
Eragrostis pseudosclerantha Chiov.

Eulalia Kunth. K53
Eulalia villosa (Thunb.) Nees (326)

Eustachys Desv. K302
Eustachys paspaloides (Vahl.) Lanza & Mattei

Festuca L. K417
Festuca costata Nees (596)

Harpochloa Kunth K298
Harpochloa falx (L. f.) Kuntze (576)

Hemarthria R. Br. K21
Hemarthria altissima (Poir.) Stapf & C.E. Hubb.

Heteropogon Pers. K80
Heteropogon contortus (L.) Roem. & Schult.

Hyparrhenia Anderss. ex Fourn. K73
Hyparrhenia anamesa Clayton (616)
Hyparrhenia filipendula (Hochst.) Stapf var. *pilosa* (Hochst.) Stapf (293)
Hyparrhenia hirta (L.) Stapf (294)
Hyparrhenia sp. (415)
Hyparrhenia tamba (Steud.) Stapf (615)
Hyparrhenia variabilis Stapf (577)

Hyperthelia Clayton K73
Hyperthelia dissoluta (Nees ex Steud.) Clayton (789)

Imperata L. K37
Imperata cylindrica (L.) Raeuschel

Koeleria Pers. K374
Koeleria capensis (Steud.) Nees

Loudetia Hochst. ex Steud. K175b
Loudetia simplex (Nees) C.E. Hubb. (402, 426)
Loudetia sp. (470)

Melinis Beauv. K134
Melinis minutiflora Beauv. (578)
Melinis nerviglume (Franch.) Zizka (286, 327)
Melinis repens (Willd.) Zizka subsp. *repens* (746)
Melinis tenuissima Stapf (487)

Microchloa R. Br. K294
Microchloa caffra Nees

Miscanthus Anderss. K40
Miscanthus junceus (Stapf) Pilg.

Monocymbium Stapf K75
Monocymbium ceresiiforme (Nees) Stapf

Oplismenus Beauv. K115
Oplismenus hirtellus (L.) Beauv.

Panicum L. K116
Panicum ecklonii Nees (702,806)
Panicum maximum Jacq.
Panicum natalense Hochst. (289,810)

Paspalum L. K107
Paspalum sp.

Pentaschistis Stapf K205
Pentaschistis natalensis Stapf (398, 561)

Perotis Aiton K280
Perotis patens Gand.

Phragmites Trin. K214
Phragmites mauritianus Kunth

Pogonarthria Stapf K334
Pogonarthria squarrosa (Roem. & Schult.) Pilg.

Rendlia Chiov. K294
Rendlia altera (Rendle) Chiov. (353)

Schizachyrium Nees K68
Schizachyrium sanguineum (Retz.) Alst. (290, 292)

Setaria Beauv. K128
Setaria megaphylla (Steud.) Dur. & Schinz (410)
Setaria sphacelata (Schumach.) Moss var. *sphacelata* (291, 600)
Setaria sphacelata (Schumach.) Moss var. *torta* (Stapf) Clayton (639,751)

Sporobolus R. Br. K283
Sporobolus africanus (Poir.) Robyns & Tournay (414)
Sporobolus centrifugus (Trin.) Nees (750)
Sporobolus congoensis Franch. (700)
Sporobolus pectinatus Hack. (745)

Stiburus Stapf K400
Stiburus alopecuroides (Hack.) Stapf (397)

Themeda Forssk. K83
Themeda triandra Forssk.

Trachypogon Nees K78
Trachypogon spicatus (L.f.) Kuntze (355)

Trichopteryx Nees K174
Trichopteryx dregeana Nees (449)

Triraphis R. Br. K350
Triraphis andropogonoides (Steud.) Phill. (602,764)

Tristachya Nees K175
Tristachya leucothrix Nees

Urelytrum Hack. K17
Urelytrum agropyroides (Hack.) Hack. (790)

Restionaceae
Ischyrolepis Steud. 804c
Ischyrolepis schoenoides (Kunth) Linder (562,894)

Restio L. 804
Restio sieberi Kunth

Velloziaceae
Xerophyta Juss. 1247
Xerophyta retinervis Bak.
Xerophyta viscosa Bak. (654)

Xyridaceae
Xyris L. 826
Xyris congensis Buettn. (575)

Xyris nivea Welw. ex Rendle (433, 575a)

DICOTYLEDONAE

Acanthaceae

Barleria L. 7973
Barleria ovata E. Mey. ex Nees (425)

Crabbea Harv. 7972
Crabbea angustifolia Nees
Crabbea hirsuta Harv. (303,859)

Dyschoriste Nees 7939
cf. *Dyschoriste fischeri* Lindau (861)

Isoglossa Oerst. 8079
Isoglossa grantii C.B. Cl. (609)

Mackaya Harv. 8039
Mackaya bella Harv.

Sclerochiton Harv. 7978
Sclerochiton harveyanus Nees (884)

Thunbergia Retz. 7914
Thunbergia atriplicifolia E. Mey. ex Nees

Ruellia L. 7965
cf.*Ruellia cordata* Thunb. (608)

Aizoaceae

Psammotropha Eckl. & Zeyh. 2379
Psammotropha myriantha Sond.

Amaranthaceae

Aerva Forsk. 2317
Aerva leucura Moq.

Anacardiaceae

Lannea A. Rich. 4563
Lannea edulis (Sond.) Engl.

Ozoroa Deliliet 4589a
Ozoroa sp. (585)

Protorhus Engl. 4576

Protorhus longifolia (Bernh.) Engl.

Rhus L. 4594
Rhus chirindensis Bak. f.
Rhus dentata Thunb. (749)
Rhus discolor E. Mey. ex Sond. (870)
Rhus ernestii Schonl. (841)
Rhus gracillima Engl. (788,899)
Rhus lancea L. f.
Rhus pentheri Zahlbr.
Rhus pyroides Burch. var. *integrifolia* (Engl.) Moffett (330)
Rhus cf. rigida Mill. var. *dentata* (Engl.) Moffett (670)
Rhus tumulicola S. Moore (842)
Rhus zeyheri Sond.

Apiaceae

Alepidea De La Roche 5922
Alepidea gracilis Duemmer var. *major* Weim. (297)

Annesorrhiza Cham. & Schlechtd. 6078
Annesorrhiza flagellifolia Burtt Davy

Heteromorpha Cham & Schlectd. 5992
Heteromorpha pubescens Burtt davy (769)
Heteromorpha trifoliata (Wendl.) Eckl. & Zeyh.

Peucedanum L. 6116
Peucedanum caffrum (Meisn.) Phill. (653)

Pimpinella L. 6033
Pimpinella transvaalensis Wolff (429)

Apocynaceae

Carissa L. 6559
Carissa bispinosa (L.) Desf. ex Brenan var. *acuminata* (E. Mey.) Codd (692)

Landolphia Beauv. 6562
Landolphia capensis Oliv.

Strophanthus DC. 6688
Strophanthus speciosus (Ward & Harv.) Reber

Aquifoliaceae

Ilex L. 4614
Ilex mitis (L.) Radlk. var. *mitis* (728)

Araliaceae

Cussonia Thunb. 5872
Cussonia natalensis Sond.
Cussonia paniculata Eckl. & Zeyh.
Cussonia spicata Thunb.

Schefflera J.R. & G. Forst.
Schefflera umbellifera (Sond.) Baill.

Seemannaralia R. Viguier 5872a
Seemannaralia gerrardii (Seemann) Vig.

Asclepiadaceae

Anisotoma Fenzl 6868
Anisotoma pendunculata N.E. Br. (888)

Asclepias L. 6791
Asclepias brevipes (Schltr.) Schltr.
Asclepias burchellii Schltr. (919)
Asclepias cucullata (Schltr.) Schltr. (AEW 10249)
Asclepias fruticosa L.

Brachystelma R. Br. 6870
Brachystelma macropetalum (Schltr.) N.E. Br. (770)

Pachycarpus E. Mey. 6787a
Pachycarpus campanulatus (Harv.) N.E. Br. var. *sutherlandi* N.E. Br.

Schizoglossum E. Mey. 6778
Schizoglossum bidens E. Mey. subsp. *productum* (N.E. Br.) Kupicha (479)

Asteraceae

Anisopappus Hook. & Arn. 9096
Anisopappus smutsii Hutch. (918)

Artemisia L. 9330
Artemisia afra Jacq. ex Willd.

Aspilia Thouars 9195
Aspilia mossambicensis (Oliv.) Wild (860)

Aster L. 8900
Aster lydenburgensis Lippert (660)

Athrixia Ker-Gawl 9055
Athrixia phylicoides DC.

Berkheya Ehrh. 9438
Berkheya carlinopsis Welw. ex O. Hoffm. subsp. *magalismontana* (H. Bol.) Roessl. (817)
Berkheya echinacea (Harv.) O. Hoffm. ex Burtt Davy subsp. *echinacea* (321,845)
Berkheya insignis (Harv.) Thell. (753)
Berkheya radula (Harv.) De Wild. (466)
Berkheya subulata Harv. var. *subulata* (467)
Berkheya zeyheri (Sond. & Harv.) Oliv. & Hiern subsp. *zeyheri* (714)

Bidens L. 9237
Bidens pilosa L.

Brachylaena R. Br. 8936
Brachylaena discolor DC.

Callilepis DC. 9094
Callilepis leptophylla Harv. (649)

Chrysanthemoides Tourn. ex Medik. 9427b
Chrysanthemoides monilifera (L.) T. Norl. subsp. *septentrionalis* T. Norl. (898)

Cineraria L. 9406
Cineraria sp. (570)

Conyza Less. 8925
Conyza bonariensis (L.) Cronq. * (421)

Dicoma Cass. 9501
Dicoma anomala Sond. subsp. *anomala* (371)
Dicoma anomala Sond. subsp. *cirsioides* (Harv.) Wild (544)
Dicoma zeyheri Sond. (793)

Eumorphia DC. 9323
Eumorphia davyi H. Bol. (916)

Euryops Cass. 9417
Euryops brevipapposus M.D. Henderson (AEW10040)
Euryops laxus (Harv.) Burtt Davy (707)
Euryops pedunculatus N.E. Br. (302,891)
Euryops transvaalensis Klatt subsp. *setilobus* (N.E. Br.) B. Nord. (497,731,811)

Felicia Cass. 8919
Felicia mossamedensis (Hiern) Mendonca (813)
Felicia muricata (Thunb.) Nees subsp. *muricata* (529)

Gazania Gaertn. 9434
Gazania krebsiana Less.

Geigeria Griesselich 9090
Geigeria elongata Alston (418)

Gerbera Cass. 9528
Gerbera ambigua (Cass.) Sch. Bip. (668)
Gerbera jamesonii H. Bol. ex Adlam
Gerbera piloselloides (L.) Cass. (364)
Gerbera viridifolia (DC.) Sch. Bip. subsp. *viridifolia* (536)

Haplocarpha Less. 9434
Haplocarpha scaposa Harv. (363)

Helichrysum Mill. 9006
Helichrysum acutatum DC. (314,631,773)
Helichrysum adenocarpum DC. subsp. *adenocarpum* (335)
Helichrysum albilanatum Hilliard (848)
Helichrysum aureonitens Sch. Bip. (457)
Helichrysum aureum (Houtt.) Merr. var *monocephalum* (DC.) Hilliard (677)
Helichrysum caespititium (DC.) Harv. (680)
Helichrysum callicomum Harv. (522)
Helichrysum cephaloideum DC. (347,565,830)
Helichrysum chrysargyrum Moeser (553)
Helichrysum confertifolium Klatt (895)
Helichrysum cooperii Harv. (597)
Helichrysum epapposum H. Bol. (598)
Helichrysum galpinii N.E. Br. (AEW 10529)
Helichrysum glomeratum Klatt (531)
Helichrysum herbaceum (Andr.) Sweet (423)
Helichrysum kraussii Sch. Bip. (595)
Helichrysum mariepscopicum Hilliard (799)
Helichrysum miconiifolium DC. (360)
Helichrysum mimetes S. Moore (AEW 10551)
Helichrysum mixtum (Kuntze) Moeser var. *mixtum* (723)
Helichrysum nudifolium (L.) Less (361,630,772)
Helichrysum obductum H. Bol. (917)
Helichrysum opacum Klatt (349)
Helichrysum oreophilum Klatt (365,644)
Helichrysum pilosellum (L. f.) Less. (362,637)
Helichrysum platypterum DC. (348)
Helichrysum polycladum Klatt (478)
Helichrysum reflexum N.E. Br. (381)
Helichrysum rudolfii Hilliard (499,889)
Helichrysum rugulosum Less. (530)
Helichrysum setosum Harv.
Helichrysum spiralepis Hilliard & Burtt (388, 568)
Helichrysum splendidum (Thunb.) Less.
Helichrysum thapsus (Kuntze) Moeser (797,846)

Helichrysum truncatum Burtt Davy (375)
Helichrysum umbraculigerum Less. (393)
Helichrysum uninervium Burtt Davy (613)
Helichrysum wilmsii Moeser (476)

Hirpicium Cass. 9435
Hirpicium linearifolium (H. Bol.) Roessl. (756)

Inezia Phill. 9337a
Inezia integrifolia (Klatt) Phill. (320)

Inulanthera Kallersjo 9326a
Inulanthera calva (Hutch.) Kallersjo (546,563)

Lactuca L. 9596
Lactuca capensis Thunb.

Lopholaena DC. 9401
Lopholaena disticha (N.E. Br.) S. Moore (339,914)

Nidorella Cass. 8925
Nidorella auriculata DC. (462)

Osteospermum L. 9427
Osteospermum auriculatum (S. Moore) T. Norl. (552)

Othonna L. 9420
Othonna natalensis Sch. Bip. (666)

Pentatrichia Klatt 9061a
Pentatrichia alata S. Moore

Phymaspermum Lees. Emend. Kallersjo 9336
Phymaspermum acerosum (DC.) Kallersjo (477,589,882)
Phymaspermum argenteum Brusse (896)
Phymaspermum bolusii (Hutch.) Kallersjo (574)

Pseudognaphalium Kirp. 8992e
Pseudognaphalium oligandrum (DC.) Hilliard & Burtt (422)

Schistostephium Lees. 9356
Schistostephium crataegifolium (DC.) Fenzl ex Harv. (407)
Schistostephium heptalobum (DC.) Oliv. & Hiern (551)

Senecio L. 9411
Senecio barbertonicus Klatt
Senecio coronatus (Thunb.) Harv.

Senecio discodregeanus Hilliard & Burtt (802,829)
Senecio erubescens Ait. var. *crepidifolius* DC. (822)
Senecio junodii Hutch. & Burtt Davy (482)
Senecio latifolius DC. (AEW10244)
Senecio lydenburgensis Hutch. & Burtt Davy
Senecio microglossus DC.
Senecio oxyriifolius DC.
Senecio polyodon DC. var. *polyodon* (732)
Senecio speciosus Willd.
Senecio sp. (908)
Senecio subcoriaceus Schltr. (695)
Senecio venosus Harv. (310)

Stoebe L. 9037
Stoebe vulgaris Levyns

Tagetes L. 9311
Tagetes minuta L. *

Tarchonanthus L. 8937
Tarchonanthus trilobus DC.

Tenrhynea Hilliard & Burtt 8994
Tenrhynea phylicifolia (DC.) Hilliard & Burtt (401)

Tithonia Desf. 9196
Tithonia rotundifolia (Mill.) Blake *

Tolpis Adans. 9561
Tolpis capensis (L.) Sch. Bip. (527)

Vernonia Schreb. 8751
Vernonia centaureoides Klatt (521)
Vernonia galpinii Klatt (646)
Vernonia hirsuta (DC.) Sch. Bip. (678)
Vernonia natalensis Sch. Bip.
Vernonia neocorymbosa Hilliard
Vernonia oligocephala (DC.) Sch. Bip. ex Walp.
Vernonia staehelinoides Harv.
Vernonia stipulaceae Klatt

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

Balsaminaceae
Impatiens L. 4856
Impatiens cf. sylvicola Burtt Davy & Greenway

Begoniaceae
Begonia L. 5397
Begonia sutherlandii Hook. f.

Bignoniaceae
Tecomaria Spach. 7713
Tecomaria capensis (Thunb.) Spach

Boraginaceae
Cynoglossum L. 7064
Cynoglossum hispidum Thunb. (657)

Ehretia L. 7043
Ehretia rigida (Thunb.) Druce

Campanulaceae
Craterocapsa Hilliard & Burtt 8668a
Craterocapsa tarsodes Hilliard & Burtt (325)

Lightfootia L'Herit. 8670
Lightfootia paniculata Sond. (379,827)

Wahlenbergia Schrad. ex Roth 8668
Wahlenbergia huttonii (Sond.) Thulin (318)
Wahlenbergia krebsii Cham. subsp. *krebsii* (312)
Wahlenbergia lycopodioides Schltr. & V. Brehm. (496)
Wahlenbergia squamifolia V. Brehm. (440)
Wahlenbergia virgata Engl. (542, 593)

Capparaceae
Cleome L. 3101
Cleome monophylla L. (384)

Celastraceae
Cassine L. 4641
Cassine eucleiformis (Eckl. & Zeyh.) Kuntze

Catha Forsk. ex Scop. 4629
Catha edulis (Vahl) Forssk. ex Endl.

Maytenus Molina 4626
Maytenus acuminata (L. f.) Loes.
Maytenus angularis
Maytenus cordata (E. Mey. ex Sond.) Loes. (737)
Maytenus heterophylla (Eckl. & Zeyh.) N.K.B. Robson (643)
Maytenus tenuispina (Sond.) Marais
Maytenus peduncularis (Sond.) Loes (550)

Maytenus mossambicensis (Klotzsch) Blakelock var. *mossambicensis* (690)
Maytenus sp. (843)
Maytenus undata (Thunb.) Blakelock

Pterocelastrus Meisn. 4630
Pterocelastrus echinatus N.E. Br.
Pterocelastrus rostratus Walp. (383,734)
Pterocelastrus sp. (876)

Chrysobalanaceae
Parinari Aubl. 3405
Parinari capensis Harv.

Clusiaceae
Hypericum L. 5168
Hypericum aethiopicum Thunb. subsp. *sonderi* (Bred.) N.K.B. Robson (389)
Hypericum revolutum Vahl

Combretaceae
Combretum Loefl.
Combretum erythrophyllum (Burch.) Sond.
Combretum kraussii Hochst.
Combretum moggii Exell
Combretum molle R. Br. ex G. Don

Convolvulaceae
Ipomoea L. 7003
Ipomoea bathycolpos Hallier f. var. *bathycolpos* (720)
Ipomoea crassipes Hook.
Ipomoea papilio Hallier f. (862)
Ipomoea purpurea (L.) Roth (853)
Ipomoea ommaneyi Rendle

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

Cornaceae
Curtisia Ait. 6156
Curtisia dentata (Burm. f.) C.A. Sm.

Crassulaceae
Crassula L. 3168
Crassula alba Forssk. var. *parvisepala* (Schonl.) Toelken (311)
Crassula compacta Schonl. (682)
Crassula lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. *transvaalensis* (Kuntze) Toelken (828)
Crassula pellucida L. subsp. *brachypetala* (Drege ex Harv.) Toelken (502)

Crassula sarcocaulis Eckl. & Zeyh. subsp. *sarcocaulis* (AEW 10541)
Crassula swaziensis Schonl. (903)
Crassula vaginata Eckl. & Zeyh. subsp. *vaginata* (346, 450)
Crassula sp. (573)

Kalanchoe Adans. 3166
Kalanchoe rotundifolia (Harv.) Harv.
Kalanchoe thyrsiflora Harv.

Cucurbitaceae
Momordica L. 8591
Momordica foetida Schum.

Dichapetalaceae
Dichapetalum Thouars. 4283
Dichapetalum cymosum (Hook.) Engl.

Dipsacaceae
Cephalaria Roem. & Schult. 8541
Cephalaria pungens Szabo (392)

Scabiosa L. 8546
Scabiosa columbaria L.

Droseraceae
Drosera L. 3136
Drosera madagascariensis DC.

Ebenaceae
Diospyros L. 6406
Diospyros lycioides Desf.
Diospyros whyteana (Hiern) f. White (781)

Euclea Murray 6404
Euclea crispa (Thunb.) Guerke
Euclea linearis Zeyh. ex Hiern
Euclea natalensis A. DC.
Euclea undulata Thunb.

Ericaceae
Erica L. 6237
Erica atherstonei Diels ex Guth. & Bol. (465,726,864)
Erica caffrorum H. Bol. var. *caffrorum* (672)
Erica cerinthoides L. var. *cerinthoides* (681)
Erica drakensbergensis Guth. & Bol.
Erica holtii Schweick.
Erica sp. (387)

Erica woodii H. Bol. (336)

Vaccinium L. 6216
Vaccinium exul H. Bol. (328)

Escalloniaceae
Choristylis Harv. 3241
Choristylis rhamnoides Harv.

Euphorbiaceae
Acalypha L. 4407
Acalypha angustata Sond. var. *glabra* Sond. (761)
Acalypha caperonioides Baill. (647)

Clutia L. 4448
Clutia alaternoides L. var. *alaternoides* (844)
Clutia monticola S. Moore
Clutia virgata Pax & K. Hoffm. (640,785)

Euphorbia L. 4498
Euphorbia striata Thunb. var *striata* (825)

Phyllanthus L. 4299
Phyllanthus nummulariifolius Poir. (687)
Phyllanthus parvulus Sond.
Phyllanthus sp. (610)

Fabaceae
Acacia Mill. 3446
Acacia ataxacantha DC.
Acacia caffra (Thunb.) Willd.
Acacia karroo Hayne
Acacia mearnsii De Wild. *

Aeschynomene L. 3793
Aeschynomene nodulosa (Bak.) Bak. f. var. *nodulosa* (306)

Argyrolobium Eckl. & Zeyh. 3673
cf. *Argyrolobium frutescens* Burtt Davy (901)
Argyrolobium lancifolium Burtt Davy (628)
Argyrolobium sp. (673)
Argyrolobium wilmsii Harms (897)

Caesalpinia L. 3559
Caesalpinia decapetala (Roth) Alston *

Calpurnia E. Mey. 3607

Calpurnia aurea (Ait.) Benth. subsp. *aurea* (856)

Cassia L. 3536
Cassia comosa (E. Mey.) Vogel
Cassia italica (Mill.) Lam. ex F.W. Andr.
Cassia mimosoides L. Group 1 (305)
Cassia biensis (Steyaert) Mendonca & Torre (358)

Crotalaria L. 3669
Crotalaria doidgeae Verdoorn (814,855)

Dalbergia L. F. 3821
Dalbergia armata E. Mey.

Desmodium Desv. 3807
Desmodium repandum (Vahl) DC.

Dolichos L. 3910
Dolichos angustifolius Eckl. & Zeyh. (663)
Dolichos trilobus L. subsp. *transvaalicus* Verdc. (779)

Elephantorrhiza Benth. 3467
Elephantorrhiza elephantina (Burch.) Skeels

Eriosema (DC.) G. Don 3898
Eriosema angustifolium Burtt Davy (471)
Eriosema ellipticifolium Schinz (367)
Eriosema cf. gunniae C.H. Stirton (724)

Erythrina L. 3870
Erythrina lysistemon Hutch.

Indigofera L. 3702
Indigofera atrata N.E. Br. (359,775,784)
Indigofera brevifolia N.E. Br. (826)
Indigofera dregeana E. Mey. (849)
Indigofera hedyantha Eckl. & Zeyh. (481)
Indigofera hilaris Eckl. & Zeyh. (535,658)
Indigofera masonae N.E. Br. (816)
Indigofera melanadenia Benth. ex Harv.
Indigofera oxalidea Welw. ex Bak.
Indigofera rostrata H. Bol. (763)
Indigofera sanguinea N.E. Br. (629)
Indigofera schinzii N.E. Br. (760)
Indigofera sp. (847)
Indigofera swaziensis H. Bol. var. *swaziensis* (774)
Indigofera torulosa E. Mey. var. *angustiloba* (Bak. f.) Gillett (755)

Kotschya Endl. 3796a
Kotschya thymodora (Bak. f.) Wild subsp. *thymodora* (409)

Lotononis (D.C.) Eckl. & Zeyh. 3657
Lotononis florifera Duemmer (787)
Lotononis eriantha Benth. var. *eriantha* (338)
Lotononis pulchra Duemmer (464)

Melilotus Adans. 3689
Melilotus alba Desr. *

Mundulea Benth. 3719
Mundulea sericea (Willd.) A. Chev.

Ormocarpum Beauv. 3792
Ormocarpum kirkii S. Moore (792)

Otholobium C.H. Stirton 3703c
Otholobium polystictum (Benth. ex Harv.) C.H. Stirton (886)
Otholobium wilmsii (Harms) C.H. Stirton (865)

Pearsonia Duemmer 3657a
Pearsonia aristata (Schinz) Duemmer (752)
Pearsonia cajanifolia (Harv.) Polhill subsp. *cryptantha* (Bak.) Polhill (820)
Pearsonia obovata (Schinz) Polhill (324)
Pearsonia sessilifolia (Harv.) Duemmer subsp. *sessilifolia* (395)

Peltophorum (Vogel) Benth. 3561
Peltophorum africanum Sond.

Pseudarthria Wight & arn. 3808
Pseudarthria hookeri Wight & Arn. var. *hookeri* (287,863)

Psoralea L. 3703
Psoralea latifolia (Harv.) C.H. Stirton (AEW 10514)
Psoralea pinnata L. (AEW 10546)

Rhynchosia Lour. 3897
Rhynchosia monophylla Schltr. (712)
Rhynchosia hirsuta Eckl. & Zeyh. (742)
Rhynchosia nitens Benth. (614)
Rhynchosia thorncroftii (Bak. f.) Burtt Davy (514)
Rhynchosia totta (Thunb.) DC. var. *totta* (834)
Rhynchosia villosa (Meisn.) Druce (490)
Rhynchosia woodii Schinz (641)

Sesbania Scop. 3747

Sesbania punicea (Cav.) Benth. *

Smithia Ait. 3796
Smithia erubescens (E. Mey.) Bak. f. (430)

Sphenostylis E. Mey. 3907
Sphenostylis angustifolia Sond. (651)

Stylosanthes Swartz 3802
Stylosanthes fruticosa (Retz.) Alston (741)

Tephrosia Pers. 3718
Tephrosia elongata E. Mey. var. *elongata* (357)
Tephrosia glomeruliflora Meisn. subsp. *meisneri* (Hutch. & Burtt Davy) B.D. Schrire (757)
Tephrosia macropoda (E. Mey.) Harv. (758)

Tylosema (Schweinf.) Torre & Hillc. 3528c
Tylosema fassoglense (Schweinf.) Torre & Hillc.

Vigna Savi 3905
Vigna nervosa Markoetter (513)

Zornia J.F. Gmel. 3804
Zornia capensis Pers. (357,722)

Flacourtiaceae

Gerrardina Oliv. 5312
Gerrardina foliosa Oliv. (910,913)

Scolopia Schreb. 5304
Scolopia zeyheri (Nees) Harv.

Trimeria Harv. 5315
Trimeria grandifolia (Hochst.) Warb. (329)

Gentianaceae

Sebaea Soland. ex R. Br. 6481
Sebaea filiformis Schinz (523)
Sebaea grandis (E. Mey.) Steud. (455)
Sebaea rehmannii Schinz (332)
Sebaea sedoides Gilg var. *confertiflora* (Schinz) Marais (333)

Geraniaceae

Monsonia L. 3925
Monsonia attenuata Harv. (322)
Monsonia glauca Knuth (406)

Pelargonium L'Herit. 3928
Pelargonium album (549)
Pelargonium dolomiticum Knuth (621,904)
Pelargonium luridum (Andr.) Sweet
Pelargonium mossambicense Engl. (549)
Pelargonium multicaule Jacq. subsp. *subherbaceum* (Knuth) J.J.A. Van Der Walt (611)

Gesneriaceae
Streptocarpus Lindl. 7823
Streptocarpus sp.

Greyiaceae
Greyia Hook. & Harv. 4855
Greyia radlkoferi Szyszyl.

Hamamelidaceae
Trichocladus Pers. 3311
Trichocladus grandiflorus Oliv.

Icacinaceae
Apodytes E. Mey. ex Arn. 4686
Apodytes dimidiata E. Mey. ex Arn. subsp. *dimidiata* (905)

Cassinopsis Sond. 4671
Cassinopsis ilicifolia (Hochst.) Kuntze (688,851)

Illecebraceae
Pollichia Ait. 2467
Pollichia campestris Ait.

Silene L. 2490
Silene burchellii Otth var. *angustifolia* Sond. (832)
Silene burchellii Otth var. *burchellii* (839)
Silene undulata Ait.

Lamiaceae
Acrotome Benth. 7236
Acrotome hispida Benth. (588)

Aeollanthus Mart. 7345
Aeollanthus parvifolius Benth. (794)

Becium Lindl. 7366a
Becium obovatum (E. Mey. ex Benth.) N.E. Br.

Hemizygia (Benth.) Briq. 7365
Hemizygia albiflora (N.E. Br.) Ashby (592)
Hemizygia parvifolia Codd. (796)
Hemizygia subvelutina (Guerke) Ashby (512,669)
Hemizygia transvaalensis (Schltr.) Ashby (626)

Leucas R. Br. 7268
Leucas cf. glabrata (Vahl) Sm.

Leonotis (Pers.) R. Br. 7264
Leonotis leonurus (L.) R. Br.
Leonotis ocymifolia (Burm. f.)

Orthosiphon Benth. 7367
Orthosiphon tubiformis R. Good (604,854)

Plectranthus L'Herit. 7350
Plectranthus grallatus Briq. (868)
Plectranthus grandidentatus Guerke (378)
Plectranthus neochilus Schltr. (619)
Plectranthus rubropunctatus Codd (299, 377)

Pycnostachys Hook. 7347
Pycnostachys reticulata (E. Mey.) Benth. (824)

Rabdosiella Codd 7350c
Rabdosiella calycina (Benth.) Codd (443)

Salvia L. 7290
Salvia dolomitica Codd

Satureja L. 7305
Satureja biflora (Buch.-Ham. ex D. Don) Briq. (623,778)

Stachys L. 7281
Stachys natalensis Hochst. var. *natalensis* (301)
Stachys reticulata Codd (503)
Stachys simplex Schltr. (754)

Syncolostemon E. Mey. ex Benth. 7359
Syncolostemon eriocephalus Verdoorn (459)

Tetradenia Benth. 7339
Tetradenia riparia (Hochst.) Codd

Lauraceae
Ocotea Aubl. 2788

Ocotea bullata (Burch.) Baill.

Linaceae
Linum L. 3945
Linum thunbergii Eckl. & Zeyh. (791)

Lobeliaceae
Cyphia Berg. 8681
Cyphia elata Harv. var. *glabra* Harv. (343)
Cyphia elata Harv. var. *oblongifolia* (Sond. & Harv.) Phill. (350)
Cyphia stenopetala Diels (317)

Lobelia L. 8694
Lobelia eurypoda E. Wimm. (442)
Lobelia flaccida (Presl) A. DC. subsp. *flaccida* (435)

Monopsis Salisb. 8695
Monopsis decipiens (Sond.) Thulin

Loganiaceae
Buddleja L. 6473
Buddleja auriculata Benth.
Buddleja salviifolia (L.) Lam.

Nuxia Lam. 6469
Nuxia congesta R. Br. ex Fresen.
Nuxia floribunda Benth.

Malpighiaceae
Sphedamnocarpus Planch. ex Benth. & Hook. f. 4219
Sphedamnocarpus pruriens (Juss.) Szyszyl. var. *galphimiifolius* (Juss.) P.D. De Villiers & C.J. Botha (821)

Malvaceae
Hibiscus L. 5013
Hibiscus engleri K. Schum.

Pavonia Cav. 5007
Pavonia columella Cav. (545,872)

Melastomataceae
Antherotoma Hook. f. 5651
Antherotoma naudinii Hook. f. (439)

Dissotis Benth. 5659
Dissotis phaeotricha (Hochst.) Hook. f. var. *phaeotricha* (493)

Meliaceae
Ekebergia Sparm. 4193
Ekebergia pterophylla (C. DC.) Hofmeyr

Trichilia P. Br. 4195
Trichilia dregeana Sond.

Melianthaceae
Bersama Fres. 4853
Bersama swinnyi Phill. (735)
Bersama tysoniana Oliv.

Mesembryanthemaceae
Delosperma N.E. Br. 2405
Delosperma sp. (373)

Moraceae
Ficus L. 1961
Ficus craterostoma Warb. ex Mildbr. & Burr.
Ficus glumosa Del.
Ficus ingens (Miq.) Miq.
Ficus sur Forssk.

Myricaceae
Myrica L. 1874
Myrica pilulifera Rendle
Myrica serrata Lam.

Myrothamnaceae
Myrothamnus Welw. 3282
Myrothamnus flabellifolia (Sond.) Welw.

Myrsinaceae
Maesa Forsk. 6283
Maesa lanceolata Forssk.

Myrsine L. 6313
Myrsine africana L.

Rapanea Aubl. 6314
Rapanea melanophloeos (L.) Mez

Myrtaceae
Eugenia L. 5578
Eugenia natalitia Sond.
Eugenia woodii Duemmer
Eugenia zuluensis Duemmer

Heteropyxis Harv. 5588a
Heteropyxis natalensis Harv.

Syzygium Gaertn. 5583
Syzygium cordatum Hochst.
Syzygium gerrardii (Harv. ex Hook. f.) Burtt Davy (733)

Ochnaceae
Ochna L. 5112
Ochna arborea Burch. ex DC.
Ochna holstii Engl. (725)
Ochna cf. natalitia (Meisn.) Walp.

Oleaceae
Olea L. 6434
Olea europaea subsp. *africana*

Schrebera Roxb. 6422
Schrebera alata (Hochst.) Welw. (729)
Schrebera sp. (AEW 10540)

Oliniaceae
Olinia Thunb. 5428
Olinia rochetiana Juss. (396)

Onagraceae
Epilobium L. 5795
Epilobium salignum Hausskn. (887)

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

Oxalidaceae
Oxalis L. 3936
Oxalis obliquifolia Steud. ex Rich.

Papaveraceae
Argemone L. 2852
Argemone subfusiformis G.B. Ownbey *

Pedaliaceae
Ceratotheca Endl. 7778
Ceratotheca triloba (Bernh.) Hook. f. (417)

Periplocaceae
Raphionacme Harv 6747
Raphionacme galpinii Schltr. (590,655,771)
Raphionacme procumbens Schltr. (795)

Phytolaccaceae
Phytolacca L. 2380
Phytolacca octandra L.

Piperaceae
Peperomia Ruiz & Pav. 1866
Peperomia retusa (L. f.) A. Dietr.

Piper L. 1862
Piper capense L. f.

Pittosporaceae
Pittosporum Banks ex Soland. 3252
Pittosporum viridiflorum Sims

Plantaginaceae
Plantago L. 8116
Plantago longissima Decne.

Polygalaceae
Muraltia A.P. DC. 4278
Muraltia empetroides Chod. (911)
Muraltia flanaganii H. Bol. (AEW 10535)

Polygala L. 4237
Polygala albida Schinz var. *albida* (539)
Polygala amatymbica Eckl. & Zeyh. (776)
Polygala hispida Burch. (786)
Polygala hottentotta Presl (323)
Polygala pygmaea Guerke (571)
Polygala virgata Thunb.

Polygonaceae
Oxygonum Burch. 2204
Oxygonum cf. delagoense Kuntze (675)

Polygonum L. 2201
Polygonum lapathifolium L. *

Rumex L. 2195
Rumex crispus L. *
Rumex sagittatus Thunb. (852)

Proteaceae

Faurea Harv. 2035
Faurea galpinii Phill. (879,893)
Faurea speciosa (Welw.) Welw.

Leucospermum R. Br. 2036
Leucospermum saxosum S. Moore

Protea L. 2118
Protea caffra Meisn.
Protea gaguedi Gmel.
Protea laetans L.E. Davidson
Protea roupelliae Meisn. subsp. *roupelliae* (AEW 10556)
Protea rubropilosa Beard
Protea parvula Beard

Ranunculaceae

Clematis L. 2542
Clematis brachiata Thunb.
Clematis oweniae Harv. (858)

Knowltonia Salisb. 2541
Knowltonia transvaalensis Szyszyl. var. *transvaalensis* (715)

Ranunculus L. 2546
Ranunculus multifidus Forssk.

Rhamnaceae

Helinus E. Mey. ex Endl. 4905
Helinus integrifolius (Lam.) Kuntze (605)

Rhamnus L. 4875
Rhamnus prinoides L'Herit.

Phylica L. 4886
Phylica paniculata Willd. (885)

Ziziphus Mill. 4861
Ziziphus mucronata Willd.

Rosaceae

Agrimonia L. 3376
Agrimonia odorata Mill. *

Cliffortia L. 3388
Cliffortia nitidula (Engl.) R.E. & Th. Fries Jr. subsp. *pilosa* Weim. (369)
Cliffortia serpyllifolia Cham. & Schlechtd. (543)

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

Prunus L. 3396
Prunus africana (Hook. f.) Kalkm. (525)

Rubus L. 3353
Rubus sp.

Rubiaceae

Agathisanthemum Klotsch 8136/14
Agathisanthemum bojeri Klotzsch var. *bojeri* (819)

Anthospermum L. 8438
Anthospermum pumilum Sond. subsp. *pumilum* (528)
Anthospermum welwitschii Hiern (370,850)

Burchellia R.Br. 8281
Burchellia bubalina (L. f.) Sims

Canthium Lam. 8352
Canthium ciliatum (Klotzsch) Kuntze
Canthium inerme (L. f.) Kuntze (736)
Canthium mundianum Cham. & Schlechtd.

Cephalanthus L. 8230
Cephalanthus natalensis Oliv.

Fadogia Schweinf. 8359a
Fadogia tetraquetra Krause var. *tetraquetra* (372)

Hyperacanthus E. Mey. ex Bridson 8285
Hyperacanthus amoenus (Sims) Bridson

Kohautia Cham. & Schlechtd. 8136/6
Kohautia cf. amatymbica Eckl. & Zeyh.

Oldenlandia L. 8136/20
Oldenlandia herbacea (L.) Roxb. var. *herbacea* (437)
Oldenlandia rupicola (Sond.) Kuntze var. *rupicola* (385, 515)

Otiophora Zucc. 8450
Otiophora cupheoides N.E. Br. (376)

Pavetta L. 8383
Pavetta cataphylla K. Schum.
Pavetta inandensis Brem. (727)

Pavetta kotzei Brem. (869)

Pentanisia Harv. 8348
Pentanisia angustifolia (Hochst.) Hochst.
Pentanisia prunelloides (Eckl. & Zeyh.) Walp.

Psychotria L. 8399
Psychotria capensis (Eckl.) Vatke
Psychotria zombamontana (Kuntze) Petit

Pygmaeothamnus Robyns 8351b
Pygmaeothamnus zeyheri (Sond.) Robyns

Rothmannia Thunb. 8285a
Rothmannia capensis Thunb.

Rubia L. 3353
Rubia horrida (Thunb.) Puff (857)

Tricalysia A. Rich. 8308
Tricalysia capensis (Meisn. ex Hochst.) Sim var. *galpinii* (Schinz) Robbrecht (382,906)
Tricalysia capensis (Meisn. ex Hochst.) Sim var. *transvaalensis* Robbrecht (915)
Tricalysia lanceolata (Sond.) Burtt Davy

Trimeria Harv. 5315
Trimeria grandifolia (Hochst.) Warb. (329,686)

Vangueria Juss. 8351
Vangueria cyanescens Robyns
Vangueria infausta Burch.

Rutaceae

Calodendrum Thunb. 4035
Calodendrum capense (L. f.) Thunb.

Clausena Burm. f. 4091
Clausena anisata (Willd.) Hook. f. ex Benth.

Thamnosma Torr. & Frem. 4014
Thamnosma africana Engl. (812)

Zanthoxylum L. 3991
Zanthoxylum capensis (Thunb.) Harv.
Zanthoxylum davyi (Verdoorn) Waterm.

Salicaceae

Salicaceae
Salix L. 1873
Salix mucronata Thunb.

Santalaceae
Thesium L. 2118
Thesium costatum A.W. Hill var. *costatum* (368)
Thesium gracilentum N.E. Br. (AEW 10380)
Thesium multiramulosum Pilger (815)
Thesium transvaalensis Schltr.

Sapindaceae
Allophylus L. 4734
Allophylus africanus Beauv.

Hippobromus Eckl. & Zeyh. 4836
Hippobromus pauciflorus (L. f.) Radlk.

Sapotaceae
Bequaertiodendron De Wild. 6377a
Bequaertiodendron magalismontanum (Sond.) Heine & J.H. Hemsl.

Scrophulariaceae
Alectra Thunb. 7597a
Alectra sessiliflora (Vahl) Kuntze var. *sessiliflora* (405)

Bowkeria Harv. 7500
Bowkeria cymosa Macowan

Buchnera L. 7622
Buchnera dura Benth. (511)
Buchnera glabrata Benth. (866)
Buchnera longespicata Schinz (456)

Buttonia McKen ex Benth. 7611
Buttonia superba Oberm. (648)

Craterostigma Hochst. 7560
Craterostigma wilmsii Engl. ex Diels (380)

Cycnium E. Mey. ex Benth.
Cycnium adonense E. Mey. ex Benth. subsp. *adonense*
Cycnium racemosum Benth.

Halleria L. 7493
Halleria lucida L.

Nemesia Vent. 7476
Nemesia fruiticans (Thunb.) Benth.

Sopubia Buch.-Ham. ex Don
Sopubia cana Harv. (319)
Sopubia mannii Skan var. *tenuifolia* (Engl. & Gilg) Hepper (516)

Striga Lour. 7625
Striga asiatica (L.) Kuntze
Striga bilabiata (Thunb.) Kuntze
Striga elegans Benth.

Sutera Roth 7519
Sutera accrescens Hiern (618)
Sutera burkeana (Benth.) Hiern (607)
Sutera floribunda (Benth.) Kuntze (840)
Sutera neglecta (Wood & Evans) Hiern (334)

Teedia Rudopphi 7494
Teedia lucida Rudolphi (892)

Zaluzianskya F.W. Schmidt 7523
Zaluzianskya elongata Hilliard & Burtt (298)
Zaluzianskya maritima (L. f.) Walp.

Selaginaceae

Hebenstretia L. 7566
Hebenstretia angolensis Rolfe
Hebenstretia comosa Hochst. (664)
Hebenstretia dura Choisy (491, 540)

Selago L. 7568
Selago atherstonei Rolfe
Selago elata Rolfe (871)
Selago hyssopifolia E. Mey. (366)

Tetraselago Junell 7568d
Tetraselago wilmsii (Rolfe) Hilliard & Burtt (308)

Walafrida E. Mey. 7568a
Walafrida tenuifolia Rolfe (594,783)

Solanaceae

Solanum L. 7407
Solanum panduriforme E. Mey.
Solanum pseudocapsicum L. *
Solanum mauritianum Scop. *

Sterculiaceae

Dombeya Cav. 5053
Dombeya pulchra N.E. Br.
Dombeya rotundifolia (Hochst.) Planch.

Hermannia L. 5168
Hermannia floribunda Harv. (556)
Hermannia lancifolia Szyszyl. (304) (599)
Hermannia staurostemon K. Schum. (419)

Melhania Forsk. 5047
Melhania integra Verdoorn (606)

Thymelaeaceae

Gnidia L. 5435
Gnidia capitata L. f. (386)
Gnidia caffra Meisn.
Gnidia kraussiana Meisn. var. *kraussiana* (706)
Gnidia cf. nodiflora Meisn. (679)
Gnidia splendens Meisn. (620,818)
Gnidia sp (674)
Gnidia sp. (835)

Passerina L. 5461
Passerina montana Thoday

Peddiea Harv. 5434
Peddiea africana Harv.

Tiliaceae

Grewia L. 4966
Grewia occidentalis L. (634)
Grewia vernicosa Schinz (748)

Sparrmannia L.f. 4957
Sparrmannia ricinocarpa (Eckl. & Zeyh.) Kuntze (883)

Triumfetta L. 4975
Triumfetta cf. welwitschii Mast. var. *welwitschii* (627)

Trimeniaceae

Xymalos Baill. 2759
Xymalos monospora (Harv.) Baill.

Ulmaceae

Celtis L. 1898
Celtis africana Burm. f.

Chaetacme Planch. 1906
Chaetacme aristata Planch.

Trema Lour. 1902
Trema orientalis (L.) Blume

Urticaceae
Pouzolzia Gaudich. 1992
Pouzolzia mixta Solms

Vebenaceae
Clerodendrum L. 7191
Clerodendrum glabrum E. Mey.
Clerodendrum triphyllum (Harv.) H. Pearson var. *triphyllum* (537)

Lippia L. 7145
Lippia javanica (Burm. f.) Spreng. (416)

Verbena L. 7138
Verbena bonariensis L. *
Verbena brasiliensis Vell. *
Verbena venosa Gill. & Hook. (671)

Vitex L.7186
Vitex obovata E. Mey.

Vitaceae
Cyphostemma (Planch.) Alston 4918a
Cyphostemma lanigerum (Harv.) Desroings ex Wild & Drum.

Rhoicissus Planch.
Rhoicissus tomentosa (Lam.) Wild & Drum.
Rhoicissus tridentata (L. f.) Wild & Drum.
Rhoicissus rhomboidea (E. Mey. ex Harv.) Planch.

ACKNOWLEDGEMENTS

I am sincerely grateful to persons and institutions who have made this study possible. I am especially thankful for the help, guidance and comments received from Prof. G.J. Bredenkamp, Dr. N. Van Rooyen and Prof. A.E. van Wyk of the Department of Botany of the University of Pretoria. Mrs. Miranda Deutschländer is thanked for all her help with the computer.

I am particularly grateful to Mr Art Snyman for making the facilities of the Veld School Pilgrim's Rest available to me and a special word of thanks to all the personnel of the Veld School Pilgrim's Rest for making my stay so much like home, specifically Gideon and Charmine Visser who made their home available to me.

The plant collecting permits provided by the Transvaal Division of Nature Conservation and by the Department of Forestry is acknowledged with thanks.

I am indebted to many people and friends who helped and supported in many ways during fieldwork and in other ways, I would like to thank them all, a special word of thanks goes to Jerry Theron, Peter Nelson and Berndt van Rensburg.

The University of Pretoria and the Foundation of Research and Development is thanked for financial assistance. The University is also thanked for the use of it's facilities, particularly Mrs. Geringer of the Geography Department who drew many of the diagrams.

SUMMARY

Phytosociology of the North-eastern Mountain Sourveld

by

WAYNE MATTHEWS

Supervisor: Prof. G.J. Bredenkamp
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Submitted in partial fulfilment of the requirements
for the degree

MAGISTER SCIENTIAE

The aim of this study was to identify, classify and interpret ecologically by using habitat properties, the major vegetation units and their variations, as well as the development of management and conservation strategies for the North-eastern Mountain Sourveld of the Eastern Transvaal Escarpment.

The study area covers an area of approximately 2 000 km^2. Most of the area is utilized by forestry, but some of Transvaal's biggest nature reserves are to be found here.

The study area was stratified according to relatively homogenous units of major attributes such as geology, land form (topography), physiognomy and dominant species. The position of the sample plots was chosen subjectively within each of these units. A total of 200 sample plots were used to survey the area. A floristic survey, according to Braun-Blanquet procedures and a habitat survey was carried out. This data was classified by means of TWINSPAN and refined by Braun-Blanquet procedures.

The classification of the floristic data resulted in four different phytosociological tables, representing four major grassland types namely the vegetation of the Black Reef Quartzite and associated large rocky outcrops, the dry dolomitic regions, the high altitude hygrophilous vegetation and the relatively low altitude vegetation regions. All identified plant communities were ecologically interpreted, and described. Thirty plant communities

were identified. These communities were summarized in a synoptic table.

The endemic seed plant flora was analyzed with respect to substrate. It is proposed to call this major centre of biodiversity of the escarpment the Wolkberg Centre, with two subunits of endemism, the Blyde Subcentre and the Serala Subcentre. A total of 106 seed plant taxa are considered to be endemic or near-endemic. The species were listed.

OPSOMMING

Fitososiologie van die Noord-oostelike Berg Suurveld

deur

WAYNE MATTHEWS

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Voorgelê ter vervulling van 'n deel van die vereistes
vir die graad

MAGISTER SCIENTIAE

Die doel van hierdie studie was om die hoofplantegroei-eenhede en hul variasies, van die Noord-oostelike Berg Suurveld van die Transvaalse platorand te identifiseer en klassifiseer en aan die hand van die habitat ekologies te interpreteer, sowel as om bewaring en bestuurmaatreëls vir die gebied te ontwikkel.

Die studiegebied beslaan ongeveer 2 000 km^2 waarvan die grootste gedeelte deur bosbou gebruik word, maar van Transvaalse grootste natuurreservate is hier te vinde.

Die gebied was gestratifieër op grond van relatiewe homogene eenhede van hoof kenmerke soos geologie, land vorm (topografie), fisionomie en dominante spesies. Die monsterpersele is subjektief in elk van die eenhede uitgeplaas. 'n Totaal van 200 monsterpersele is in die studie gebied uitgeplaas. 'n Floristiese opname volgens die Braun-Blanquet-tegniek, en 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 vier verskillende fitososiologiese tabelle tot gevolg gehad, verteenwoordigend van die vier hoof plantegroeitipes, naamlik die Swart Rif Kwartsiet en geassosieerde groot rotsagtige gebiede, die droë dolomitiese gebiede, die plantegroei van hooggeleë en nat gebiede en die plantegroei van relatiewe

laagliggende gebiede. Al die geïdentifiseerde plantgemeenskappe is ekologies geïnterpreteer en beskryf. Dertig plantgemeenskappe is geïdentifiseer. Hierdie plantgemeenskappe word saamgevat in 'n sinoptiese tabel.

Die endemiese saadplante van die noord-oostelike Transvaalse platorand met betrekking tot substraat is ondersoek. Dit word voorgestel om hierdie sentrum van endemisme van die platorand die Wolkberg Sentrum, met twee sub eenhede van endemisme, die Blyde Sub Sentrum en die Serala Sub Senter. 'n Totaal van 106 saad plant taxa word aanvaar as endemies of naby endemies. Die spesies word gelys.

REFERENCES

Acocks, J.P.H. 1988. Veld Types of South Africa. Mem. bot. Surv. S. Afr. 40: 1-128.

Adams, F. 1981. Nutritional imbalances and constraints to plant growth on acid soils. J. Plant Nutr. 4, 81–87.

Balkwill, K. & Balkwill, M-J. 1988. Studies on serpentine flora: A new species of Brachystelma (Asclepiadaceae). S. Afr. J. Bot. 54, 60–62.

Barkman, J.J., Moravec, J. & Rauschert, S. 1986. Code of phytosociological nomenclature. Vegetatio. 67, 3:145-197.

Bayer, A.W. 1970. Plant ecology in the service of man in southern Africa. S. Afr. J. Sci. 66: 71-77.

Behr, C.M. & Bredenkamp, G.J. 1988. A phytosociological classification of the Witwatersrand National Botanical Garden. S. Afr. J. Bot. 54: 525-533.

Bezuidenhout, H. 1988. 'n Plantsosiologiese studie van die Mooirivier opvangs gebied Transvaal. M.Sc. Potchefstroom University for Christian Higher Education. Potchefstroom.

Bezuidenhout, H., Bredenkamp, G.J. & Elsenbroek, J.H. 1988. The vegetation of the alkali-granite and bordering quartzite in the Vredefort dome, north-west of Parys. S.A. Tydskrif vir Natuurwetenskap en Tegnologie 7, 1: 4-9.

Bezuidenhout, H. & Bredenkamp, G.J. 1990. A reconnaissance survey of the vegetation of the dolomitic region in the Potchefstroom - Ventersdorp - Randfontein area, South Africa. Phytocoenologia 18: 387-403.

Bezuidenhout, H. & Bredenkamp, G.J. 1991. The vegetation of the Bc land type of the Western Transvaal grassland, South Africa. Phytocoenologia 19(4): 497-518.

Bloem, K.J. 1988. 'n Plantsosiologiese studie van die Verlorenvaleinatuurreservaat, Transvaal. M.Sc. thesis. University of Pretoria.

Branch, B. 1988. Field Guide to the Snakes and other Reptiles of Southern Africa. Struik Publishers, Cape Town.

Braun - Blanquet, J. 1964. Pfanzensociologie. 3 Aufl. Wein. Springer.

Bredenkamp, G.J. & Theron, G.K. 1975. 'n Plantekologiese studie van die Suikerbosrandnatuurreservaat. M.Sc thesis. University of Pretoria, Pretoria.

Bredenkamp, G.J. & Theron, G.K. 1978. A synecological account of the Suikerbosrand Nature Reserve I. The phytosiciology of the Witwatersrand geological system. Bothalia 12, 513–529.

Bredenkamp, G.J. & Theron, G.K. 1980. Die Plantegroei van die Manyeleti Wildtuin. KION, Departement Samewerking & Ontwikkeling, Pretoria.

Bredenkamp, G.J. 1982. 'n Plantekologiese studie van die Manyeleti - Wildtuin. D.Sc dissertation. University of Pretoria. Pretoria.

Bredenkamp, G.J., Joubert, A.F. & Bezuidenhout, H. 1989. A reconnaissance survey of the vegetation of the plains in the Potchefstroom - Fochville - Parys area. S. Afr. J. Bot. 55: 199-206.

Bredenkamp, G.J. & Bezuidenhout, H. 1990. The vegetation of the Faan Meintjies nature reserve, western Transvaal. S. Afr. J. Bot. 56, 1: 54-64.

Bykov, B.A. 1979. On a quantitative estimate of endemism. Botan. Mater. Gerb. Inst. Botan. Akad. Nauk Kazakh. SSR. 11, 3–8.

Coetzee, B.J. 1972. 'n Plantsosiologiese studie van die Jack Scott-natuurreservaat. M.Sc. thesis. University of Pretoria, Pretoria.

Coetzee, B.J. 1983. Phytosociology, vegetation structure and landscapes of the central district, Kruger National Park. D.Sc. thesis. University of Pretoria.

Daubenmire, R. 1968. Plant communities. A textbook of plant synecology. Harper & Row. New York.

Deall, G.B. 1985. A plant-ecological study of the Eastern Transvaal escarpment in the Sabie area. M.Sc. Thesis, University of Pretoria, Pretoria.

Deall, G.B., Scheepers, J.C. & Schutz, C.J. 1989a. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 1. Physical environment. Bothalia 19: 53-67.

Deall, G.B., Theron, G.K. & Westfall, R.H. 1989b. The vegetation ecology of the Eastern Transvaal Escarpment in the Sabie area. 2. Floristic classification. Bothalia 19: 69-89.

De Dalla Torre, C. G. & Harms, H. 1958. Genera Siphonogamarum. Engelmann, Leipzig.

Denys, E. 1980. A tentative phytogeographical division of tropical Africa based on a mathematical analysis of distribution maps. Bull. Jard. Bot. Nat. Belg. 50, 465–504.

Du Preez, P.J. & Bredenkamp, G.J. 1991. Vegetation classes of the south-eastern Orange Free State. Bloemfontein museum (in press).

Du Preez, P.J., Bredenkamp, G.J. & Venter, H.J.T. (1991). The syntaxonomy and synecology of the dry forests in the south-eastern Orange Free State, I. the Podocarpetalia latifolii. *S. Afr. J. Bot.* **57**, 189-206.

Du Preez, P.J. & Bredenkamp, G.J. (1991). The taxonomy and synecology of the forests in the south-eastern Orange Free State, II. the Pittosporetalia viridiflorii. *S. Afr. J. Bot.* **57**, 207-212.

Du Toit, A.L. 1956. The Geology of Southern Africa. 3rd ed. Oliver & Boyd, Edinburgh.

Edwards, D. & Leistner, O.A. 1971. A degree reference system for citing biological records in southern Africa. Mitt. Bot. Staatssamml. München 10, 501–509.

Erasmus. J.F. 1987. Rainfall Deciles for Transvaal Region. Department of Agriculture and Water supply.

Fabricius, A.F. 1988. Klimageographie – Südafrica (Moçambique, Swaziland, Republik Südafrika). Afrika-Kartenwerke S5, Beiheft S5. Deutsche Forschungsgemeinschaft, Bonn-Bad Godesberg.

Fabricius, A.F. 1969. In Schutte, J.M. 1971. Die onttreking van water uit die newellaag en lae wolke by Mariepskop. S.A Department of water Affairs, Division Hydrological Research, Technical note 20: 1-21.

Ferrar, A.A., Isaacs, G. & Stacey, J.R. (eds). 1988. Environmental Conservation Features of the Transvaal Escarpment: an Information Base for Regional Planning. Ecosystem Programmes Occasional Report 31. Foundation for Research Development, Pretoria.

Fourie, S.P. 1986. The Transvaal, South Africa, threatened plants programme. Biol. Conserv. 37, 23–42.

Fourie, S.P., Jacobsen, N.H.G., Kleynhans, C.J. & Tarboton, W. 1988. Biogeographical importance and species/areas warranting particular conservation attention, In Environmental Conservation Features of the Transvaal Escarpment, eds A.A. Ferrar, G. Isaacs, & J.R. Stacey. Ecosystem Programmes Occasional Report 31, 46–70. Foundation for Research Development, Pretoria.

Gamble, F. 1988. Climate of the Transvaal Escarpment, In Environmental Conservation Features of the Transvaal Escarpment, eds A.A. Ferrar, G. Isaacs, & J.R. Stacey. Ecosystem Programmes Occasional Report 31, 1–4. Foundation for Research Development, Pretoria.

Gankin, R. & Major, J. 1964. Arctostaphylos myrtifolia, its biology and relationship to the problem of endemism. Ecology 45, 793–808.

Geological Survey. 1986. Geology map 1:250 000 geological series. 2430 Pilgrim's Rest. Government Printer, Pretoria.

Gibbs-Russell, G.E., Reid, C., Van Rooy, J & Smook, L. 1985. List of species of southern African plants. 2nd edn, Part 1, Mem. bot. Surv. S. Afr. 51: 1-152.

Gibbs-Russell, G.E., Watson, L.,Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M.P. & Dallwitz, M.J. 1990. Grasses of Southern Africa. Mem. bot. Surv. S. Afr. 58: 1-437.

Gibbs-Russell, G.E., Welman, W.G., Retief, E.,Immelman, K.L., Germishuizen, G., Pienaar, B.J., Van Wyk, M., Nicoholas, A., De Wet, C., Mogford, J.C. & Mulvena, J. 1987. List of species of southern African plants. 2nd edn, Part 2, Mem. bot. Surv. S. Afr. 56: 1-270.

Greig-Smith, P. 1983. Quantitative plant ecology. 3rd ed. Blackwell, Oxford.Hedberg, O. 1957. Afroalpine vascular plants. Symb. Bot. Ups. 15, 1–411.

Grondklassifikasiewerkgroep. 1991. Grondklassifikasie.'n Taksonomiese sisteem vir Suid-Afrika. Memoirs oor die Natuurlike Landbouhulpbronne van Suid-Afrika Nr. 15. - Dept. Agriculture-technical services, Pretoria.

Henning, S.F. 1989. South African red data book: Butterflies. S.A. National Scientific Programmes Report 158, 1–175.

Hill, M.O. 1979a. DECORANA. A FORTRAN programme for detrended correspondence analysis and reciprocal averaging. Department of Ecology and Systematics, Cornell University. Ithaca, New York.

Hill, M.O. 1979b. TWINSPAN. A FORTRAN programme for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Cornell University. Ithaca, New York.

Hilliard, O.M. & Burtt, B.L. 1987. The Botany of the Southern Natal Drakensberg. Annals of Kirstenbosch Botanic Gardens Vol. 15. National Botanic Gardens, Cape Town.

Killick, D.J.B. 1963. An account of the plant ecology of the Cathedral Peak area of the Natal Drakensberg. Mem. bot. Surv. S. Afr. 34: 1-178.

Kooij, M.S. 1990. A phytosociological survey of the vegetation of the North Western Orange Free State. M.Sc. Thesis, University of Pretoria, Pretoria.

Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. 1990a. The vegetation of the B Land Type in thre north-western Orange Free State. S. Afr. J. Bot. 56: 309-318.

Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. 1990b. The vegetation of the north-western Orange Free State 2. The D Land Type. Bothalia 20: 241-248.

Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. 1990c. The vegetation of the A Land Type in the north-western Orange Free State. Bot. Bull. Academia Sinica 31: 235-243.

Kooij, M.S., Bredenkamp, G.J. & Theron, G.K. 1990d. The vegetation of the hills in the north-western Orange Free State. Bot. Bull. Academia Sinica 31: 295-304.

Kruckeberg, A.R. 1986. An essay: The stimulus of unusual geologies for plant speciation. Systematic Botany 11, 455–463.

Kruckeberg, A.R. & Rabinowitz, A.R. 1985. Biological aspects of endemism in higher plants. Ann. Rev. Ecol. Syst. 16, 447–479.

Küchler, G.P. 1967. Vegetation mapping. Ronanld, New York.

Larcher, W. 1983. Physiological Plant Ecology. Second edition. Springer-Verlag, Berlyn.

Land Type Survey Staff. 1989. Land types of the maps 2330 Tzaneen and 2430 Pilgrim's Rest. Mem. agric. nat. Resour. S. Afr. No. 12.

MacVicar, C.N. & co-workers 1977. Soil classification - A binomial system for South Africa. -Dept. Agriculture-technical services, Pretoria.

Major, J. 1988. Endemism: a botanical perspective. In Analytical Biogeography, eds A.A. Myers & P.S. Giller. Chapman & Hall, London, pp. 117–146.

Martini, J.E.J. 1987. Limestone and Dolomite resources of the Republics of South Africa, Bophuthatswana, Ciskei, Transkei and Venda: Handbook of the Geological Survey of South Africa 9. Government Printer, Pretoria.

Matthews, W.S., Bredenkamp, G.J. & van Rooyen, N. 1991a. The grassland associated vegetation of the Black Reef Quartzite and associated large rocky outcrops in the North-eastern mountain sourveld of the Transvaal Escarpment. S. Afr. J. Bot. 57(3): 143-150.

Matthews, W.S., Bredenkamp, G.J. & van Rooyen, N. 1991b. The vegetation of the dry dolomitic regions of the North-eastern mountain sourveld of the Transvaal escarpment, South Africa. Phytocoenologia (in press).

Matthews, W.S., Bredenkamp, G.J. & Van Rooyen, N. (19- a). The phytosociology of the high altitude hygrophilous vegetation regions of the North-eastern Mountain Sourveld of the Transvaal, South Africa. Phytocoenologia.(submitted).

Matthews, W.S., Van Wyk, A.E. & Bredenkamp, G.J. (19– b). Endemic flora of the quartzitic and related rock types of the north-eastern Transvaal Escarpment, South Africa. Biol. Conserv. (submitted).

Matthews, W.S., Van Wyk, A.E. & Bredenkamp (19– c). Endemic flora of the dolomitic areas of the North-eastern Transvaal Escarpment, South Africa. Biol. Conserv. (submitted).

Meadows, M.E. & Linder, H.P. 1989. A reassessment of the biogeography and vegetation history of the southern Afromontane Region. In Biogeography of the Mixed Evergreen Forests of Southern Africa, ed. C.J. Geldenhuys. Ecosystem Programmes Occasional Report 45, 15–29. Foundation for Research Development, Pretoria.

Mentis, M.T. & Huntley, B.J. 1982. A description of the Grassland Biome Project. S. Afr. Nat. Sci. Prog. Report No. 62, CSIR, Pretoria.

Moore, P.D. & Chapman S.B. (eds). 1986. Methods in Plant Ecology. Blackwell Scientific Publications, London.

Morrey, D.R., Balkwill, K. & Balkwill, M-J. 1989. Studies on serpentine flora: Preliminary analysis of soils and vegetation associated with serpentine rock formations in the south-eastern Transvaal. S. Afr. J. Bot. 55, 171–177.

Morris, J. W. 1973. Automatic classification and ecological profiles of southwestern Transvaal Highveld grassland. Ph.D Thesis, University of Natal.

Mueller-Dombois, D. & Ellenberg, H. 1974. Aims and methods of vegetation Ecology. John Wiley & Sons, New York.

Partridge, T.C. & Maud, R.R. 1987. Geomorphic evolution of southern Africa since the Mesozoic. S. Afr. J. Geol. 90, 179–209.

Pentz, J.A. 1938. The value of botanical survey and the mapping of vegetation as applied to farming systems in South Africa. Mem. bot. Surv. S. Afr. No. 19: 1-15.

Phillips, E.P. 1917. A contribution to the flora of the Leribe plateau and environs. Ann. S. Afr. Mus. 16, 1–379.

Scheepers, J.C. 1978. Vegetation of Westfalia Estate on the North-Eastern Transvaal Escarpment. Mem. bot. Surv. S. Afr. 42: 1-230

Scheepers, J.C. 1987. Grassland Biome Project: Proceedings of the workshop on classification and mapping. Ecosystems Prog. Occas. Report Series No. 16, CSIR, Pretoria.

Shackleton, C.M. 1989. An Ecological survey of a selected area of Pondoland Sourveld with emphasis on it's response to the management practices of burning and grazing. M.Sc. thesis. University of Transkei, Umtata.

Shimwell, D.W. 1971. Description and classification of vegetation. Sidgwick and Jackson, London.South African Committee for Stratigraphy [SACS] 1980. Stratigraphy of South Africa. Part 1 (Compiled by L.E. Kent). Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda [also Errata compiled by F. Walraven & M.R. Johnson]: Handbook of the Geological Survey of South Africa 8. Government Printer, Pretoria.

Stace, C.A. 1989. Plant Taxonomy and Biosystematics, 2nd ed. Edward Arnold, London.

Turner, B.J. 1989. A Phytosociological study of the South-eastern Transvaal Highveld grasslands. M.Sc. thesis. University of Pretoria, Pretoria.

Van Der Maarel, E., Espejal, I. & Moreno-Casasola, P. 1987. Two-step vegetation analysis based on very large data sets. Vegetatio 68: 139-143.

Van Rooyen, N., Theron, G.K. & Grobbelaar, N. 1981. A floristic description and structural analysis of the plant communities of the Punda Milia-Pafuri-Wambiya area in the Kruger National Park. 1. The hygrophilous communities. Jl. S. Afr. Bot. 47: 213-246.

Van Wyk, A.E. 1990. The sandstone regions of Natal and Pondoland: remarkable centres of endemism, in Palaeoecology of Africa, ed. K. Heine, vol. 21. A.A. Balkema, Rotterdam, pp. 243–257.

Van Wyk, S. 1983. 'n Plantekologiese studie van die Abe Bailey-Natuurreservaat. M.Sc. Potchefstroom University for Christian Higher Education. Potchefstroom.

Walker, B.H. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. S. Afr. J. Wildl. Res. 6: 1-32.

Werger, M.J.A. 1973. Biogeography and ecology of southern Africa: 19 - 52. Junk, The Hague.

Werger, M.J.A. 1974. On concepts and Techniques applied in the Zurich-Montpellier method of vegetation survey. Bothalia 11: 309-323.

Westfall, R.H. 1981. The plant ecology of the farm Groothoek, Thabazimbi district. M.Sc. Thesis. University of Pretoria, Pretoria.

White, A.C., Dyer, R.A. & Sloane, B.L. 1941. The Succulent Euphorbiae (Southern Africa), 2 vols. Abbey Garden Press, Pasadena.

White, F. 1978. The Afromontane Region, In Biogeography and Ecology of Southern Africa, ed. M.J.A. Werger. Junk, The Hague, pp. 463–513.

White, F. 1981. The history of the Afromontane archipelago and the scientific need for its conservation. Afr. J. Ecol. 19, 33–54.

White, F. 1983. The Vegetation of Africa. Unesco, Paris.

Whittaker, R.H. 1962. Classification of natural communities. Ecol. Monogr. 26: 1-80.

Whittaker, R.H. 1967. Gradient analysis of vegetation. Bio. Rev. 49: 207-264.

Whittaker, R.H. 1980. Approaches to classifying vegetation. In. Whittaker, R.H. (Ed.). Classification of Plant Communities. Junk, The Hague.

Wild, H. 1964. The endemic flora of the Chimanimani Mountains and their significance. Kirkia 4, 125–157.