PHYTOSOCIOLOGY OF THE MPUMALANGA HIGH ALTITUDE GRASSLANDS

By

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[28.] God blessed them and said to them, "Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground."

– Genesis 1: 28, The Holy Bible, 1979

'Those who are enamoured of practice without science are like a pilot who goes into a ship without rudder or compass and never has certainty where he is going. Practice should always be based upon a sound knowledge of theory...'

– Leonardo da Vinci, Geodesy and map projections

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ABSTRACT

A phytosociological study of the Southeastern Mpumalanga high altitude grasslands using the Braun-Blanquet approach, resulted in the classification and description of three vegetation types. The three vegetation types are the Southeastern Mpumalanga Mountains Vegetation Type, Southeastern Mpumalanga Hills and Lowlands Vegetation Type and the Southeastern Mpumalanga Plains Vegetation Type. Each vegetation type consisted of woodland and grassland communities associated either with the terrestrial ecosystem or with the wetlands of the aquatic ecosystem.

The following conclusions were reached from this study:

- Landforms are important parameters in the classification of vegetation on a small scale within biomes.
- Landform slope configuration and climate influences soil water availability and therefore plant distribution.
- Geographic information systems are useful in obtaining environmental attributes, which are generally estimated (slope, aspect) or available from existing databases (geology, geomorphology).
- Soil characteristics and vegetation distribution are closely related.
- Extensive small-scale surveys determine environmental trends, but intensive large-scale surveys are needed for management guidelines.

Phytosociology is the science in which different vegetation types and plant communities are recognised and defined. A plant community can be defined as a collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent & Coker 1992). A vegetation type, depending on the scale and environment of the research, can represent an individual plant community or a number of plant communities with the same or different physiognomy distributed over a certain environment. Depending again on the scale and environmental complexity of the study area, from one to several vegetation types could be identified.

The towns of Belfast, Barberton, Piet Retief and Wakkerstroom lie at the four corners of the study area. They are situated between 25° 30' and 27° 30' southern latitude and 30° and 32° eastern longitude, in southeastern Mpumalanga, South Africa. This area is highly diverse with regard to altitude, geological time and formations, climates, landform, soil patterns and soil forms as well as species of both flora and fauna. This study included those soil patterns not included in the undulating plains and wetland studies of Coetzee, Bredenkamp and Van Rooyen (1993a & b).

In describing the South African Grassland Biome project, Mentis & Huntley (1982) stated that it was necessary to identify, describe and determine the location of the major vegetation types and subtypes within the biome. Turner (1989), Matthews (1991), Smit (1992), Myburgh (1993) and Burgoyne (1995) cited the lack of knowledge of the eastern Highveld and Escarpment areas and the threat of habitat destruction, due to overgrazing, afforestation and industrialisation as further reasons for research in the Grassland Biome. These trends continue to this day; the natural vegetation of the study area impacted upon by farming (livestock and crops), mining and forestry, of which the first is a necessity, the second controlled and the latter expanding rapidly! Thus, the primary aim of this research is to supply information of both academic and applied value (Kent & Coker 1992), to be used in environmental policies and conservation strategies on national and provincial levels. This goal was achieved through vegetation description and analysis in the discipline known as vegetation science (Kent & Coker 1992) while making use of existing **methods** and *latest technology.*

The **method** applied was principally the Braun-Blanquet approach. Researchers in South Africa have been using this approach since 1969 (Werger 1974) and since 1982 extensively by Grassland Biome Project phytosociological researchers (*Inter alia* Mentis & Huntley 1982; Turner 1989; Matthews 1991; Smit 1992; Coetzee *et al.* 1993a; Coetzee *et al.* 1993b; Eckhardt 1993; Myburgh 1993; Burgoyne 1995). The method is based on total floristic composition and consists of an analytical, sampling phase and a synthetic phase (Werger 1974).

Analytical sampling (fieldwork, GIS analysis and literature studies) started in January 1994, fieldwork was completed in 1995, while GIS analysis and literature studies continued and overlapped with the synthetic phase until 1997. The *computer assisted* synthetic phase consisted of a TWINSPAN (Hill 1979a) classification of the floristic relevé data and refinement of the classification by Braun-Blanquet procedures. Ordination by means of DECORANA (Hill 1979b) was used to indicate relationships between vegetation types, plant communities and the environment. Braun-Blanquet floristic tables were created through a combination of the programme BBNEW on the mainframe computer of the University of Pretoria and spreadsheets from personal computers. Two different geographic information systems (GIS) application software were used to digitise, model, extract and create data from maps or to create maps. Geographical features were digitised and modelled in IDRISI, a raster format application software (1999). Attribute information from these features was extracted and maps created in vector format Arc-Info/View (1999). The environmental and floristic data were combined in a spreadsheet and analysed.

Chapter two describes the methods used during the survey and analysis of the collected data. Chapter three describes the study area from both global and local perspective to enable a thorough understanding of the environmental factors (geology, climate, geomorphology, pedology, flora and fauna) and trends associated with it. The global perspective provided an overview of accepted theories and processes associated with the different environmental factors against which the results and hypotheses of the local perspective could be compared. Chapter four contains the results from the overall classification while chapters five, six and seven describe the three discrete vegetation types: Southeastern Mpumalanga Mountain Vegetation Type, Southeastern Mpumalanga Hills and Lowlands Vegetation Type and Southeastern Mpumalanga Plains Vegetation Type respectively. A detailed description of the abstract vegetation communities and the ecological parameters which separate them, is given for the terrestrial ecosystem and wetland areas of the aquatic ecosystems of these vegetation types. The role and application of Global Positioning System (GPS), remote sensing and Geographical Information Systems (GIS) within this study and wildlife management in general, are explained in chapter eight. In the discussion (Chapter IX), it is proposed that the boundary between the grassland and savanna biome be shifted. In the final chapter (Chapter X) a conclusion is put forward concerning the three discrete vegetation types, their abstract vegetation communities and the ecological parameters which support them.

1. Introduction

Phytosociology (synecology) is one of the larger segments of plant ecology and consists of four phases: paleoecology, plant sociology, community dynamics and evolutionary ecology (Barbour, Burk & Pitts 1980). In the current study plant sociology was dealt with thoroughly and the rest only touched on. Plant sociology is the classification (description) and mapping of vegetation types and communities, of which a proliferation of standard methods for sampling vegetation as well as treating and analysing sampling data exist (Barbour *et al.* 1980). Valid conclusions can be drawn with these standard methods and vegetation from all over the world can be compared on an equal basis (Barbour *et al.* 1980). The Braun-Blanquet approach (Werger 1974; Westhoff & Van der Maarel in: Whittaker 1980; Kent & Coker 1992) is one such method.

The Braun-Blanquet (Zürich-Montpellier) approach has been used by researchers in South Africa since 1969 (Werger 1974) and since 1982 extensively by Grassland Biome Project researchers (Mentis & Huntley 1982; Turner 1989; Matthews 1991; Smit 1992; Coetzee *et al.* 1993a; Coetzee *et al.* 1993b; Eckhardt 1993; Myburgh 1993; Burgoyne 1995). This method samples selected, representative, homogeneous plots of certain minimum size in the phytocoenoses (plant community stands) making up the vegetation of the area to be surveyed, recording all species and rating them on a cover-abundance scale. Some other analytical characteristics of the vegetation in the plot might also be recorded. The samples are entered in a table from which the vegetation units are extracted. The units are interpreted ecologically and ranked in a hierarchy. Thus the method consists of an analytical, sampling phase and a synthetic phase, which will be discussed separately (Werger 1974).

The information needed for this study was gathered from the two components of an ecosystem namely the abiotic and biotic components (Bredenkamp 1987). This was achieved through fieldwork, geographical information system (GIS) analysis and literature studies. Their inter- and intraspecific relationships were detected by means of computer assisted analysis. The analytical sampling phase consisted of fieldwork, GIS analysis and literature studies and the synthetic phase of computer assisted procedures to generate tables, maps and text. The hard line abiotic components were the geological, climatic and geomorphological environments with the pedological environment being intermediate, while the flora and fauna comprised the biotic components.

The fieldwork was documented on coloured A4 field forms. As well as the attributes of the different environments and the floristic species composition and physiognomics, the Global Positioning System's (GPS) geographical co-ordinates in degrees, minutes and seconds, the date and general notes were documented.

2. Analytic phase

Two Geographic Information Systems (GIS) software packages were used during the analytic phase. Raster format IDRISI (1999) was used to digitise and model environmental attributes from hard copies and existing digital data. Vector format Arc-Info/View (1999) was used to create maps and query data from existing, digital environmental attribute maps. Data and results were exchanged between these two packages, enabling the use of the best capabilities of each package.

2.1. Geological environment

2.1.1. Fieldwork

When correlation between certain lithostratigraphic units and plant communities were obvious or when in doubt about a certain lithostratigraphic unit's petrology, samples were taken with a prospector's pick.

2.1.2. Geographic Information System

Spatial geological information was extracted using the plots' geographical co-ordinates from a clipped section of the 1: 1 000 000 scale geological coverage[1] of Southern Africa.

2.1.3. Literature study

Additional geological information was obtained from the explanations accompanying the 1: 1 000 000 scale hard copy map (Visser 1989) and three 1: 250 000 scale Geological series maps: 2530 Barberton (Walraven 1989a), 2630 Mbabane (Walraven 1989b) and 2730 Vryheid (Linström 1987). Another source of geological information was the Memoirs that correspond with the 1:250 000 Land type series maps 2530 Barberton (Land Type Survey Staff 1989), 2630 Mbabane (Land Type Survey Staff 1985) and 2730 Vryheid (Land Type Survey Staff 1986) used in the survey. Strahler and Strahler (1987) described the broad trends associated with geology and the rest of the abiotic components.

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[1]Available form the GIS section, Council of Geoscience, Silverton, Pretoria.

2.2. Climatic environment

2.2.1. Fieldwork

One of the features of local climatology[2] is topography. The following attributes of topography were documented during fieldwork: altitude, aspect and slope.

2.2.2. Geographic Information System

A. Climate zones

Land Type Survey Staff (1985, 1986 & 1989) subdivided the macroclimate[3] in climate zones (local climate zones) using climate measurements, natural vegetation, soils, crop performance, altitude and topography. Although most of the climate measurements were incomplete, actual or estimated mean annual rainfall was available from the Memoirs (Land Type Survey Staff 1985, 1986 & 1989) for these climate zones. A map representing the climate zones was digitised using GIS IDRISI. It was based on the red boundaries from the 1:250 000 Land type series maps 2530 Barberton (Land Type Survey Staff 1989), 2630 Mbabane (Land Type Survey Staff 1985) and 2730 Vryheid (Land Type Survey Staff 1986), reflecting the individual climate zones and their mean annual rainfall. Only those climate zones which correspond to the Ab, Ac, Ad, Ae, Ea, Fa, Fb and Ib soil patterns were digitised between the towns of Belfast, Barberton, Piet Retief and Wakkerstroom.

B. Insolation attitudes

The surface of the study area was classified into insolation attitudes based on slope and aspect.

Four surface models (digital terrain models or digital elevation models) were created using 100 m contour intervals, obtained from the GIS LAB of the national Department of Environmental Affairs and Tourism. Two were based on 100 m vertical intervals, at low and high resolution and two were based on 500 m vertical intervals at low and high resolution. At low resolution one pixel equals 1 000m x 1

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[2]One of the divisions of microclimatology, concerned mainly with weather and climate over short distances, concentrating especially on the effects of water surfaces and topography, including urban areas (Buckle 1996)

[3]Large-scale climatic regions (Buckle 1996)

000m and at high resolution one pixel equals 100m x 100m. These two resolutions were selected because at 100 m resolution one pixel represents one hectare, which is the basic unit for several agricultural variables, e.g. carrying capacity and maize production. The 1 000 m resolution was selected because it is twice the distance of a 500 m vertical interval and enables images to be printed without reduction. The 500 m vertical interval was selected to coincide with the altitudinal belts (Barbour *et al.* 1980). The data was exported from GIS Arc-Info/View to GIS IDRISI. In GIS IDRISI it was changed from vector format to raster format and a surface model created with the intercon module. This procedure was repeated four times, twice at 100 m vertical intervals, once at low resolution and a second time at high resolution and twice using 500 m verticals intervals at the same resolution. The four surface models were used to create images reflecting the altitude in metres above sea level, aspects in azimuths and slope in both degrees and percentages.

Altitude values and classifications were obtained from the four surface models. The 100m vertical interval surface model was reclassified into 100 m intervals ranging from 100 m to 2 200 m, while the 500 m vertical interval surface model was reclassified into 500 m intervals ranging from 500 m to 2 500 m. Real altitude values were extracted from the original low-pass filtered 100 m vertical interval surface model, while integer altitude values were extracted from the classified altitudinal images (Figure 1).

Slope angles which would be perpendicular exposed to the sun, were determined using the altitude of the sun at noon during different season of the year (Table 1 and 2) (Strahler & Strahler 1987). These values were checked against those obtained from an analemma (Strahler 1962). The following categories of slopes perpendicular to the sun at noon and sunrise and sunset were determined:

Slope	Period of perpendicular insolation
0-2°	Never
2-25°	Summer solstice
25-49°	Summer solstice and equinox
49-90°	All four seasons, in the mornings and in the evenings

The surface module used the four surface models to create slope images in degrees and percentage. The slope images based on degrees were classified using the reclass module into the four perpendicular insolation slope categories (Figure 2).

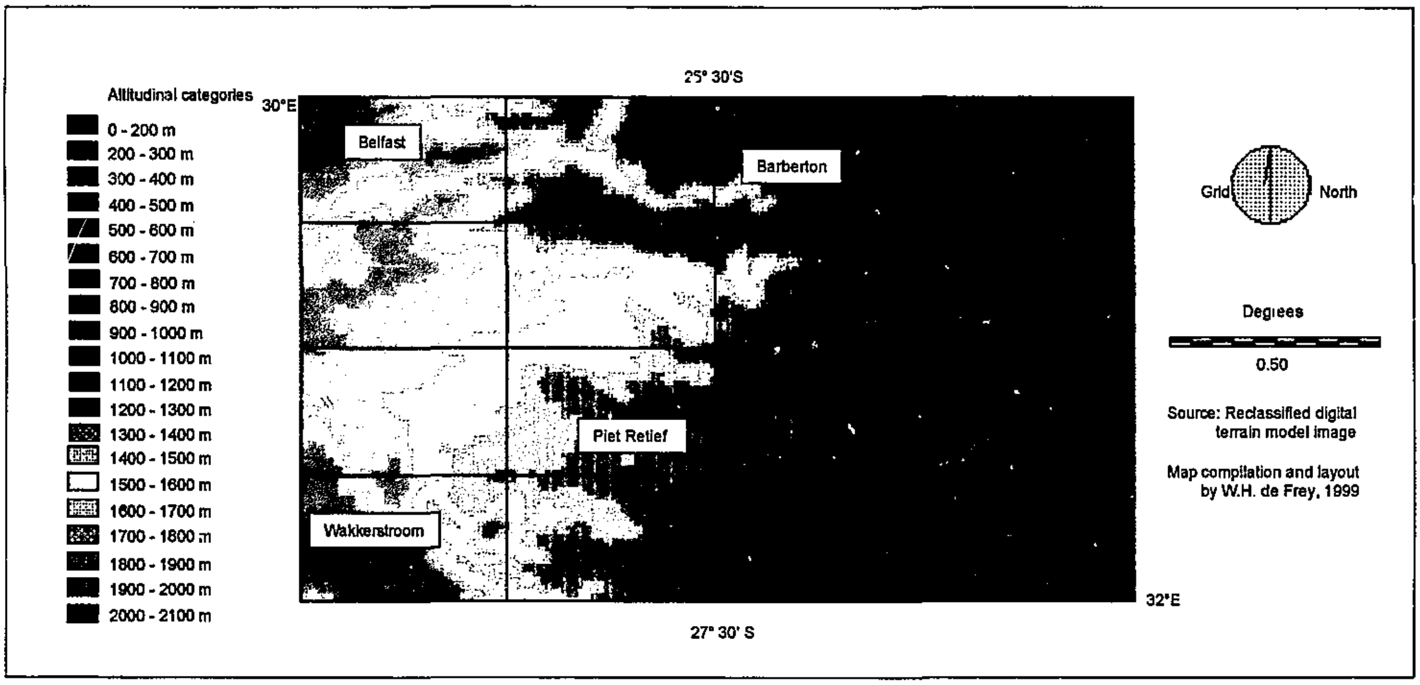


Figure 1: Modelled altitudinal classes based on the 100 m interval digital terrain model

Table 1: Altitude of sun during different seasons at different latitudes: values in bold are relevant to the study area

Latitude	22 Dec/ Summer solstice, southern hemisphere	21 Mar/ Equinox global	21 Jun/ Winter solstice, southern hemisphere	23 Sept/ Equinox global
	North pole away from the sun	Poles perpendicular to the sun	North pole towards the sun	Poles perpendicular to the sun
	Altitude of the sun above the horizon			
+90° North pole	Not visible (-23.5°)	0°	+23.5°	0°
+66° 30'	0°	23.5°	47°	23.5°
+41°	25.5°	49°	72.5°	49°
+23° 30'	43°	66.5°	90°	66.5°
0° Equator	66.5°	90°	66.5°	90°
-23° 30'	90°	66.5°	43°	66.5°
-25° 30'	**88°**	**64.5°**	**41°**	**64.5°**
-27° 30'	**86°**	**62.5°**	**39°**	**62.5°**
-41°	72.5°	49°	25.5°	49°
-66° 30'	47°	23.5°	0°	23.5°
-90° South pole	+23.5°	0°	Not visible (-23.5°)	0°

Table 2: Noon altitude of the sun at different season and latitudes with soil angles, which would be perpendicular to it.

Latitude (S)	Day/ Season	Sunrise		Noon		Sunset	
		Sun angle	Soil angle	Sun Angle	Soil angle	Sun angle	Soil angle
25° 30'	22 Dec/ Summer	0°	90°	88°	2°	0°	90°
	21 Mar/ Autumn	0°	90°	64.5°	25.5°	0°	90°
	21 Jun/ Winter	0°	90°	41°	49°	0°	90°
	23 Sept/ Spring	0°	90°	64.5°	25.5°	0°	90°
27° 30'	22 Dec/ Summer	0°	90°	86°	4°	0°	90°
	21 Mar/ Autumn	0°	90°	62.5°	27.5°	0°	90°
	21 Jun/ Winter	0°	90°	39°	51°	0°	90°
	23 Sept/ Spring	0°	90°	62.5°	27.5°	0°	90°

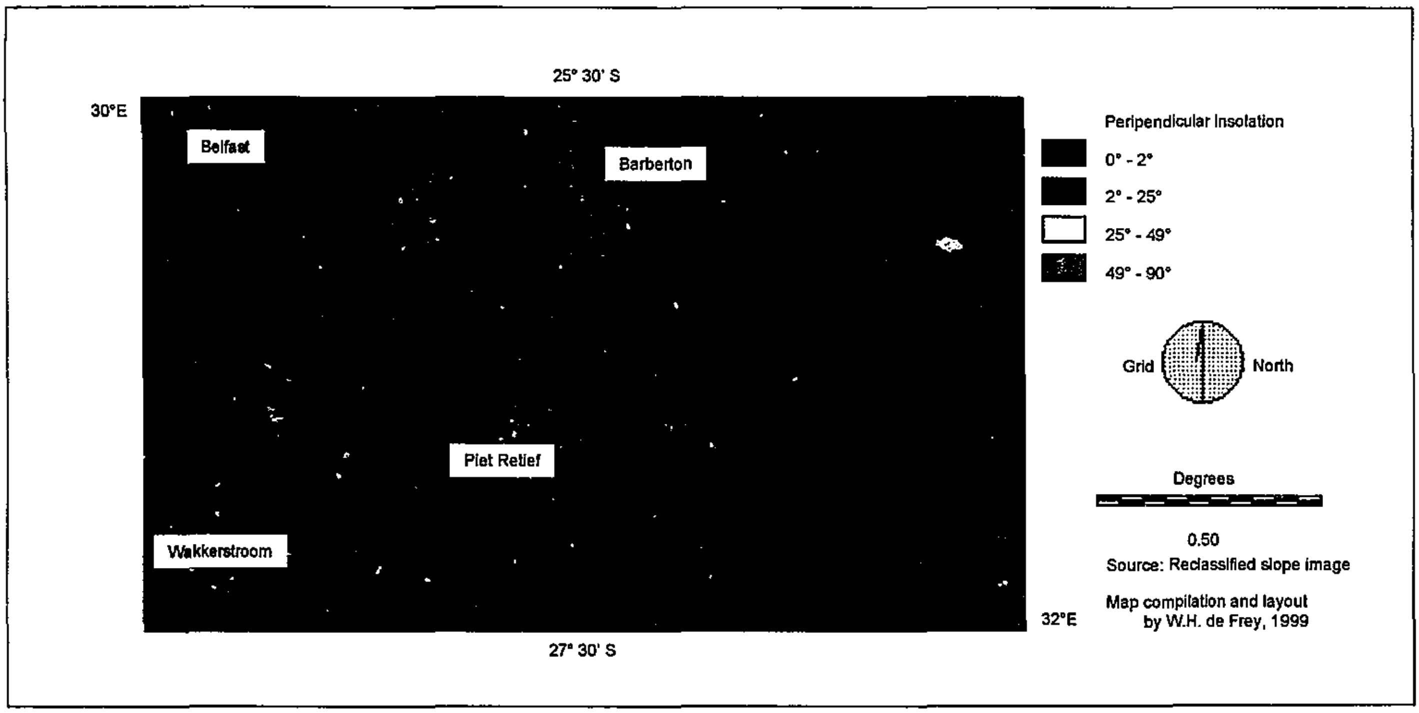


Figure 2: Modelled perpendicular insolation classes using the degree slope surface model

The same module created the aspect images, which were reclassified to represent the following categories of aspects exposed to the sun, based on the azimuth of sunrise and sunset during the different seasons (Figure 3) (Strahler & Strahler 1987):

Azimuths	Bearings	Exposure
-1	No aspect	All seasons
135-225°	SE-SW	Never
90-135°	SE-E	Summer solstice - sunrise
225-270°	W-SW	Summer solstice - sunset
45-90°	E-NE	Equinox - sunrise, summer mornings
270-315°	NW-W	Equinox - sunset, summer afternoons
0-45°, 315-360°	NE-NW	Winter - sunrise to sunset, other seasons midday

The aspect categories were given user ID's from one to seven, while those of the perpendicular slope were given values from eight to eleven to create a matrix.

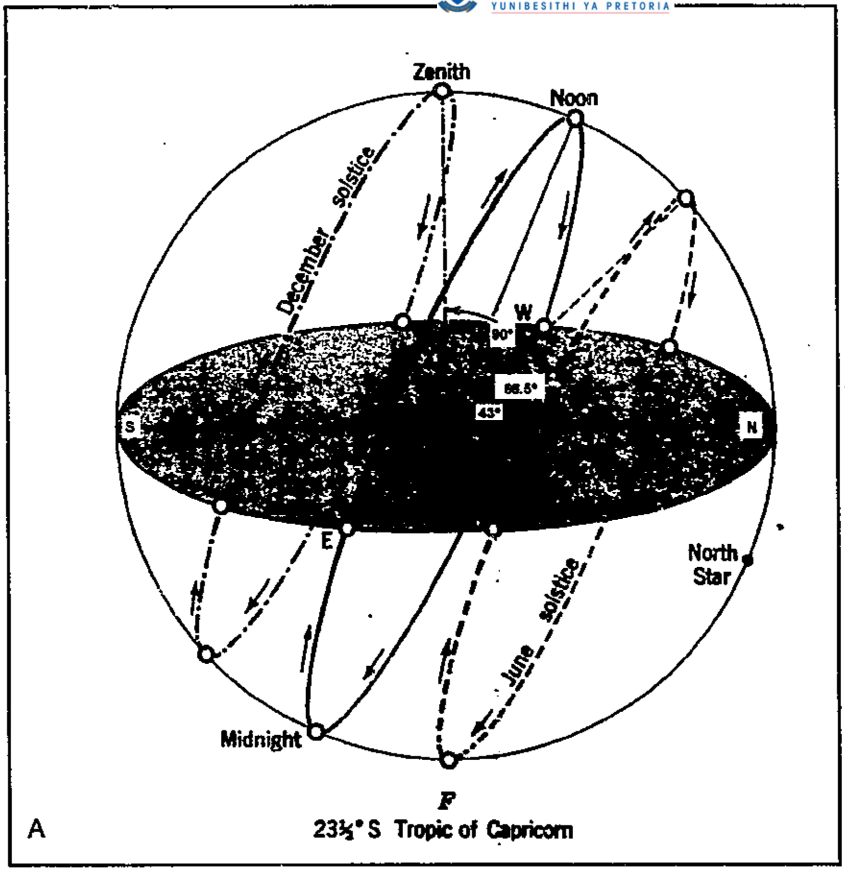
The overlay module with the multiplication function was used to combine the two images (Figure 4). A matrix of 28 possible insolation attitudes was produced (Table 3). This procedure was repeated for both resolutions and vertical intervals. Although forty occurs twice in the matrix it is easy to determine through visual inspection of the separate images whether it originated from a combination of user ID's five and eight or four and ten. If both combinations are possible, then the image could be reclassified to have a value of 41 or any other value not included in the matrix.

Attribute information for the different relevés was extracted by means of the geographical co-ordinates with the extract module, extraction being by maximum value. This was repeated at both vertical scales and resolutions.

2.2.3 Literature study

Macroclimate information was obtained from Strahler and Strahler (1987) and Buckle (1996). The influence on insolation and climate was described by the earth's inclination, while the rotation of the earth explained broad weather trends associated with the African continent.

Data concerning local climate was obtained from the Weather Bureau in Pretoria. The Weather Bureau provided data from eight weather stations in the study area (Appendix A). A spreadsheet was used to store and manage the data. This enabled the verification of the climate within climate classifications of the world by applying the three different approaches: empirical, genetic and applied. The applied approach was based on soil-water balance (Strahler & Strahler 1987) and made use of three annual mean variables: precipitation, evaporation and expected evapotranspiration. Walter diagrams (Barbour *et al.* 1980) were drawn for all eight weather stations, but only two weather stations, Carolina and Piet Retief, close to the northern and southern boundaries of the study area respectively, were used to create soil-water balance diagrams and climographs (Strahler & Strahler 1987). Both these two



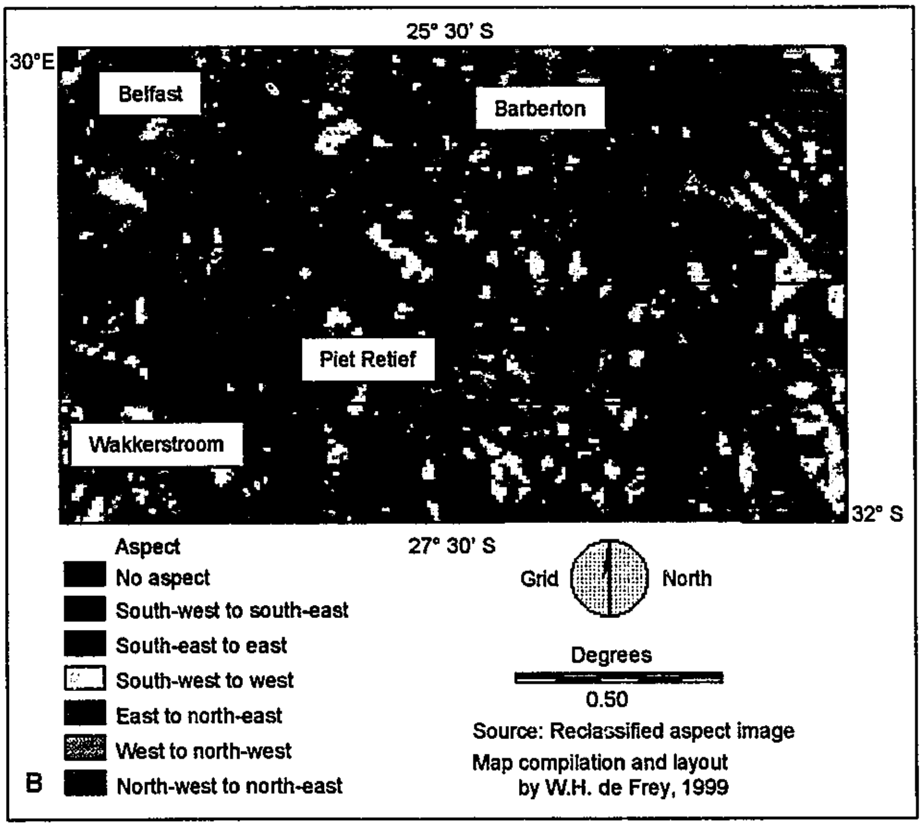


Figure 3: A) Sunrise and sunsets for different seasons on which B) the insolation exposure classes were based, using the aspect surface model

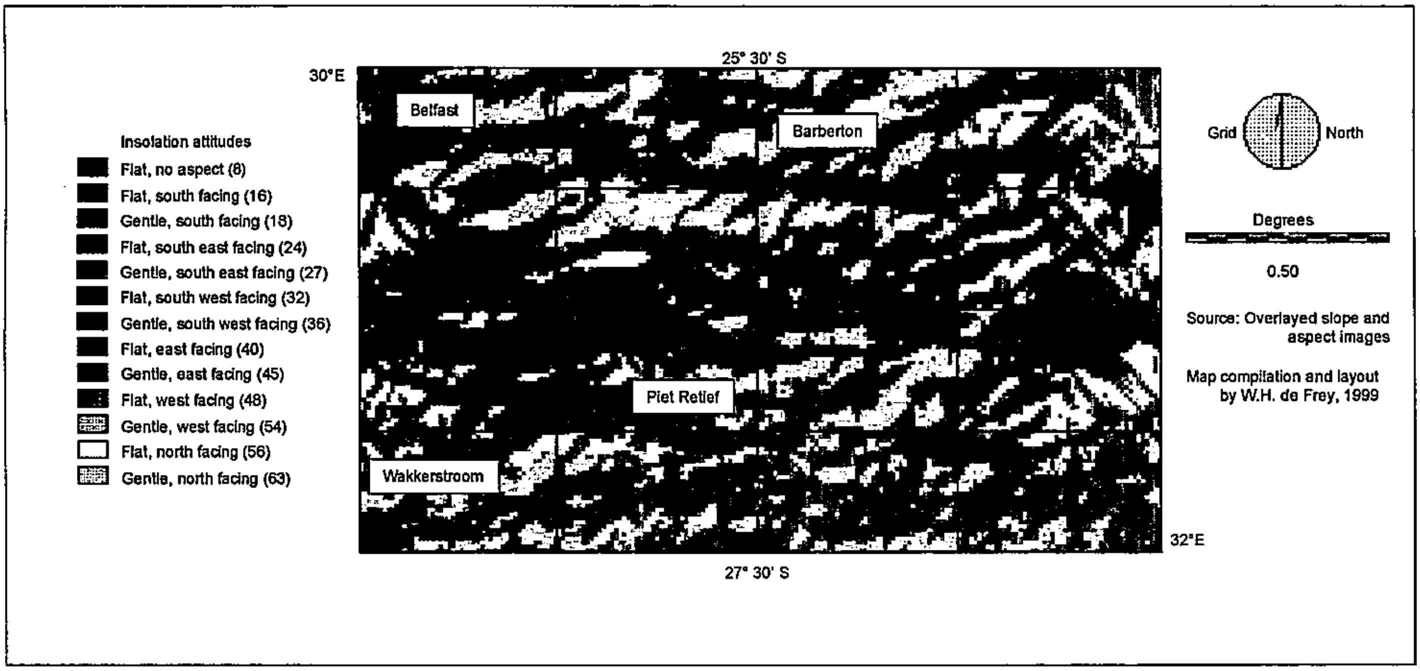


Figure 4: Modelled insolation attitudes using slope and aspect surface models

Table 3: Twenty-eight possible insolation atti[illegible]es and aspects exposed to perpendicular insolation

User ID	**Aspect**	8	9	10	11
Slope	Attributes	*0-2°*	*2-25°*	*25-49°*	*49-90°*
7	**NE-NW**	56	63	70	77
6	**NW-W**	48	54	60	66
5	**E-NO**	40	45	50	55
4	**SW-W**	32	36	40	44
3	**SE-E**	24	27	30	33
2	**SE-SW**	16	18	20	22
1	**No aspect**	8	9	10	11

weather stations had complete data sets. Two different soil-water balance diagrams were completed for each of these two stations, one for the macroclimate using a factor of 0.5 for calculating actual evapotranspiration from potential evapotranspiration figures, and 0.84 for the microclimate (Louw & Kruger 1968).

The altitudes of the sun at noon at the solstice and equinox of different seasons, when used in calculations to determine perpendicular slope angles, were used in the compilation of the climographs. The rest of the attributes such as mean monthly temperatures and mean annual rainfall were used to determine Holdrige life zones and Thornthwaite humidity provinces (Barbour *et al.* 1980).

2.3. Geomorphological environment

2.3.1. Fieldwork

Landforms and terrain morphological units were subjectively identified and documented. Scarps were associated with slopes steeper than that of the surrounding area and rockiness (granite or dolerite outcrops) but did not qualify as a scarp which, according to the Land Type Survey Staff (1985, 1986, 1989), was defined as having a slope of more than 100% (45°) or 70°. Footslopes were associated with level areas adjacent to streambeds while valley bottoms were associated with streambeds. Crests were level areas above scarps and midslopes or between two consecutive midslopes in the absence of a streambed, while midslopes were associated with areas of average slope below crests or scarp, but away from level areas next to streambeds. Estimated slope angles and aspect were documented for each relevé.

Mountainous areas were associated with areas of extreme terrain morphological complexity, steep slopes and high relief. Hills were associated with dykes or sills or areas of moderate terrain morphological complexity and high to moderate relief at the base of mountainous areas. Plains and valleys were associated with areas that did not qualify for inclusion in any of the previous defined landforms.

Additional notes were taken of the size and water status of the drainage lines or streambeds. Rivers were associated with tree-covered levees and broad streambeds with or without flowing water. Streams were associated with grass- or shrub-covered levees and narrow streambeds with or without running water.

The third dimension of the four provided by GPS for spatial registration, altitude, was recorded for each of the relevés.

2.3.2. Geographical Information System

Landform attributes of the relevé were extracted from a digitised section of the 1: 1 000 000 Terrain morphological classification map of South Africa (Kruger 1983). An attribute file for the coverage was created using a spreadsheet and used to create the legend. Attribute data used were broad division (terrain group), description (terrain type), slope form, relief (m), kilometres of drainage per square kilometre, drainage density, streams per square kilometre and stream frequency.

A reclassified slope image provided an image of the terrain morphological units, which were queried using the geographical co-ordinate of the plots. The results were compared with the subjectively assesed terrain morphological units of the fieldwork.

2.3.3. Literature study

Descriptions of the physiography (topography and vegetation described together) were provided by Visser (1989), Walraven (1989a & b), Linström (1987) and the Land Type Survey Staff (1985, 1986, 1989). Strahler and Strahler (1987) explained the influence of geology and climate upon geomorphology. Buckle (1978) described the landforms of Africa.

Land type inventories within the Memoir (Land Type Survey Staff 1985, 1986, 1989) accompaning the 1: 250 000 scale Land Type Maps provided detailed information concerning terrain type and percentage slope (Appendix B).

2.4. Pedological environment

2.4.1. Fieldwork

Only soils of the Ab, Ac, Ad, Ae, Ea, Fa, Fb and Ib soil patterns were surveyed as they represent the boundaries of the study area in southeastern Mpumalanga between the towns of Belfast, Barberton, Piet Retief and Wakkerstroom. Average rock size was classified according to qualitative categories (Table 4).

Percentage surface rock was estimated. The following method was devised to standardise estimates: walking ten paces in a straight line at random, the number of times rocks were stepped on was counted. Stepping on a rock once in ten paces is equivalent to ten percent rock coverage, while depending on the size of the rock, five percent was added or subtracted. If the size of the last rock stepped on was smaller or larger than the average rock size, five percent was subtracted for smaller than average rocks and five percent added for rocks larger than average.

Table 4: Quantitative and qualitative rock siz stimated surface cover

Quantitative categories	Qualitative categories	Qualitative description
≤ 10] mm	Gravel	Very small - shoot with finger
(10; 50] mm	Pebbles	Small - throw with one hand
(50; 200] mm	Stones	Large - throw with two hands
(200; 1 000] mm	Rocks	Very large - unable to throw, but humanly movable
(1 000 mm ≥	Boulders	Larger than a human and not humanly movable
Covers areas of 1 m^2 or more	Rock sheets (outcrops)	Igneous - domes, sills or dykes Sedimentary/ metamorphic - Bedding planes Excavations or cuttings

In general, the A horizon soil texture was estimated from surface observations. The obvious presence of quartz gravel and pebbles was associated with sandy soils, while the absence of quartz gravel and pebbles and the presence of surface cracks was associated with clay soils. A soil survey of randomly sampled relevés, using a soil auger, enabled a correlation between expected and actual soil forms within the different terrain units of the soil patterns. Soils were classified according to the taxonomic system of South Africa (Soil Classification Workgroup 1991).

Attention was given to excavations and road cuttings as these made it possible to form an overall view of the soils as well as what type of diagnostic horizons could be expected. Other attributes of soil exposed by excavations and road cuttings are stonelines, soil depth and parent material.

Additional notes were made of accelerated erosion or other human influences.

2.4.2. Geographical Information System

A map representing the broad soil patterns was digitised along the colour difference between soil patterns on the 1:250 000 Land type series maps 2530 Barberton, 2630 Mbabane and 2730 Vryheid. Boundaries between individual land types within the soil patterns were ignored. This coverage was printed from the layout module of Arc-View.

2.4.3. Literature study

Three Memoirs which accompany the 1:250 000 Land type series maps 2530 Barberton (Land Type Survey Staff 1989), 2630 Mbabane (Land Type Survey Staff 1985) and 2730 Vryheid (Land Type Survey Staff 1986), provided the information associated with the soil patterns. This information was stored in a spreadsheet and processed to create frequency histograms of soil forms within different terrain morphological units of the 89 different land types within the soil patterns (Appendix C). The land type inventories were applied to determine the total area of each soil pattern.

Making use of the GPS co-ordinates it was also possible to plot the relevés on the maps and determine their individual land types. These land types were used for detailed analysis of pedological factors such as soil texture and soil depth.

2.5. Flora

2.5.1. Fieldwork

As required by the Braun-Blanquet method, plots of minimum size were sampled within homogenous stands. The minimum size of the plots ranged from 100 m² (10m x 10m) for grasslands to 200 m² (10m x 20m) for woodlands (Matthews 1991; Smit 1992; Coetzee *et al.* 1993a; Coetzee *et al.* 1993b; Eckhardt 1993; Myburgh 1993; Burgoyne 1995). Based on the concept that vegetation reflects its environment, the assumption was made that the soil patterns represent homogenous stands consisting of a continuum of terrain morphological units (Matthews 1991; Smit 1992; Coetzee *et al.* 1993a; Coetzee *et al.* 1993b; Eckhardt 1993; Myburgh 1993; Burgoyne 1995).

The fieldwork consisted of two phases: a reconnaissance phase and a sampling phase. During the reconnaissance phase, the different physiognomic units were sampled, providing an overall view of the study area, and the general distribution of species and a preliminary species list was recorded. A complete list was compiled of all the plant species present within a plot during the sampling phase. A cover abundance value was estimated for each species, using the Braun-Blanquet scale symbols (Table 5). Additional information documented was physiognomy according to Edwards (1983), estimates of the grazing intensity, whether the area had been burned previously, and the presence of alien plants or human influences.

Specimens of plants not identified during the reconnaissance phase were collected and pressed in a plant press for later identification.

2.5.2. Geographical Information System

Two coverages, one of Acocks Veld Types of South Africa (1988) and one of Low and Rebelo's Vegetation of South Africa, Lesotho and Swaziland (1996) were provided by GIS LAB of the National Department of Environmental Affairs and Tourism. Attribute information contained in these coverages were veld type, vegetation type and biome.

The Low and Rebelo coverage also provided the biome map of South Africa.

Table 5: Braun-Blanquet cover-abundance scale and applied categories

Symbol	Qualitative Braun-Blanquet scale categories (Whittaker 1980)	Applied qualitative scale categories
r	one or a few individuals	Known endemic or endangered species or first time occurrences after a number of plots within a certain physiognomic unit were sampled
+	occasional and less than 5% of total plot area	Regularly to generally present
1	abundant and with very low cover, or less abundant but with higher cover; in any case less than 5% cover of total area	
2a	5 - 12.5 % cover, irrespective of number of individuals	Conspicuously present, usually shrubs or trees or prominent grasses
2b	12.5 - 25 % cover of total plot area, irrespective of number of individuals	
3	25 - 50 % cover of total plot area, irrespective of number of individuals	Strongly present to pure stand
4	50 - 75 % cover of total plot area, irrespective of number of individuals	
5	75 - 100 % cover of total plot area, irrespective of number of individuals	

2.5.3. Literature study

Kent and Coker (1992) made the following statement concerning the Braun-Blanquet method and floristics; the site for vegetation description is thus deliberately and carefully selected as a representative area of a particular vegetation type. This presupposes that the worker already has a clear, if subjective, impression of the major vegetation types. The samples are thus selected to be representative of those types. This means that the methodology is really only capable of being used by those who have had a long and intimate experience of the vegetation. This statement emphasises the importance of reconnaissance before the actual sampling phase.

This study follows the scientific method (Kent & Coker 1992), with the hypothesis that vegetation communities exist within the study area along an environmental gradient reflected by the soil patterns. A second hypothesis is that within vegetation communities associated with soil patterns, other vegetation communities occur which are governed by the environmental factors of the different terrain morphological units. These hypotheses were tested through sampling of the vegetation within these two sets of homogenous units. Bredenkamp (1987) stated that statistical analysis of vegetation is possible if the plots are placed *pro rata* randomly within the stratified units. This approach makes it possible to apply both numerical classification and ordination techniques to the data. Thus both the community and continuum concept of vegetation distribution could be tested using statistical procedures such as TWINSPAN and DECORANA (Bredenkamp 1987, Barbour *et al.* 1980, Kent & Coker 1992). In order to distribute the plots *pro rata*, a sample size had to be calculated and distributed on an area or size basis.

The following approach was used to meet these two conditions. The sample size was calculated as follows: recognising that the surface measure of one hectare is a standard measure by which to quantify environmental quantities such as plant densities, biomass production and carrying capacity, it was decided that the minimum surface to be surveyed in each soil pattern should be one hectare. A minimum of eight hectares should therefore be surveyed across the eight soil patterns representing the study area. A maximum plot size of 200 m^2 or 0.02 ha was considered relevant because of the woodland areas within the grassland. The plot size was used to calculate that at total of 50 plots per soil pattern (10 000m^2/ 200m^2) or 400 plots (50 plots * 8 soil patterns) had to be sampled. To determine the *pro rata* distribution or number of plots per soil pattern, the total surface of each soil pattern was divided by the total area of the all the soil patterns (study area). The resulting fraction was multiplied by 400, which gave the rounded off number of plots for that specific soil pattern (Table 6). A minimum limit of five plots per soil pattern was created by the theoretical probability that the smallest soil pattern consists of at least five terrain morphological units, which should be sampled individually. Therefore the number of plots per soil pattern had to be adapted to reflect this limit, resulting in a sample size of 405 plots for the study area. This resulted in 81 plots being distributed within each of the five terrain morphological units across the eight soil patterns (Table 7).

Table 6: Sample size *pro rata* distribution of the eight soil patterns within the study area

Soil pattern	Number of land types per soil pattern	Number of hectares per soil pattern	Number of plots per soil pattern	Adapted number of plots per soil pattern
Ab	8	52 670	18	20
Ac	25	453 340	157	155
Ad	4	65 850	23	25
Ae	3	46 520	16	15
Ea	6	28 100	10	10
Fa	41	469 300	162	160
Fb	1	40 950	14	15
Ib	1	1 880	1	5
Totals	89	1 158 610	401	405

Table 7: The *pro rata* stratified distribution of th ngst the eight soil patterns and the expected terrain morphological units within each soil pattern

Soil pattern	Sample size	Terrain morphological units				
		Crest	Scarp	Midslope	Footslope	Valley bottom
Ab	20	4	4	4	4	4
Ac	155	31	31	31	31	31
Ad	25	5	5	5	5	5
Ae	15	3	3	3	3	3
Ea	10	2	2	2	2	2
Fa	160	32	32	32	32	32
Fb	15	3	3	3	3	3
Ib	5	1	1	1	1	1
Totals	405	81	81	81	81	81

Additionally these 405 plots were divided between the three land type maps used in the survey to prevent over-sampling of one map, and to evenly distribute the plots throughout the study area (Table 8). This table differs from Table 7 because not all the soil patterns occur in all three land types and not all of them consist of five terrain morphological units. The ratio between the area of a specific soil pattern in a specific land type map and the total area of the specific soil pattern in the study area was used to distribute the samples amongst the three maps. Those plots belonging to absent terrain morphological units were, where possible, evenly distributed among the other terrain morphological units occurring in that soil pattern.

Plant specimens were identified using field guides (Palgrave 1983, Van Wyk 1984, Van Wyk & Malan 1988, Van Oudtshoorn 1991, Bromilow 1995). A preliminary species list was compiled from data of Acocks (1988) veld types and Coetzee *et al.* (1993a & b) to assist in the identification of the species. Furthermore a table was compiled of certain plant families and their associated life forms or physiognomic categories (Appendix D), to further facilitate species identification.

2.6. Fauna

2.6.1. Fieldwork

As this was mainly a phytosociological study within the concept of wildlife management, little attention was given to domestic or wild animals. If these were seen or their presence deduced from tracks or faeces, it was documented on the field form.

2.6.2. Geographical Information System

The percentage slope images created from the digital terrain model in GIS IDRISI, was reclassified to represent areas associated with different land use practices. The three images were created, based on pasture classes , susceptibility to erosion and sub-humid land use categories.

2.6.3. Literature study

The categories used in the GIS modelling were obtained from two sources. The pasture and land use classes were described in Tainton (1981), while Matthee (1984) described the slope limitations with respect to erosion. Although the original pasture classes corresponded to nine different classes depending on slope, drainage and rockiness, they were reduced to four for the purpose of modelling based on percentage slope: flat (0-8%) [5°], medium (9-15%) [8°], steep (16-25%) [14°] and very steep (>25%). The other two classifications were not changed (Table 9). It therefore appears as if the

Table 8: Frequency of relevés in the Barberton, Mbabane and Vryheid areas per soil pattern and terrain morphological unit

Barberton area (Land Type Map: 2530 Barbeton)								
Soil pattern	Ab	Ac	Ad	Ae	Ea	Fa	Fb	Ib
Terrain unit								
Crest	1	7	2	3		18		
Scarp	1	7				18		
Midslope	1	7	2	2		18		
Footslope	1	7	2	3		18		
Valley bottom	1	7	2	3		18		
Totals	5	35	8	11		90		
Mbabane area (Land Type Map: 2630 Mbabane)								
Crest	1	15	3	1	1	8		
Scarp	1	15			1	8		
Midslope	1	15	3	1	1	8		
Footslope	1	15	3	1	1	8		
Valley bottom	1	15	4	1	1	8		
Totals	5	75	13	4	5	40		
Vryheid area (Land Type Map: 2730 Vryheid)								
Crest	2	9	1		1	6	4	2
Scarp	2	9			1	6	4	
Midslope	2	9	1		1	6	3	1
Footslope	2	9	1		1	6		
Valley bottom	2	9	1		1	6	4	2
Totals	10	45	4		5	30	15	5

Table 9: Different percentage slope categories associated with different land use or wildlife management strategies

Adapted pasture classes		Erosion limitation classes		Land use classes	
Qualitative description	Quantitative % (°)	Suggested use	Quantitative % (°)	Recommended land use classes in sub-humid climates	Quantitative % (°)
Flat	0-8 (5)	Crop growth	0-15 (8)	Annual cropping	0-3 (2)
Medium	9-15 (8)			Annual cropping with occasional ley or special tillage	4-7 (4)
Steep	16-25 (14)	Grazing	15-30 (17)	Rotation of ley and crops	8-12 (7)
Very steep	>25			Permanent cover crop e.g. pasture	13-20 (11)
		Wildlife & Afforestation	>30	Natural veld grazing or afforestation with special treatment	21-30 (17)
				Natural veld grazing or afforestation with special treatment or total protection form agricultural use e.g. wildlife	>31

influence of domestic animals and wildlife is concentrated on areas with slopes of more than 15% (8°). The upper limit of this category would most probably be in the vicinity of 34° to 36° (67-73%), the natural resting angle of dry sand (Read & Watson 1968, Strahler & Strahler 1987). Slopes steeper than this would be associated with fault planes, folding, igneous and or incised rock. These very steep slopes, have sparse vegetation and can only be traversed with the help of ropes, four legs or wings! It should be noted that this category includes scarp slopes at angles of more than 100% or 70°.

3. Synthetic phase

Barbour *et al.* (1980) describe the aims of the different methods of describing the plant community as follows: if the aim is to draw lines and describe discrete entities, then the table method and vegetation mapping are good choices. If the aim is to let the reader draw the lines between entities, then cluster analysis and association analysis are the methods of choice. If the continuum of vegetation is to be emphasised, then gradient analysis and ordination are preferable. As the aim of the Grassland Biome project was the classification (description) and mapping of vegetation types and communities within the biome, the Braun-Blanquet table method was chosen and its sampling method used, except for the *pro rata* randomly stratified placement of the plots to facilitate statistical analysis.

During the synthetic phase, the data from the samples are entered in a table from which the vegetation units are extracted. The units are interpreted ecologically and ranked in a hierarchy. Computer applications software such as BBNEW on mainframe (Matthews 1991; Smit 1992; Coetzee *et al.* 1993a; Coetzee *et al.* 1993b; Eckhardt 1993; Burgoyne 1995), PHYTOTAB (Turner 1989, Myburgh 1993) and more recently TURBOVEG/MEGATAB (Hennekens 1996a & b) on personal computers are available. Many of these computer packages include statistical modules such as TWINSPAN (Hill 1979a) and DECORANA (Hill 1979b)

3.1. Computer assisted procedures to generate phytosociological tables

3.1.1. Floristic data

After most of the collected specimens were identified, the floristic data were stored on the mainframe, using the BBNEW program. Species not identified retained their unique references, as long as they corresponded to eight digits plus one for the cover abundance value. For future research the floristic data will be exported from the BBNEW program through a Cornell Condensed File to TURBOVEG, which currently is being used as the central phytosociology database for South Africa at the Ecology section of the Botany Department, University of Pretoria. Unidentified species would be lost, seeing that TURBOVEG does not allow for pseudo species. The latter would result either in more complete floristic data sets or shorter ones. The *pro rata* randomly stratified placement of the plots enables the execution of either a numerical classification of the data such as TWINSPAN or an ordination such as DECORANA.

From the assumption that vegetation reflects its environment and the environment regulates the presence or absence of species, it is logical that species which prefer the same environment would be grouped together. Traditionally the grouping or clustering of species would have been by hand, arranging the species in alphabetical order and the relevés in numerical order forming a matrix, with the cover abundance values as mutual points. The next step would be to move all the species belonging to the same pattern together, followed by their representative relevés (Werger 1974, Whittaker 1980, Barbour *et al.* 1980, Kent & Coker 1992). This time consuming procedure has now largely been superseded by computer procedures and, more recently, by computer driven algorithms such as the hierarchical, polythetic, divisive classification software TWINSPAN (Two-way indicator species analysis) (Bredenkamp 1982; Behr & Bredenkamp 1988; Kent & Coker 1992).

Polythetic, divisive classification divides quadrats (plots/relevés) into groups on the basis of all the species information. Thus division is not made on the presence/absence of one species, as with association analysis, but on the basis of the total species composition of the entire data set. TWINSPAN (Hill 1979a) produces a table, which provides a useful starting point for a full Zurich-Montpellier type exercise in phytosociology (Kent & Coker 1992).

In the Braun-Blanquet approach, two types of plant communities are distinguished: abstract and discrete. Purpose and scale determine whether Braun-Blanquet tables reflect either abstract plant communities the precise location of which is not known and has not been mapped, or discrete plant communities which occur as distinct units at a mappable scale in the field (Whittaker 1980, Kent & Coker 1992). The question of scale therefore enters the study at this point, bearing in mind that the aim of the project is to describe and map the vegetation types and communities of the grassland biome.

At small scales (larger areas, limited information), few plant communities will qualify as discrete while the opposite is the case at a large scale (small area, detail information). The biome itself is mapped at a scale of 1: 10 000 000 (Rutherford & Westfall 1994), and therefore discrete plant communities should be mappable at scales equal to and larger than 1: 10 000 000. Discrete plant communities associated with climate types are excluded because this is already used in the classification of biomes. Only land forms and soils remain, because it is known that these differentiate the next level of floristic species distribution and composition (Strahler & Strahler 1987). The spatial distribution of both of these environmental attributes allows them to be mapped at scales of 1: 10 000 000 and larger.

From the field of remote sensing, the following two conditions, to which classes of pattern recognition must comply in order to be useful, are considered. Firstly, each pattern must be separable from all others and secondly, each must have information value. A second consideration is to determine when a class actually becomes defined. Therefore, an important step in the procedure is the selection of training samples that are sufficiently typical of the whole class in question. It must also be recognised that the definition of a class is a relative matter. It is relative to the other classes used in the same classification. It is well known that in this regard the broader the classes, the more accurate identification will be. Finally, in comparing supervised versus non-supervised classifiers, it is accurate to say that in the supervised case classes are named according to informational value and then checked to see whether these classes are separable, whereas in the non-supervised case the reverse is true (Landgrebe in: Lintz & Simonett 1976).

The supervised approach was taken with the TWINSPAN classification, with discrete floristic associations expected to be separable in terms of soil patterns with information values related to the environmental factors which create these soil patterns. This was confirmed by linking environmental with the floristic data.

3.1.2. Environmental data

A spreadsheet was used as the main link between floristic and environmental data. Data extracted from GIS as well as information from the literature studies were stored in spreadsheets. The data in the spreadsheets were sorted, combined and statistically analysed or exported to other software applications such as Statgraphics and Access database for further analysis or output as hardcopies. Statistical analyses executed range from descriptive methods (frequency tabulation, cross table queries, histograms, frequency polygons, average and mode) to inference methods (hypothesis testing, analysis of variance).

The environmental data extracted from the digital terrain model at the two resolutions and vertical contour intervals were analysed in terms of variance. One way analysis of variance inference was executed using the module available in commercial spreadsheets. The following hypothesis was used:
H_0: The average values or classes of the different attributes for the 405 plots are the same
H_1: The average values or classes of the different attributes for the 405 plot are not the same.

Raster images with pixel sizes of 100 m by 100 m represented high resolution, while pixels of 1000 m by 1000 m represented low resolution and were used for digital terrain models at both a 100 m vertical interval and 500 m vertical interval.

In each case the naught hypothesis was statistically significantly falsified at alpha ($\propto$) = 0.05;
$P < \propto$ (Table 10). It was therefore decided to use the data extracted at 100 m vertical interval and high resolution, because it showed in most cases the highest variance and each plot represented 10 000 m^2 or one hectare instead of 1 000 000 m^2, 100 hectare or 1 km^2.

Table 10: Results of the analysis of variance inferences, executed on the environmental attributes at both resolutions and vertical intervals, for the 405 plots sampled, indicating that the naught hypothesis has been rejected every time (F > F-crit, P < α @ 0.5)

Environmental attributes	***F***	***P-value***	***F-crit***
Altitudinal classes	75.662166	8.555e-46	2.6104088
Aspect in azimuths	4.7539919	0.0026405	2.6104088
Exposure classes	6.6280206	0.0001895	2.6104088
Slope in degrees	43.035724	9.389e-27	2.6104088
Erosional classes	18.817059	5.358e-12	2.6104088
Digital terrain model heights (m.a.s.l.)	13.369165	7.012e-13	2.2177885
Perpendicular insolation classes	36.817734	5.162e-23	2.6104088
Land use classes	42.667051	1.561e-26	2.6104088
Insolation attitudes	5.1597782	0.0014975	2.6104088
Pasture classes	48.568879	4.725e-30	2.6104088
Slope in percentage	40.045186	5.848e-25	2.6104088
Terrain unit classes	37.30088	2.636e-23	2.6104088

3.1.3. Floristic-environmental data

The physical link between the floristic data and environmental data was made possible by the development of computer networks. Mainframe files containing floristic data were exported to desktop computers and retrieved in commercially available spreadsheets (Quattro Pro, MS Office). The spreadsheets containing the floristic data were then combined with the spreadsheets containing the environmental data (Appendix E).

3.1.4. Phytosociological table

Once the discrete vegetation types within the total data set were separated by the first TWINSPAN classification and confirmed, the relevant relevés of each vegetation type were subjected to a second TWINSPAN classification. The output file was exported by FTP to the PC and then combined with the environmental data. Those clusters separated by TWINSPAN were tested for separability and informational value. To qualify as a cluster (or abstract plant community), it had to comply to the following conditions:

1. No cluster could have less than three relevés, representing the smallest practical soil pattern with only three possible terrain morphological units: crest/scarp, midslope/footslope and valley bottom and a unique floristic composition, eg. stands of forest associated with ravines.
2. Each cluster should be associated with a certain specific floristic, physiognomic and environmental attribute, distinguishable in the field.

The TWINSPAN output was used to create a phytosociological table of those clusters which qualified as abstract plant communities recognisable in the field (which are not mappable at scales between 1: 10 000 000 and 1: 250 000).

The TWINSPAN sequence of the relevés was exported back to the mainframe and was used to generate the new phytosociological table in BBNEW. Lines separating the clusters were added and a new table created which was exported to a spreadsheet on a PC. This table contained the complete species list. To distinguish quantitatively between diagnostic and companion species, constancy and fidelity indices (Werger 1974, Whittaker 1980, Barbour *et al.* 1980) were used:

Constancy index		Percentage interval	Fidelity index	
Category	Symbol		Symbol	Category
Very low	1	0-20	V	Very high
Low	2	20-40	IV	High
Average	3	40-60	III	Average
High	4	60-80	II	Low
Very high	5	80-100	I	Very low

With the aid of a spreadsheet it was possible to determine each species' constancy within a cluster and its fidelity between clusters (Appendix F). This was achieved by replacing every cover abundance value with "1", calculating the percentage constancy using the formula: Species A constancy = (number of relevés with species A in cluster A)/ (total number of relevés in cluster A)*100. Percentage fidelity was calculated, using the formula: Species A fidelity = (number of clusters containing species A)/ (Total number of cluster in the table)*100. Barbour *et al.* (1980) described the following cutlevels of constancy and fidelity for species to be useful in distinguishing between different plant communities. The exact level of fidelity demanded vary from investigator to investigator, but as a general rule is that a species which helps to define a plant community cannot occur in more than 20% of the stands outside that plant community. Useful species must have both moderately high fidelity and moderately high constancy; again, the required level of constancy varies, but in general it must be > 50%.

Initially a constancy cutlevel of 50% and higher was used to determine if a species belong to a certain cluster or not. If it did qualify, it was assigned to a specific cluster using the "if" statement in Quattro Pro: @if(percentage constancy >= 50, 1,0). This resulted in a one being placed in a column if the condition is true or a zero if it is not. From this the percentage fidelity for the qualifying species was calculated. The percentage fidelity was used to sort the species in a descending order of percentage fidelity, placing those species which did not qualify for inclusion in the table as diagnostic or constant species at the bottom of the table.

Those species which qualified as diagnostic and constant were sorted once again in ascending order, placing those with the highest percentage but lowest fidelity at the bottom and those with the lowest percentage but highest fidelity at the top. The species at the bottom with percentage fidelities of between 80 and 100% were considered constant species and sorted in a descending order. Optionally a second set of columns could be created, reflecting the clusters to which the qualifying species belong, which helps with the next step. The remaining species were moved to form the hierarchy from left to right in the tables. Species which did not qualify as diagnostic, were moved below the constant species and used to indicate and support different ecological trends. All the diagnostic species groups were sorted internally from highest to lowest percentage constancy in a descending order.

The decision not to rearrange any relevés within the table is based on the following reasons:

1. The clusters created in TWINSPAN are based on the total species list, with those relevés associated with the same community values grouped together (Barbour *et al.* 1980, Kent & Coker 1992).
2. The clusters are separable and informational, representing abstract plant communities at a non-mappable scale, but with distinct floristic, physiognomic and environmental attributes.
3. Moving relevés from one cluster to another only enhances already recognised plant communities, while changing the species constancy and fidelity values for those specific clusters.
4. It discards previously set conditions and assumptions concerning relevés, clusters and species.
5. The final description of the plant community uses the general environmental trends or factors associated with it while, depending on scale, mapping is normally based along physiognomic or environmental boundaries and not individual relevés (Barbour *et al.* 1980).

Thus, in this case moving relevés would not necessarily improve the classification or its purpose but only its appearance. If appearance is a problem, those cover-abundance values of species with constancy less than the cutlevel could be omitted, resulting in a table without distributional noise, emphasising the community concept and suppressing the continuum concept within vegetation science. Relevés were sorted within the cluster, using the diagnostic species group at the top, with the occupied relevés to the left and the empty ones to the right.

The final relevé and species sequences were exported back to the mainframe, and the final table was generated. This file was once again retrieved into a spreadsheet. Species with the same constancy index within a diagnostic species group were sorted so as to place the highest cover abundance value first. Furthermore, the diagnostic species groups were individually blocked to indicate character, differential, constant and ecological/environmental-trend species groups. Abbreviated species names were replaced with the latest species names used in TURBOVEG. This procedure was repeated for each of the three vegetation types.

3.1.5. Ordination

DECORANA or Detrended Correspondence Analysis (Hill 1979b) ordination was applied to the floristic data in the same way as the TWINSPAN output files. The DECORANA output files were exported from the mainframe. They were then combined with the already existing floristic communities, TWINSPAN and environmental attribute Quattro Pro files, making it possible to plot the vegetation types, plant communities and different environmental factors along the different ordination axes. The most statistically significant environmental trends were determined using multiple regression analysis at $\propto = 0.05$ and $P < \propto$. Thirty-three environmental factors were used as independent variables and plotted against the AX 1 to AX 4 axis of the ordination. Numerical values were assigned to categorical data following general trends. These variables together with the quantitative data were analysed within Quattro Pro, using the regression sub-module within the advanced math module of the tool module.

3.1.6. Interpretation

A. TWINSPAN classification results

To facilitate the interpretation of the interaction between the floristic data and the environment, percentage frequency and the TWINSPAN cutlevels were used. In MS Office Access database, the crosstab query wizard module was used to calculate the frequency of every environmental attribute for each TWINSPAN cluster (Appendix G). The results were pasted into a spreadsheet. The maximum frequency of each environmental attribute per cluster was assigned the value of one using the following formula: =if(cell=max(cellx..celly), 1, 0). The next step was to calculate the percentage frequency of each maximum frequency attribute at each TWINSPAN cutlevel, using the formula: =round((((sum(cellx..celly)/ total numbers of clusters)*100),0) for level one and for levels two to six, the formula: =if(and(cell<80, cell<>0),round((((sum(cellx..celly)/ total numbers of clusters per division of each level)*100),0),0). Finally the specific attributes of each level were determined using the formula: =if(cell>=80, attribute,0).

B. DECORANA results

To facilitate the interpretation of the DECORANA data, the most significant environmental trends were assigned letters and displayed along their relevant axes. Graphs were produced in Quattro Pro.

CHAPTER III - STUDY AREA

1. Location

The study area is situated within the Mpumalanga province of the Republic of South Africa (Figure 5). This used to be part of the Transvaal province before 1994. Mpumalanga is bordered on its northern boundary by Northern Province, on its eastern boundary by Swaziland, on its southern boundary by KwaZulu-Natal province and its western boundary by Gauteng province.

Geographically, the study area is within the southeastern region of Mpumalanga, between 25° 30' S and 27° 30' S and 30° E and 32° E (Figure 5). The towns of Belfast, Barberton, Piet Retief and Wakkerstroom comprise the corners of the bounding rectangle of the study area.

Vegetation surveys in this study were limited to the N4 national route in the north, Swaziland border in the east, KwaZulu-Natal in the south and the following soil patterns in the west: Ab, Ac, Ad, Ae, Ea, Fa, Fb and Ib. They covered an area of approximately 11 586.1 km^2 or 1 158 610 ha.

Depending on location and size, a study area can consist of a single or several plant communities. The distribution and composition of a plant or plant community are determined by the environment (Barbour *et al.* 1980; Strahler & Strahler 1987; Kent & Coker 1992), which consists of the lithosphere and atmosphere. The lithosphere contains different rocks, landforms and soil types, representing the geological, geomorphological and pedological environment. The atmosphere consists of gases and water vapour, forming a shield against the sun's dangerous rays and protection from extremes of heat and cold. It is the single most important determinant of life (Buckle 1996), providing the air we breathe and also, by trapping the sun's heat, gives rise, through its circulatory motions, to our weather[4] (Buckle 1996). Climate is the composite of all the many varied, day-to-day weather conditions in a region over a considerable time (Buckle 1996) and represents the climatic environment. Due to its location and size, the study area is highly diverse regarding altitude, geological time and formations, climates, landforms, soil patterns and soil forms as well as species of both flora and fauna.

In a study concerned with how various factors of the physical environment influence plants and animals, two scale ranges can be treated. One is the global scale, which considers the various

[4]It is the state of the atmosphere at any one specific time and place. Another definition describes it as the short-term variations of the atmosphere in terms of pressure, wind, temperature, moisture, cloudiness, precipitation, and visibility (Buckle, 1996).

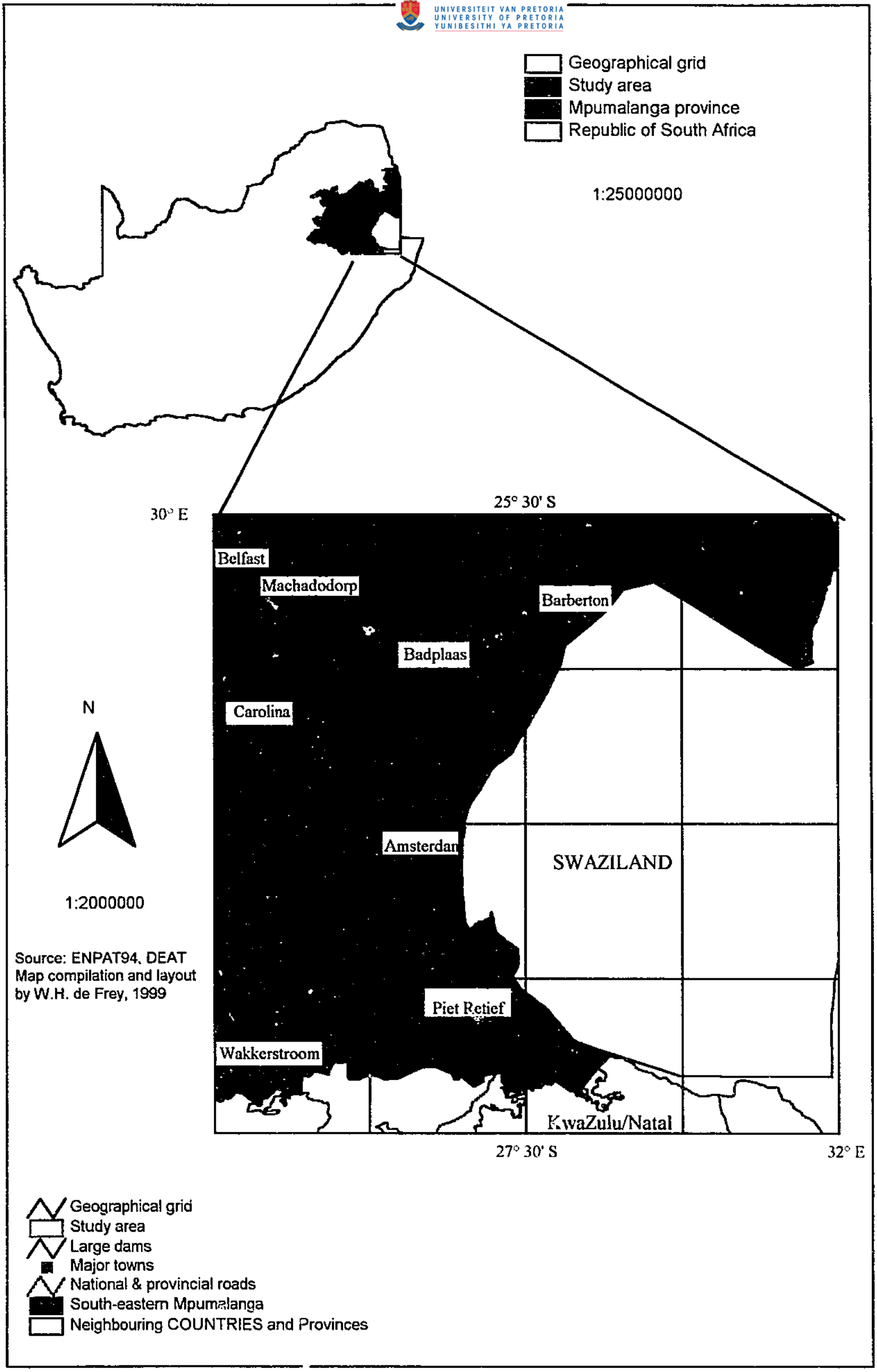


Figure 5: Global and local location of the study area

influences from a global perspective on a specific areas for example, with regard to geomorphology i.e. the landforms present.

The other scale of consideration of the same influence is from a local perspective, for example, the slopes and aspect configuration of the landforms present in the area (Strahler & Strahler 1987). Thus, the local perspective involves more detail or a specific aspect of the study area while the global perspective emphasises the general trends or accepted theories.

2. Global perspective

2.1. Geological environment

The Republic of South Africa is part of the African tectonic plate, which consists of light continental rock on top of heavier oceanic rock (Buckle 1978). Within the continent and study areas' geographical region, igneous, metamorphic and sedimentary rock occur, which represent the beginning of the earth's crust 4 500 million years ago to those associated with the present surface configuration of Africa (Table 11) (Figure 6a & b). During this period, Africa formed part of two supercontinents Pangaea and Gondwanaland (Burn 1980) and consisted of a number of mobile and stable crustal regions due to periods of orogensis (mountain making) and epeirogenics (continent-making) (Read & Watson 1968; Visser 1989). Associated with these crustal activities are changes in climate, of which the most significant of the last two million years occurred during the Pleistocene (20 000 to 12 000 years ago) (Buckle 1978; Buckle 1996). Periods of orogensis resulted in initial landforms[5] due to tectonic and volcanic activity, while during periods of epeirogenics, depending on the climate and process of denudation, specific sequential landforms were formed. Stable areas or continental shield can be divided into exposed shields of Precambrian igneous and metamorphic rock and covered shields overlain by sedimentary rock. Regions of hills and low plateaus are related to exposed shields, while arched (upwarped) areas are associated with covered shields (Strahler & Strahler 1987).

Since the final breakup of Gondwanaland at the end of the Cretaceous period, Africa has been experiencing a period of epeirogenics. The interior experienced extensive warping (down and up) resulting in basins and swells (Figure 7) (Buckle 1978). In southern Africa the Cainozoic epeirogeny era was characterised by transgression and regressions on the coasts caused by volumetric changes in the ocean basins, and associated changes in climate, while conditions developed for present physiographic features in the interior (Visser 1989). During the late Pleistocene epoch the

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[5] A three-dimensional part of the land surface, formed of soil, sediment, or rock that is distinctive because of its shape, that is significant for land use or to landscape genesis, that repeats in various landscapes, and that also has a fairly consistent position relative to surrounding landforms (Van der Watt & Van Rooyen 1990)

Table 11: International and national chronostratigraphy of the study area (Approximate age in million of years **(ma)**, numbers refer to Figure 6.B)

International			National
Eonothem	Erathem	System	Erathem
Phanerozoic	Cenozoic/ Cainozoic **(65 ma)**	1. Quaternary **(1.8 ma)**	4. Phanerozoic
		Tertiary	
	2. Mesozoic **(230 ma)**	Cretaceous	
		Jurassic	
		Triassic	
	3. Palaeozoic **(575 ma)**	Permian	
		Carboniferous	
		Devonian	
		Silurian	
		Ordovician	
		Cambrian	
Cryptozoic	Proterozoic **(2 500 ma)**	Precambrian	Namibian **(1 080 ma)**
			5. Mokolian **(2 070 ma)**
			6. Vaalian **(2 620 ma)**
	9. Archaeozoic (Archaean) **(4 500 ma)**		7. Randian **(2 870 ma)**
			8. Swazian

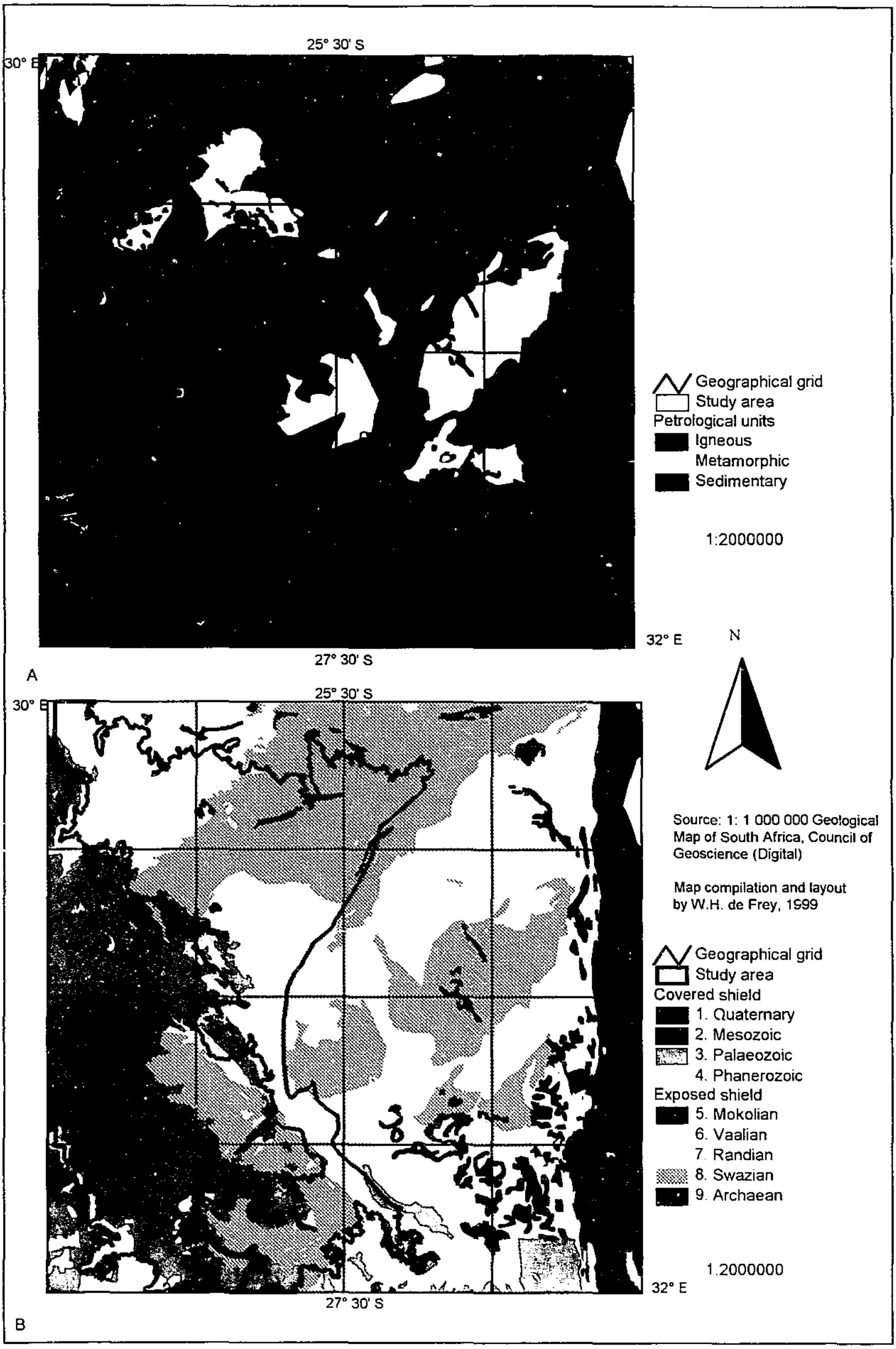
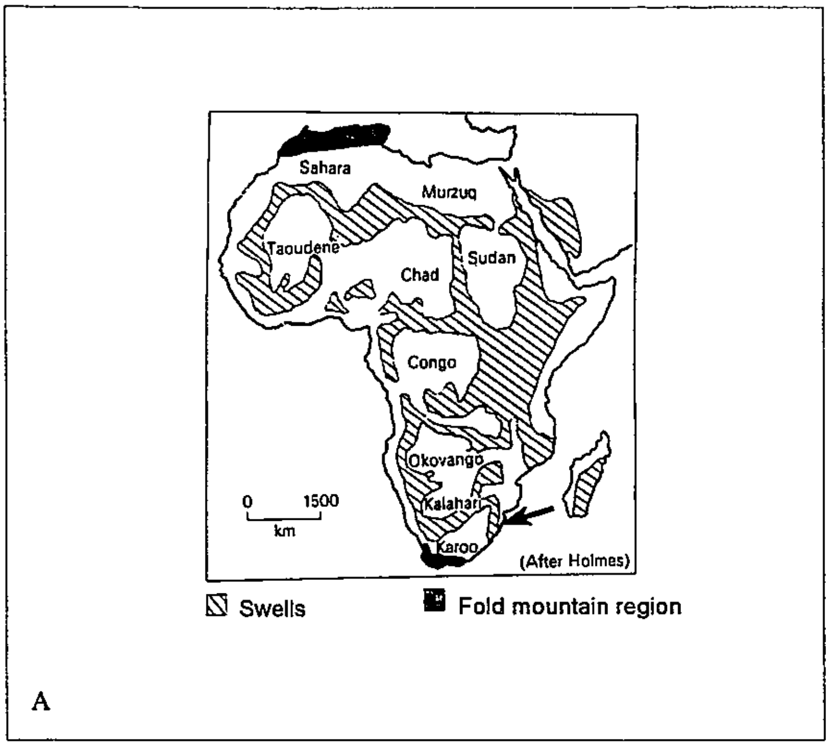


Figure 6: A) Petrological units and B) chronostratigraphic units underlying the study area (numbers refer to Table 11)



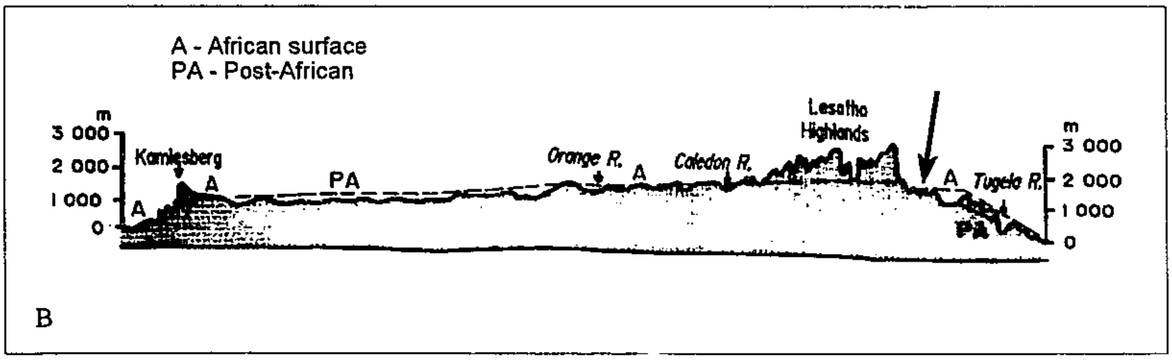


Figure 7: (A) Swells and basins of Africa due to epeirogenics resulting in (B) mountainous areas and plains, **arrow indicates approximate location of study area.**
(A. Figure.1.14 from Buckle 1978, B. Figure. 2 from Cowan 1996)

climates were colder and drier while during the Holocene period climates were wetter and even in the last thousand years a number of wet and dry periods occurred (Buckle 1996).

2.2. Climatic environment - macroclimate

2.2.1. Introduction

Synoptic climatology[6] is concerned with the study of the climatic regions of the Earth from the viewpoint of the different types of weather experienced in each region (Buckle 1996). Similar regions can be grouped together in climatic types. One or a combination of climatic attributes can be used to classify macroclimatology[7] or microclimatology, resulting in a number of climatic classifications. These classification systems can be divided into three main approaches: empirical, genetic and applied. Empirical classifications use summarised data (mean temperatures and precipitation), genetic classifications are based on the factors that cause the different climates (air masses and frontal zones), while applied classification aims to classify climate in terms of its effect on other phenomena, such as soil-water availability and plant growth. Classification involves simplification and this, by its very nature, gives rise to a number of basic weaknesses common to all systems:

1. There is inadequate suitable climatic data, both in terms of the global coverage and the reliability and duration of measurement.
2. The boundaries separating one climatic type from the next are largely artificial. In reality there is rarely a sharp divide, since one type is likely to grade into another across a broad transition zone.
3. Each climatic type is generally only accurate for a core area, becoming progressively less reliable towards a region's boundaries.
4. Many classifications confine themselves to the continents and do not include the oceans.
5. Classifications are static systems, taking no account of climatic changes or variations. There is a range of evidence to show that at various times, in both the distant and recent past, the climate has been markedly different from that prevailing today. Sometimes the changes have been global, affecting

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[6]Climatology as a science, is concerned with the mean values and frequencies of the meteorological quantities (pressure, wind, temperature, humidity, precipitation and cloud cover) and also the variations about these means, including the extremes (Buckle 1996).

[7]The study of the world's large-scale climatic regions, contrasts with microclimatology, the study of small scale climates (Buckle 1996). [Note. the use of the large and small scale terminology concerning large and small areas respectively is incorrect, as small scales depict large areas, with limited detail, while large scales depict small areas in detail. (Strahler & Strahler 1987)].

quite considerable areas of the Earth, while at other times they have been restricted to particular regions. Recurring droughts, for instance, have developed in one zone while elsewhere precipitation may have increased (Buckle 1996). The two most important environmental factors that influence plant success and distribution are heat and the availability of water (Barbour *et al.* 1980).

2.2.2. Empirical classification

Based on the location of the study area within the Köppen-Geiger system of climate classification world map (Strahler & Strahler 1987), it is associated with five climate regions. Along and across its eastern boundary (30°E) the warm temperate climate region occurs, with the dry season in the winter and the warmest month mean under 22°C (Cwb). Towards the northern boundary (25° 30' S) the dry hot steppe climate region (BSh) occurs, towards the eastern boundary (32° E) the tropical savanna climate (Aw) occurs and two types of temperate rainy climate regions with hot summers (Cfa & Cfb) occur along the southern boundary (27° 30' S). Therefore a generalised trend exists from east to west of tropical savanna to warm temperate.

The Walter diagrams (Figure 8) based on the data from the Weather Bureau of six weather stations within and on the border of the study area, support this trend. Five of the six Walter diagrams occur within the warm temperate climate region (Cwb). The sixth station, Figtree, occurs within the tropical savanna climate region (Aw) with at least one month's rainfall below 60 mm and the dry season strongly developed.

The six stations are arranged in two sets of three, along an altitudinal gradient from east to west in the north and south. This arrangement confirms both trends associated with an altitudinal gradient, i.e. an increase in mean annual rainfall and a decrease in mean monthly temperatures, with an increase in altitude (Barbour *et al.* 1980; Daubenmire 1974).

2.2.3. Genetic classification

The world climate map (Strahler & Strahler 1987) places the study area within or close to the boundaries of the desert subtypes of the **dry tropical** and **subtropical climate types** within the low to midlatitude groups. This classification is based on air masses and frontal zones and allows information to be used to interpret a given climate and to provide the reasons for its occurrence in a particular location.

The **dry tropical climate** occupies source regions of the continental tropical air mass in high-pressure cells centred over the tropics of Cancer (23½° N) and Capricorn (23½° S). This subsiding air mass is stable and dry becoming highly heated at the surface under intense insolation. A strong annual temperature cycle follows the changing declination of the sun. The high-sun period brings extreme

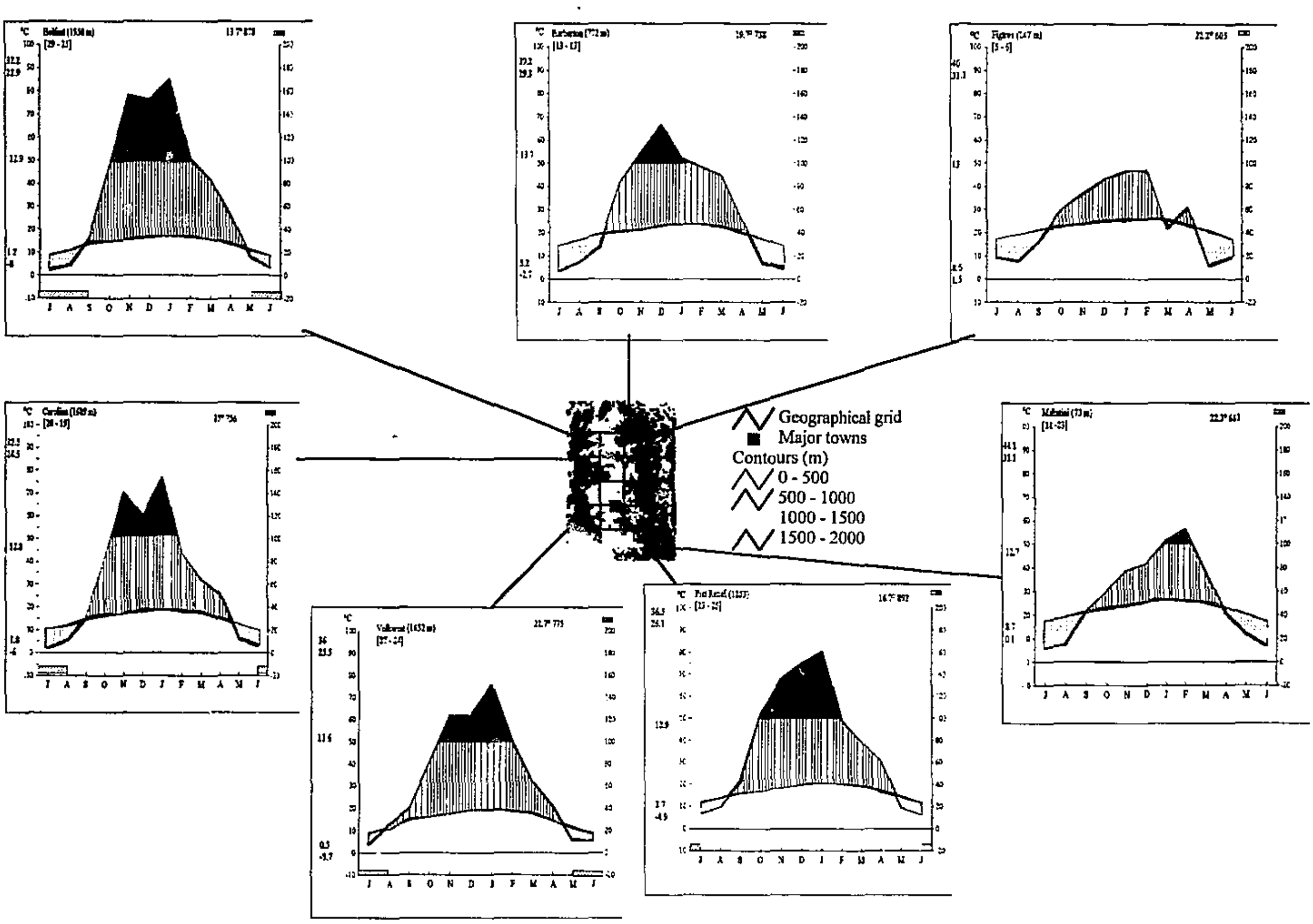


Figure 8: Walter diagrams of seven weather stations found within and next to the study area (Walter diagrams according to Barbour, Burk & Pitts 1980)

heat, the low-sun season a comparatively cool season. Extremely dry areas, recognised as desert subtype, are located over the tropics of Cancer and Capricorn (Strahler & Strahler 1987).

The **dry subtropical climate**, a midlatitude climate, and caused by the same air-mass patterns, is simply a poleward extension of the dry tropical climate, but the annual temperature range is greater. There is a distinct cool season in the lower latitude portions and a cold season in the higher latitude portions. The cold season, occurring at time of low sun, is due in part to invasions of continental polar air masses from higher latitudes and in this way the climate shows the influence of polar air masses. Precipitation that occurs in the low-sun season is produced by midlatitude cyclones that make incursions into the subtropical zone (Strahler & Strahler 1987).

2.2.4. Applied classification

C. W. Thornthwaite developed a classification system based on soil-water balance. This system has certain advantages. It gives information of direct value in assessing the conditions favourable or unfavourable to growth of plants - both indigenous plants and cultivated crops - and is used by soil scientists for a modern system of soil classification. Furthermore, the quantitative frame of reference reinforces the explanatory-descriptive framework already established by classification systems based on precipitation, temperature and air masses and frontal zones (Strahler & Strahler 1987). The system uses mean monthly precipitation, actual evapotranspiration[8] and potential evapotranspiration[9] to calculate water usage, recharge, runoff or shortage. From these values and a set of definitions the climate type and subtypes can be determined.

Evapotranspiration values are not available for all weather stations and are based on evaporation from American Class A pan data or models and relationships. Actual evapotranspiration values were calculated from 50% of the American Class A pan (Louw & Kruger 1968). In the study area complete data sets were only available for the towns of Carolina and Piet Retief (Figure 9).

Based on the values and the definitions, Carolina is situated within the dry tropical climate type of the low latitude climates, semidesert subtype. Water shortage is more than 1500 mm, there is no recharge, potential evapotranspiration is greater than and equal to 1300 mm and at least one month has water storage of more than 20 mm (Strahler & Strahler 1987). It is a warm to hot dry climate, widespread in

[8]The true or real rate of water-vapour return to the atmosphere from the ground and its plant cover. (Strahler & Strahler 1987)

[9]Represents the water-vapour flux under an ideal set of conditions; the quantity of soil water needed if plant growth is to be maximised for the given conditions of solar radiation and air temperature and the available supply of nutrients. (Strahler & Strahler 1987)

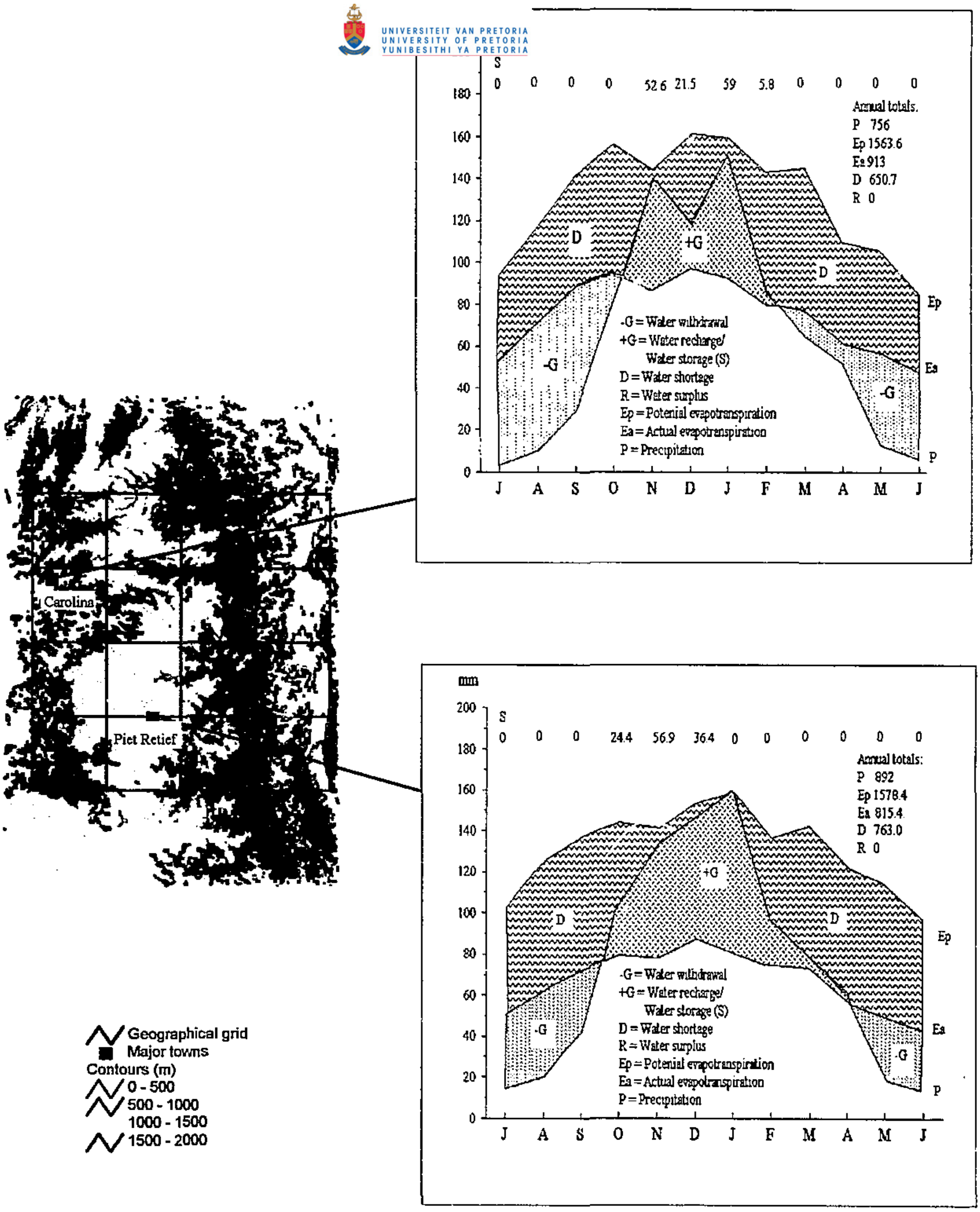


Figure 9: Soil water balance diagrams of two weather stations with complete climatic data

the tropical zone (Strahler & Strahler 1987). Piet Retief, however, is situated within the wet-dry tropical climate of the same latitude group. Water shortage is greater and equal to 200 mm, water recharge is greater than and equal to 100 mm and minimum monthly water storage is less than 30 mm, while potential evapotranspiration is greater and equal to 1300 mm (Strahler & Strahler 1987). It is a tropical-zone climate characterised by a wet season alternating with a dry season. The wet season, or rainy monsoon, occurs in the high-sun period, the dry season in the low-sun period (Strahler & Strahler 1987).

2.2.5. Discussion

Approximate equivalents (Strahler & Strahler 1987) exist between the climate types of the different classification approaches (Table 12). From the table it is concluded that the study area and surrounding areas are under the influence of weather phenomena of the tropical zone. The tropical zone is one of the world latitude zones, based on the angle of incidence of the sun's rays and the resulting thermal environment. It is astride the tropics of Cancer and Capricorn, spanning the latitude belts 10° and 25° N and S. In these zones, the sun takes a path close to the zenith at one solstice and is appreciably lower at the opposite solstice. Thus a marked seasonal cycle exists, but is combined with a large total annual insolation (Strahler & Strahler 1987). The low-sun season or winter is dry and cool (Figure 10) while the time of high sun or summer is hot to extremely hot and wet.

The mean monthly temperature values of the weather bureau were used to calculate each station's biotemperature or heat affecting plant growth. From this it was possible to determine each stations, life zone. A life zone, according to Holdrige, is a group of associations related through the three major climatic factors: heat, precipitation and moisture (Barbour *et al.* 1980). The results were that all stations lie within the dry forest life zone, with stations below 500 m above sea level in the subtropical latitude region and premontane altitudinal belt. Those between 500 m and 1000 m lie in the tropical latitudinal region and premontane altitudinal belt and those above 1000 m in the tropical latitudinal region and lower montane altitudinal belt. Buckle (1996) reasons that in Africa, where seasonal changes between summer and winter are replaced by wet and dry seasons, temperature is a less limiting factor for plant growth than it is at higher latitudes. He also states, that in much of Africa, it is moisture and precipitation rather than temperature that determine the duration of the growing season (Buckle 1996).

Mean annual precipitation for this region ranges between 500 mm and 1000 mm (Strahler & Strahler 1987) and this is confirmed by the data from the weather bureau. This places the study area within the subhumid level (500 - 1000mm) of the five annual precipitation levels, which range from 0 to 2000 mm and higher (Strahler & Strahler 1987). From the complete data sets of Carolina and Piet Retief, it was possible to calculate indices of precipitation-effectiveness for the study area, placing it within Thornthwaite's subhumid humidity province (Barbour *et al.* 1980). Both Köppen and Thornthwaite associated certain vegetation types with certain climate types or provinces (Barbour *et al.* 1980). Köppen associated forest with warm temperate climate (Cw) and open grasslands with scattered trees

Table 12: Climate types of region and study area and their equivalents on a global scale.

<table>
<tr><td rowspan="2">Locality</td><td colspan="3">Equivalent climate types of climate classifications based on</td></tr>
<tr><td>Precipitation & Temperature</td><td>Air masses & frontal zones</td><td>Soil - water balance</td></tr>
<tr><td rowspan="4">Study area</td><td>Warm temperate (Cwb)</td><td colspan="2" rowspan="2">Wet - dry tropical</td></tr>
<tr><td>Tropical savanna (Aw)</td></tr>
<tr><td rowspan="2">Desert and steppe (BWh & BSh)</td><td colspan="2">Dry tropical</td></tr>
<tr><td colspan="2">Dry subtropical</td></tr>
<tr><td>Carolina</td><td>Desert and steppe (BWh & BSh)</td><td colspan="2">Dry tropical</td></tr>
<tr><td>Piet Retief</td><td>Warm temperate (Cwb)</td><td colspan="2">Wet - dry tropical</td></tr>
</table>

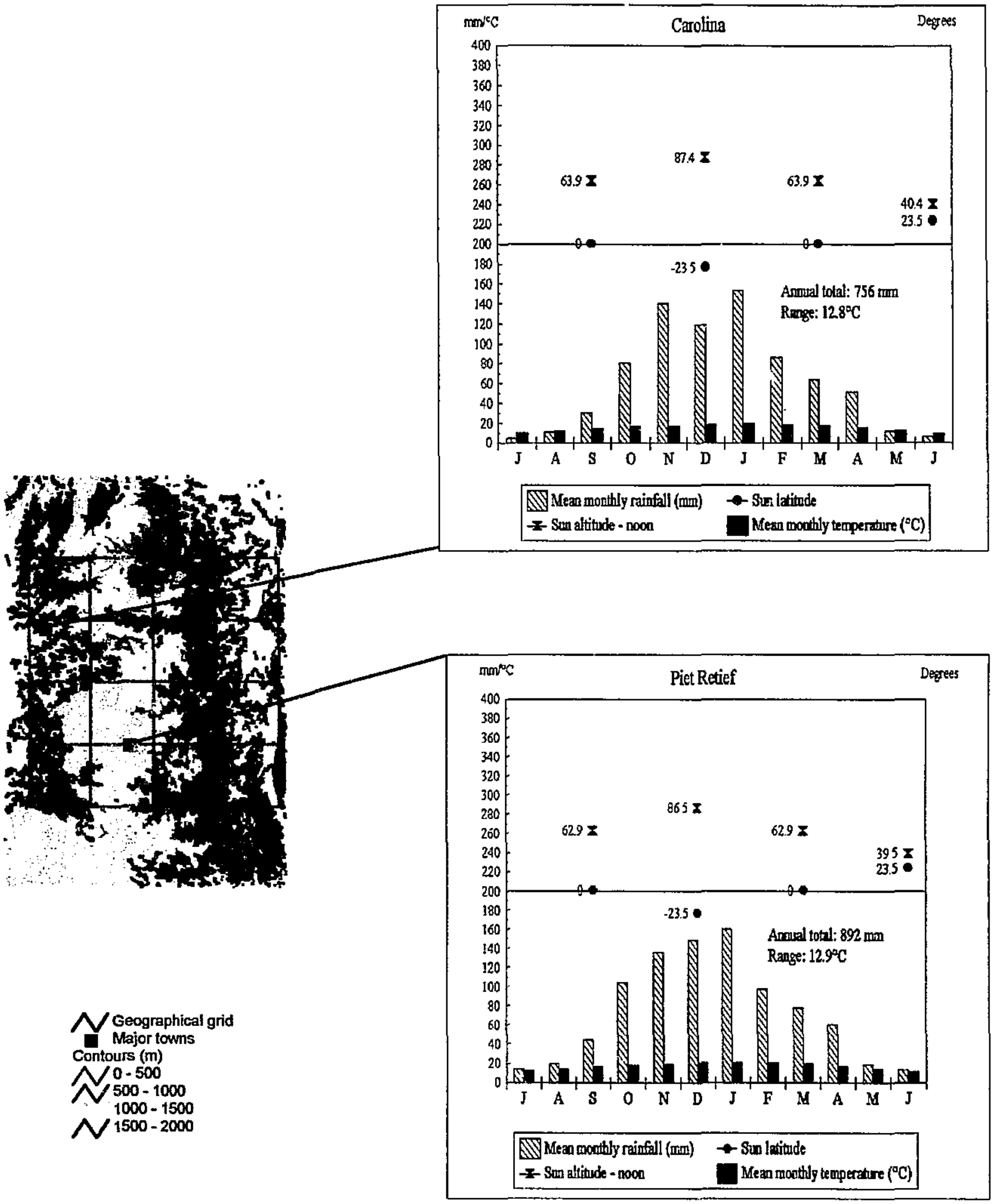


Figure 10: Climographs of two weather stations to the north and south of the study area

with tropical savanna climate (Aw) while Thornthwaite associated grassland with the subhumid humidity province.

On a global scale, forests occur where the environment is most favourable to net productivity of biomass because of the abundance of heat and soil water during a long growth season. Where soil water is in short supply but heat remains adequate, forest gives way to that savanna structure in which shrubs and herbs dominate over trees. The savanna woodland grades into grassland and this, in turn, grades into desert (Strahler & Strahler 1987).

2.3. Geomorphological environment

Located far away from the African great rift area and tectonic plate boundaries, southern Africa is still experiencing a period of epeirogeny. It's surface configuration consists of continental shields and mountain roots (previous areas of mountain making) experiencing warping and denudation, initiating a certain sequential landform physiography.

A. Physiography

The current physiography of southern Africa reflects the surface features since the previous coastal transgression. It is divided into an **Interior Plateau** with 5 **regions** and 13 *subregions*, **Marginal Coastal Areas** of 4 **regions** and 8 *subregions*, with the Great Escarpment as the boundary, and also a well-developed continental shelf offshore (Visser 1989). The study area is situated in two of these **major divisions** across the Great Escarpment.

The **Interior Plateau** is an elevated inland area. The study area cuts across two *subregions* of its third region, the **Highveld (3)**. This is an extensive region which stretches from the Great Escarpment in the south up to the Ranteveld of the former Transvaal in the neighbourhood of Pretoria. The greater part of this region is underlain with Karoo rocks but, towards the north, Archaean granite and gneiss, rocks belonging to the Witwatersrand and Ventersdorp Supergroups and to the Transvaal Sequence crop out successively. These tilted and folded rock beds build distinctly projecting ridges in an area which is otherwise comparatively level and which varies in altitude from roughly 600 m above sea-level in the south to 1 800 m in the north (Visser 1989). The two *subregions* are *Highveld sensu stricto (3a)* and the *Lesotho Highlands (3b)*.

On the edge of the Interior Plateau, the Great Escarpment was brought about by headword erosion over the course of geological time. It is constituted of a variety of rocks of various geological ages, but over nearly three-quarters of its length consists of Karoo rock, with a capping of Drakensberg lava or dolerite. Its altitude varies considerably (Visser 1989).

Below the Great Escarpment are the **Marginal Coastal Areas** or Coastal Borderland. Within this area the study area is situated within the *Eastern and Southeastern Middeveld subregion (7c)* of the **Eastern Plateau Slopes region (7)**. This *subregion* lies between the Drakensberg Escarpment and the Indian Ocean or the Lebombo Mountain Range in the north, and stretches from the Barberton Mountain Land as far south as the Southern Cape region in the vicinity of East London. In the north and along the axis of the Natal monocline it is underlain by Archaean granite, gneiss and rocks of the Barberton Sequence, the Pongola Sequence and the Natal Group of the Cape Supergroup, but elsewhere by rocks of the Karoo Sequence. Near the base of the escarpment the altitude is roughly 1 200m, from where it drops gradually towards the coast. Major differences in topography and climate may nevertheless be observed in this subregion (Visser 1989).

B. Landforms

Within these physiographic regions, predominately to the east on exposed shield, sequential landforms of igneous and metamorphic rock are found, associated with deformed strata (Figure 11). To the west, represented by the Karoo Sequence is the covered shield of relatively undisturbed strata (Strahler & Strahler 1987). The three most prominent landforms in any landscape are mountains, hills or ridges, and plains. Rounded summits of landforms indicate that denudation is influenced by a humid climate (Strahler & Strahler 1987).

This is supported by an index calculated from the following equation of the respective data from Carolina and Piet Retief:

N-value = (12*Ej)/ P

where Ej = average evaporation during January

P = average annual precipitation

N > 5 then physical weathering dominant

N < 5 then chemical weathering dominant (Snyman 1989)

For both stations, the index was less than two. Chemical alteration of minerals is most rapid in warm (and moist) climates of low latitudes (Strahler & Strahler 1987). Thus both types of shields are under the influence of running water or fluvial processes, which create two types of sequential landforms on the earth's surface: erosional and depositional. Erosional landforms are ravines, canyons, peaks, spurs and cols, while depositional landforms are fans and floodplains (Figure 12). They occur within upwarped covered shields, experiencing landmass rejuvenation (Figure 13) or along weaker rocks of metamorphic belts or igneous batholith within exposed shields. Ridges, hills and mountains (Figure 11) formed as a result of landmass rejuvenation are also subjected to fluvial processes, while valleys contain fans and floodplains. Other sources of ridges, hills and level highlying areas or plateaus, are igneous dykes and sills (Buckle 1978; Strahler & Strahler 1987). They occur within plains as inselbergs. Both plains and inselbergs are the result of either pediplanation or deep weathering and

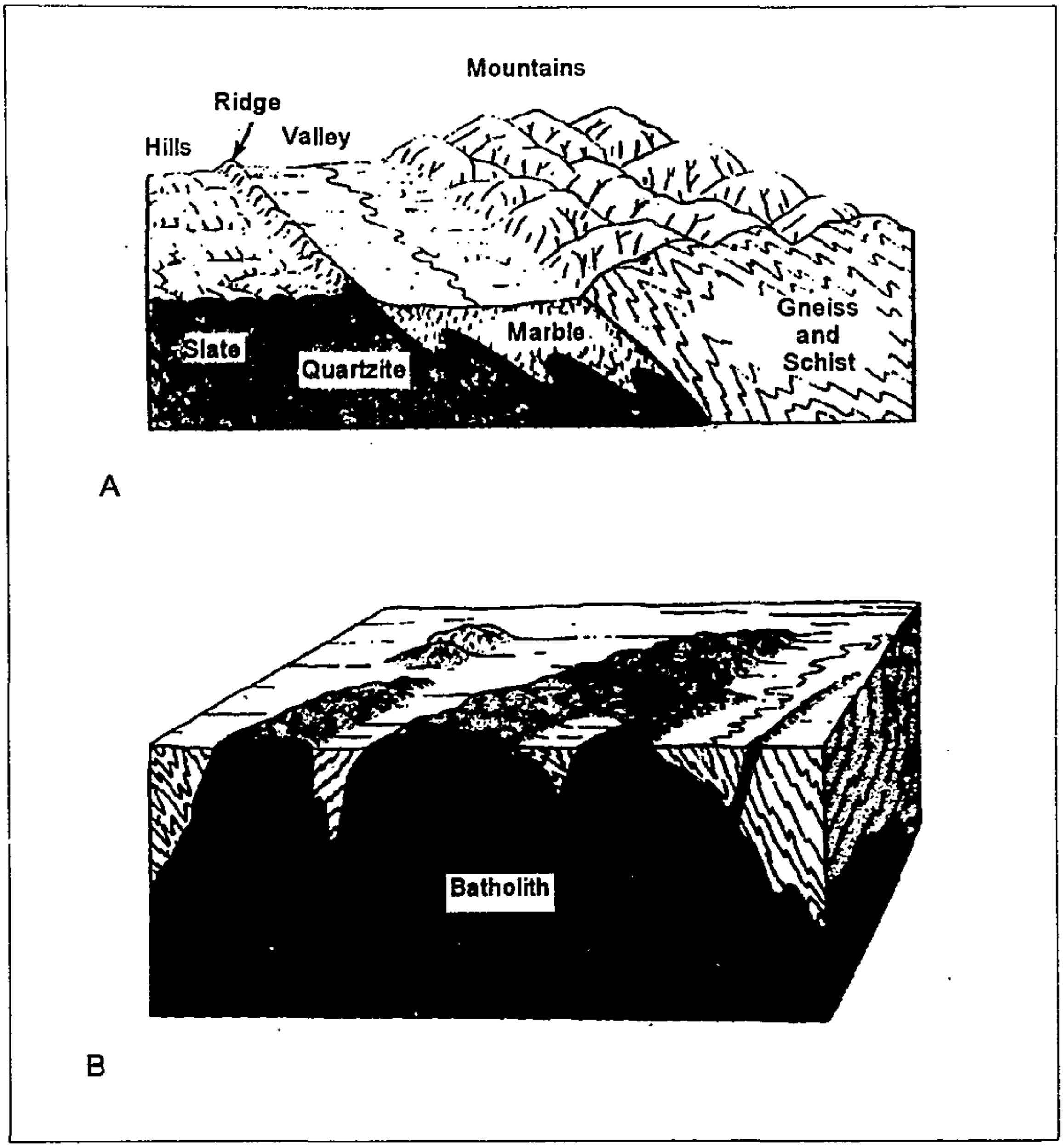


Figure 11: Landforms of the exposed shield as formed by metamorphic (A) and igneous (B) rock as represented by the Barberton Mountains and the numerous batholiths in the Badplaas area. (A Figure 18.38 Metamorphic rocks tend to form elongate, parallel belts of valleys and mountains, B - Figure 18.30 Deep-seated igneous rocks appear at the surface only after long-continued erosion has removed thousands of meters of overlying rocks. Both figures were scanned from Strahler & Strahler 1987)

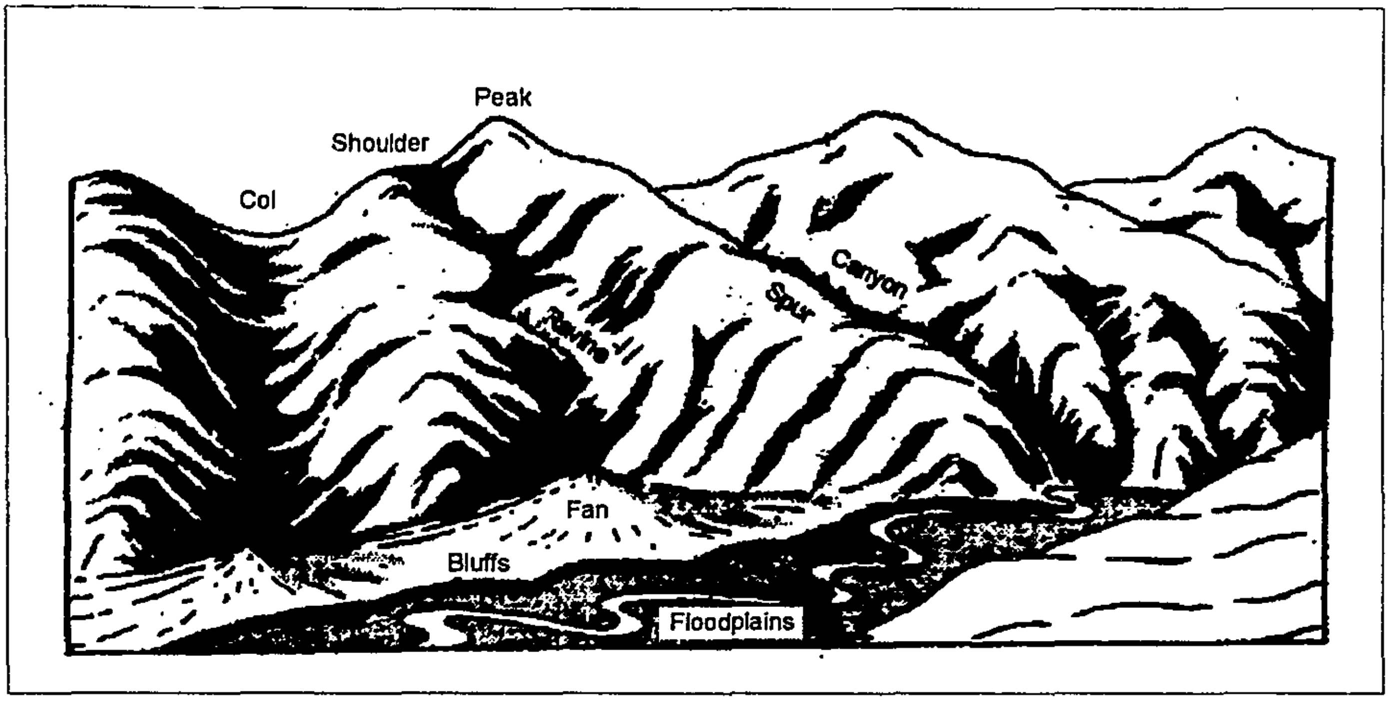


Figure 12: Erosional landforms typical of the Drakensberg escarpment and the Barberton Mountains are ravines, canyons, peaks, spur and cols, while depositional landforms are fans and floodplains (Figure 16.1 - Scanned from Strahler and Strahler 1987)

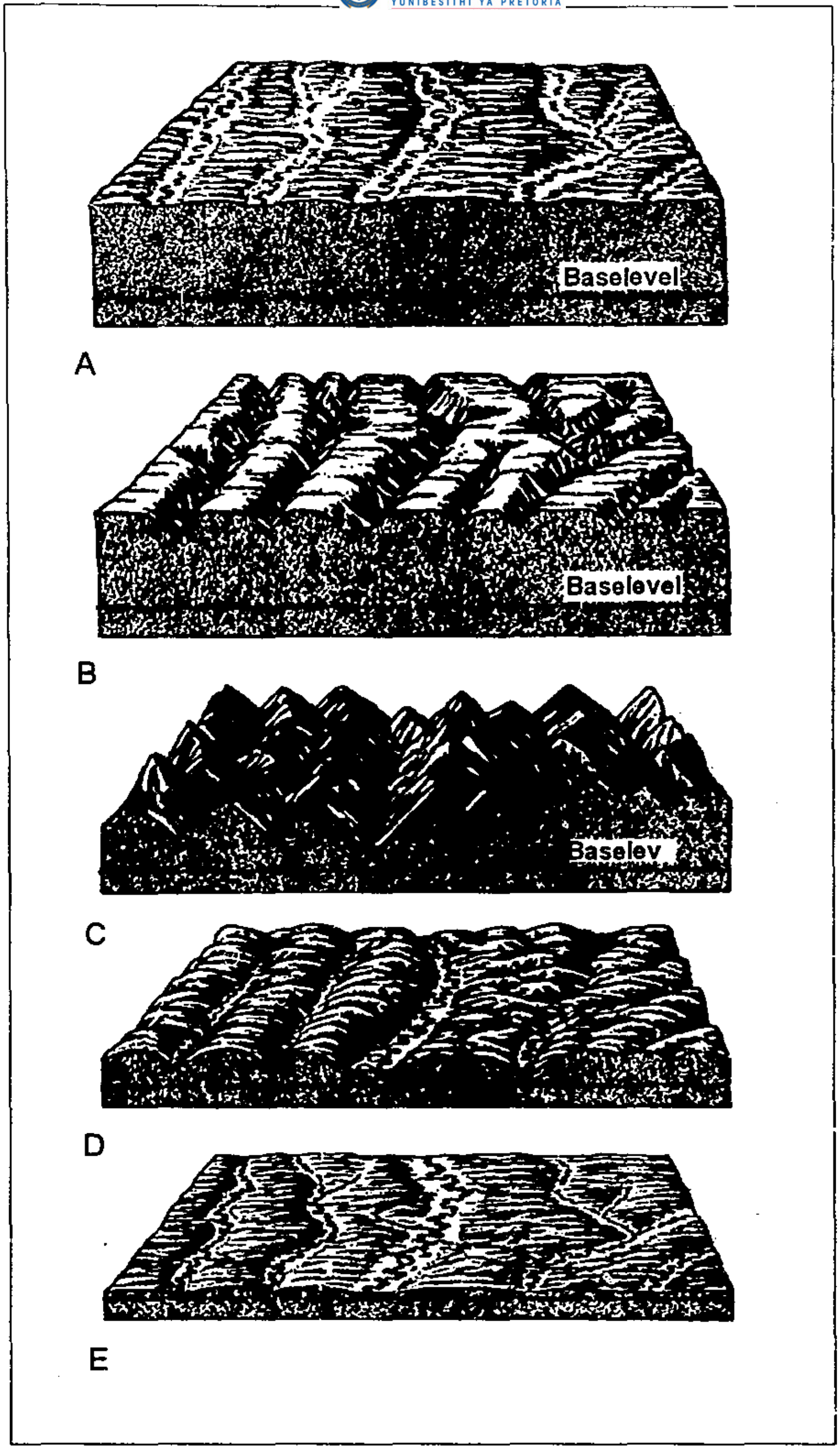


Figure 13: Landmass rejuvenation is a result of coastal transgression and regression in the Cainozoic Erathem and occured within upwarped covered shields, along weaker rocks of metamorphic belts and the igneous batholith within exposed shields. Examples of all these stages could be found throughout the study area, from the top of the Interior Plateau (A) along the Escarpment (B-D), down to the Coastal Borderland (E). (Figure 17.4 Stages in the denudation cycle caused by uplift of a peneplain and a rejuvenation of the stream system. Another uplift of the peneplain, shown in Block E, will bring a return to conditions shown in Block A and the cycle will be repeated. Scanned from Strahler & Strahler 1987)

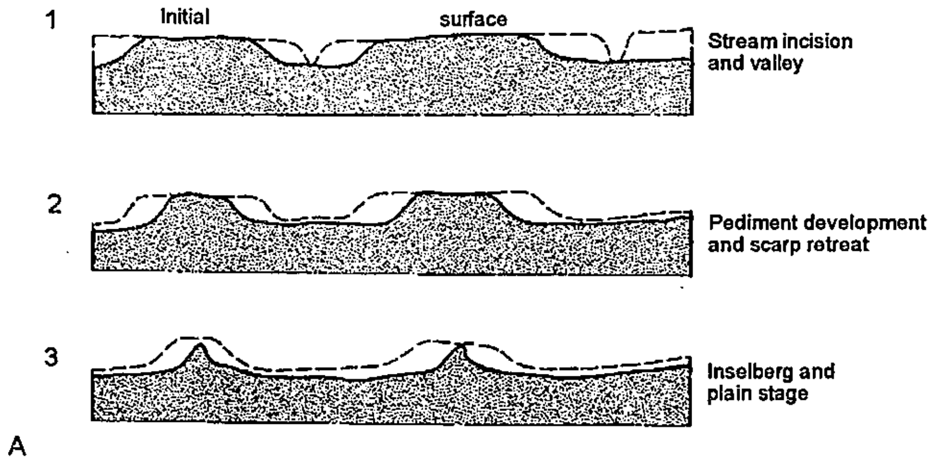
stripping or a combination thereof, during dry and wet periods (Figure 14). Inselbergs are of two types: steep-sided piles of massive crystalline boulders or castle kopjes, and high steep-sided dome-shaped hills formed mainly in massive crystalline rock or bornhardts (Buckle 1978).

Geomorphic process of the savanna environment are closely tied to soil-forming processes - not only process acting under present climates but also processes that may have acted during long time spans in the late Cenozoic (Cainozoic) Era, in which a moister climate may have prevailed (Strahler & Strahler 1987). Large areas of savanna landscape lie on stable shield areas of the former subcontinent of Gondwana. Bedrock of these shield areas is extremely complex in rock composition and structure. Exposures of plutonic igneous masses (batholiths) are numerous, while metamorphic belts of great complexity are also abundant. **This is typical of the study area to the east and northeast below the escarpment.**

Some parts of the shield bear sedimentary covers, while elsewhere are expanses of ancient basalt. Thus the landforms of the savanna regions are to a large degree structurally controlled, making the recognition of landforms governed solely by process unique to wet-dry tropical climate difficult.

Strahler and Strahler (1987) state two landscape features of the savanna region deserve notice: (1) prominent, isolated rock knobs or bornhardts and (2) benchlike upland surfaces or duricrusts (Figure 15). They attribute the formation of bornhardts to deep weathering or pediplanation. A typical bornhardt, according to them, is a steep-sided knob of granite or similar plutonic rock having a rounded summit and often showing exfoliation shells. Related to bornhardts are tors (castle kopje) (Buckle 1978), which consists of rounded joint blocks. Heaps of rounded boulders rising above a plain are a common landform of the savanna landscape.

The second landscape feature, and one that is undoubtedly associated with the tropical environment, is a stepping or benching of the land surface caused by the presence of a layer of rocklike material derived from the soil. A distinctive soil horizon known as plinthite is characteristic of very old soils of the order Oxisols. Plinthite can harden irreversibly into a rocklike layer, becoming laterite, when soil is exposed to repeated wetting and drying in the tropical wet-dry climate. Laterite represents a plinthite horizon that has become exposed to the surface environment through erosional removal of overlying soil horizons of Oxisols. Where streams have carved valleys into the laterite layer, it forms a small cliff. Laterite crusts are not necessarily related to bornhardts or other landforms and occur widely over the uplands of savanna regions. Two, three or more laterite crusts may be formed in succession at lower levels, as denudation proceeds. The benched landscape resembles in some ways the landscape of plateaus, cliffs, and mesas developed in flat-lying sedimentary strata of covered shields. Concerning duricrust, Buckle (1978) states that there are three main types: ferricrete (iron crust), silcrete (silica crust) and calcrete (calcareous crust). Ferricrete or lateritic duricrust is the most significant of these. It occurs in many parts of Africa, but is most apparent in savanna areas where it often produces



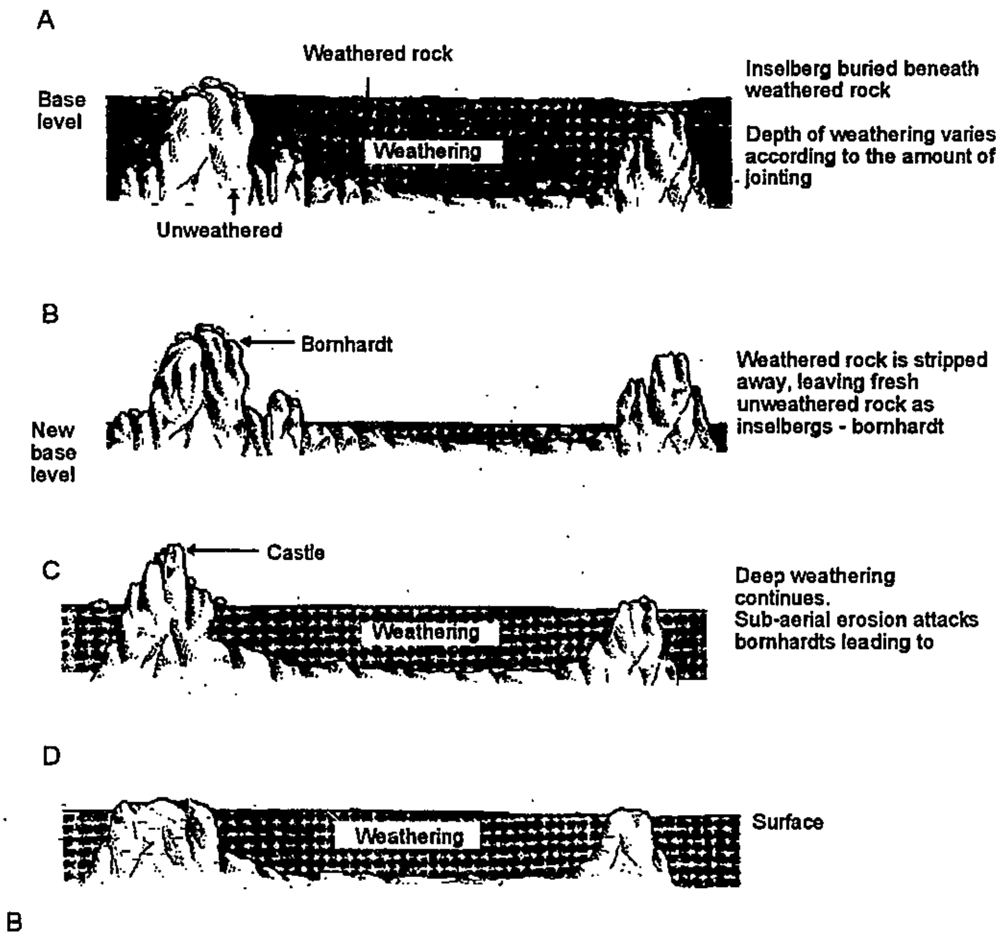


Figure 14: Two process by which inselbergs form - A) pediplanation witin the Interior Plateau of the covered shield, and B) deep weathering and stripping within the Coastal Borderland of the exposed shield. (A - Fig. 7.3 Stages in the pediplanation cycle, B Fig. 7.4 The evolution of inselbergs (A, B, C, D) Scanned from Buckle 1978)

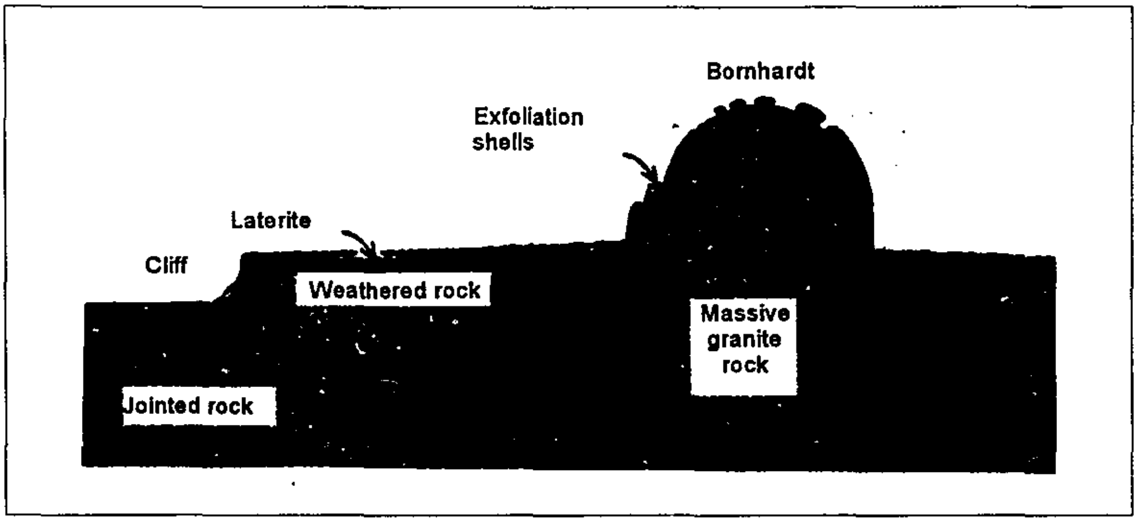


Figure 15: Bornhardt and duricrust, two landscape features of the savanna region (Figure 17.15 Schematic diagram of a bornhardt with its surrounding plain bearing a laterite crust. Drawn by A.N. Strahler, scanned from Strahler & Strahler 1987)

distinctive landforms. Once formed, all duricrusts show considerable resistance to weathering and erosion, producing distinctive landforms in many areas, notably tabular cappings on hilltops. Uplands topped by duricrust layers vary from small buttes to larger plateaus. Along hillsides and valley slopes the edge of a crust forms sharp benches or low cliffs.

A general hypothesis for the development of crusts of ferricrete and silcrete is that they originated as soil horizons during long periods of moister climate, this climate representing a former geographic expansion of the wet monsoon climate into what is today the region of wet-dry tropical climate. Exposure of the soil horizon and it's conversion into a laterite crust accompanied a change to the existing climate, as the belt of wet equatorial climate contracted and withdrew into lower latitudes (Strahler & Strahler 1987).

2.4. Pedological environment

Strahler & Strahler (1987) state that soil is the very heart of the life layer on land. The soil layer is a place in which plant nutrients are produced and held. Soil is the common ground between the living and nonliving world (Barbour *et al.* 1980). It's importance as a medium for growth cannot be overstated. White (1987) defines it as the interface between the atmosphere and lithosphere. It also has an interface with bodies of fresh and salt water (collectively called the hydrosphere). Soil sustains the growth of most terrestrial plants and animals and forms part of the biosphere.

Soils usually show soil horizons. Soil horizons are developed by the interactions through time of climate, living organisms, parent material, and the configuration of the land surface (relief) (Strahler & Strahler 1987). This sequence is also known as the Jenny's classic equation of soil formation (S) where $S = f(cl, o, r, p, t...)$, which characterise soil formation as dependent on a set of independent variables of climate (cl), organisms (o), topography (r), rock type or parent material (p), and time (t). The dots indicate factors of lesser importance such as mineral accessions from the atmosphere, or fire (Barbour *et al.* 1980; White 1987). Climate is the source of moisture and temperature, parent material influences the rate of weathering and mineral composition, organisms of both flora and fauna are sources of nutrients and transport (Barbour *et al.* 1980; White 1987). Strahler & Strahler (1987) describe the influence of topography. They state that the configuration of the ground surface as a factor in soil formation included a single word, landform. Landform includes the varying steepness of the ground surface, or slope, as well as the compass orientation - the aspect - of an element of ground surface. Another landform property is the relief, or average elevation differences between adjacent high and low points (hilltops versus valley bottoms). Strong relief and steep slopes are combined in many areas of hills and mountains. Small relief and gentle slopes are combined in low plains and flat uplands.

Figure 16 indicates the influence of landform on the thickness of A and B horizons of the soil solum. Taking the profile in an undulating upland surface (left) as the normal condition, the flat upland shows thickened horizons because removal of the soil surface by erosion is much slower on gentle slopes. In the hilly region with steep slopes, erosion removes the upper horizons more rapidly and the profile is reduced in thickness. The soil profile beneath the poorly drained meadow has an entirely different character. The combined A and B horizons are rich in organic matter, and a grey layer (glei horizon) is formed beneath the organic layer, where oxygen is deficient. In the adjacent bog a thick upper layer of peat is usually present (Strahler & Strahler 1987).

Aspect of the ground surface influences both the soil temperature and soil-water regimes. In midlatitudes, where the sun's rays strike at an intermediate angle between the horizon and zenith, slopes facing south (southern hemisphere) receive greatly reduced insolation. Soil temperatures on these south facing slopes are cooler than average, and the soil-water regime varies towards a moister climate (Strahler & Strahler 1987).

Time acts on soil formation in two ways: (a) the value of a soil-forming factor may change with time; and (b) the extent of a pedogenic reaction depends on the time over which it has operated. It is well known that the world climate has changed over geological time: the most recent, large changes were associated with the alternating glacial and interglacial periods of the Pleistocene. Major climatic changes were accompanied by the raising and lowering of sea level, erosion and deposition, and induced isostatic process in the Earth's crust, all of which produced radical changes in the distribution of parent material and vegetation, and in the shape of the landscape (White 1987).

On a global scale these soil-forming factors place the study area across the boundaries of two great soil groups of the world and within one order and across two of its suborders of the soils of the world (Strahler & Strahler 1987). The great soil groups are based on the Marbut system, while the soils of the world is based on the more recent Comprehensive Soil Classification System (CSCS) of the United States (Strahler & Strahler 1987).

2.4.1. The great soil groups of the study area according to the Marbut system

The study area contains soils belonging to the zonal order of the Marbut system. Soils belonging to the zonal order are formed under conditions of good soil drainage through the prolonged action of climate and vegetation. The soils of the study area reflect two of the great soil groups found within this order. On the western side of the study area, the great soil group consists of Red-yellow podzolic-latosolic soils, while to the east the great soil group consists of Reddish prairie, Reddish Chestnut and Reddish brown soils. Great soil groups are comprised of various suborders.

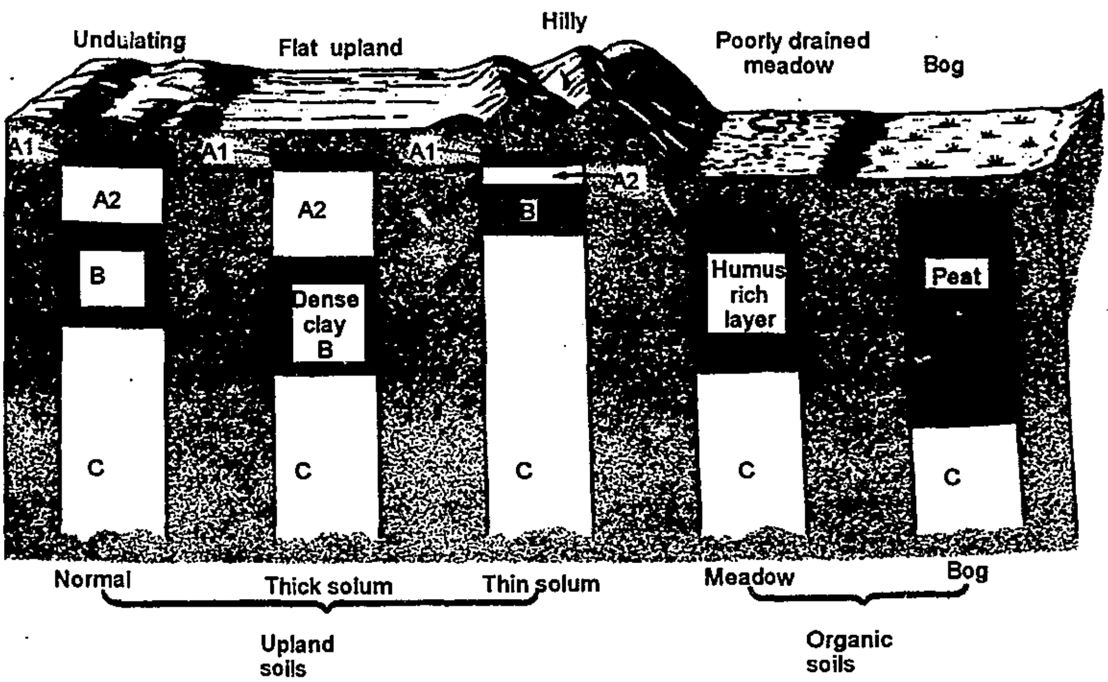


Figure 16: The influence of landforms (undulating plains, hills or mountains and lowlands) on soil depth (Figure 22.9 Relief and slope strongly influence the thickness and compostion of the soil profile Scanned from Strahler & Strahler 1987)

The great soil group, Red-yellow podzolic-latosolic soils, to the west has two suborders:

- light coloured podzolized soils of forested regions associated with the red-yellow podzolic soils
- lateritic soils of the warm, moist subtropical, tropical, and equatorial regions associated with latosolic soils.

To the east the soil group of Reddish prairie, Reddish Chestnut and Reddish brown soils, has only one suborder; dark-coloured soils of the semiarid, subhumid, and humid grasslands.

A. Soils of Red-yellow podzolic-latosolic great soil group

Red-yellow podzolic soils are formed in warmer zones that, including the moist subtropical climate. It is of the podzolic type and shows the same characteristic leaching of the A2 horizon. Warm summers and mild winters favour bacterial action which consumes much of the humus. The typical red and yellow colours are a staining in the form of sesquioxide or iron. Aluminium sesquioxide is also abundant in these soils, so that they respond well to fertilisers. Yellow soils form, on sandy regolith and these soils are strongly leached. In the United States they support longleaf, loblolly, and slash pine.

The other soil order of humid climates in the zonal zone is latosols, which form in warm, moist tropical and equatorial zones. They are characterised as follows: (1) chemical and mechanical decomposition of the parent rock is complete, owing to the favourable conditions of prevailing moisture and heat. (2) Silica has been almost entirely leached from the soil. (3) Sesquioxide of iron and aluminium have accumulated in the soil as abundant and permanent residual materials. (4) Humus is almost or entirely lacking because of rapid bacterial action. (5) The soil is distinctively reddish because of the presence of the sesquioxide of iron. Latosols are highly favourable for the growth of broadleaf evergreen rainforest of the wet equatorial climate. Other large areas have raingreen forest and woodland associated with the tropical wet-dry climate. Latosols quickly lose their fertility under crop cultivation, because excessive leaching has removed the plant nutrients in all but a thin surface layer. Associated with deep parts of the Latosol profile is laterite, a material that hardens into rocklike consistency upon exposure to the drying effects of air.

B. Soils of the Reddish prairie, Reddish Chestnut and Reddish brown great soil group

Still within the zonal zone on the eastern side, are the Reddish prairie, Reddish-chestnut and Reddish-brown soils of the semi-arid and arid climates. Reddish prairie soils occur where average annual rainfall range between 600 mm and 1 000 mm, diminishing sharply westward. They lack excess calcium carbonate and are extremely productive, combining the fertility of Chernozems with a somewhat moister climate. A typical Chernozem profile appears to consist essentially of two layers. Immediately beneath the grass sod is a dark layer rich in humus, the A horizon, with a depth up to 1 m.

In this layer the soil structure is crumb or nut. The A horizon grades downward into a B horizon of brown or yellowish brown colour, then, with sharp line of demarcation into a light-coloured C horizon. It is rich in calcium, which appears in excess as calcium carbonate precipitated in the lower B horizon or just beneath the B horizon. The continental location of these soil groups makes for hot summers and cold winters. Drought periods with strong evaporation severely dry the soil, and forest cannot exist; instead, grasses flourish. The presence of a surface layer of wind-transported silt (loess) has been especially favourable to development of these great soil groups.

Reddish-chestnut and Reddish-brown soils are widespread in the semi-arid and subhumid tropical and subtropical regions of the world. These soils are of reddish brown surface colour, grading downward into a heavier dull-red or reddish-brown subsoil, and into a zone of lime accumulation. They are found in the regions of wet-dry tropical climate with a short wet season and in the bordering low-latitude steppe subclimates. In all these regions, high air temperatures and a severe water deficit occur for one season of the year. Aridity in the seasonal cycle explains the occurrence of calcium carbonate in the lower layers of these soils, whereas the red colour is evidence of abundance of sesquioxides of iron that tend to accumulate in a warm climate.

2.4.2.The soil orders of the study area according to the Comprehensive Soil Classification System

The Marbut system is based on climate processes and plant activity and is still used at educational level where it furnishes the basis of a broad appreciation of the geography of world soils and their relationships to global climates and to global patterns of natural vegetation and agriculture. The preferred classification of soil scientists these days however, is the Comprehensive Soil Classification System, because it is less qualitative and more quantitative. It defines classes strictly in terms of morphology and composition of the soils, that is, in terms of the soil characteristics themselves.

The Alfisols order is the only order of this classification system associated with the study area. This order consists of soils from humid and subhumid climates with high base status (PBS > 35%) and an argillic horizon. Soils of high base status have high natural fertility for food crops; those of low base status are naturally low in fertility and require special treatment and the application of chemicals to correct the deficiency. An argillic horizon is a subsurface diagnostic horizon, an illuvial horizon (usually the B horizon) in which layer-lattice clay minerals have accumulated by illuviation. Clay cutans, called "argillians", are usually present. The argillic horizon normally forms beneath an eluvial (A1) horizon. In addition, the epipedon or surface layer is grey, brownish or reddish and not darkened by humus close to the surface. Soil water is available to plants for more than half the year or more than three consecutive months during a warm season. The study area qualifies as to this last property extremely well. In Africa and other regions of the southern hemisphere, these soils occur in areas of wet-dry climate and semi-arid subtypes of the tropical and subtropical dry climates. On the whole, Alfisols are agriculturally fairly productive under simple management because soil water is usually adequate in one season and bases are not depleted. Two of its suborders are found within the study area, one to the west and one to the east.

On the western side of the study area, the Udalfs suborder of the Alfisols has developed, while within the eastern side the Ustalfs suborder occurs.

Udalfs develop under the udic soil-water regime. In udic soil-water regimes, the soil is not dry in any part of the profile for as long as 90 days per year. The udic regime is found in the moist climates. The soil-water budget shows little or no water deficiency in the growing season (summer), and there is a seasonal water surplus that causes water to move through the soil at some part of the year. In the United States, deciduous forest was the natural vegetation, but today these soils are intensively farmed. They are highly productive when moderate amounts of lime and fertilisers are applied.

Ustalfs are brownish to reddish Alfisols of the warmer climates under the ustic soil-water regime. An ustic soil-water regime has a moderate quantity of water storage during the season when conditions are favourable to plant growth and the soil water is not frozen, but the soil is dry for 90 or more cumulative days in most years. It is associated with semiarid subtype(s) of the dry climates and with the tropical wet-dry climate. Ustalfs are brownish to reddish throughout the profile. They range from the subtropical zone to the equator and are found associated with the wet-dry tropical climate in Africa and other regions of the southern hemisphere. In Africa, they may owe their high base status to the constant rain of fine dust carried by prevailing winds from the adjacent tropical deserts. These soils could be highly productive under irrigation.

In terms of global soil classification, the soils found within the study area are well-drained, of varying fertility and able to support either grassland or woodlands depending on soil water availability. Soil water availability is related to climate, which in return is related to distance from the equator, the poles and oceans. Trees are found on soils with low soil water deficiencies, while grasses occur on soils with high soil water deficiencies.

2.5. Flora

On a global scale, plants and animals are distributed within one of two ecosystems: aquatic and terrestrial (Strahler & Strahler 1987). The presence or absence of plants and animals adapted to their related environmental factors reveal their location.

Aquatic ecosystems include life forms of the marine environments and fresh water environments of the lands. Freshwater ecosystems include lakes, ponds, streams, marshes and bogs. Terrestrial ecosystems comprise the assemblages of land plants and animals spread widely over the upland surfaces of continents. These are largely determined by climate and soil (Strahler & Strahler 1987).

Aquatic and terrestrial ecosystems within the same landscape are linked directly by water moving in the hydrologic cycle. Thus the connection between terrestrial and aquatic ecosystems is a functional one, and the ecological consequences of this linkage are profound (Hasler 1975).

Of the two major life forms associated with these ecosystems on land, the plants are mainly used to define ecosystem and within-ecosystem boundaries.

2.5.1. Terrestrial ecosystem

Within the terrestrial ecosystem, the largest recognisable subdivision is the biome. Although the biome includes the total assemblage of plant and animal life interacting within the life layer, the green plants dominate the biome physically because of their enormous biomass. Thus, biomes are classified by the characteristic life form of the green plants within the biome (Strahler & Strahler 1987). Strahler & Strahler (1987) describe and list the biomes in order of availability of soil water and heat, as follows:

Forest	Ample soil water and heat
Savanna	Transitional between forest and grassland
Grassland	Moderate shortage of soil water; adequate heat
Desert	Extreme shortage of soil water, adequate heat
Tundra	Insufficient heat

Barbour *et al.* (1980) also distinguishes between temperate grassland and savanna on a global scale, when discussing productivity and biomass. Biomes are further subdivided into formations based on the size, shape and structure of the plants. Local variation in plants and animals occur within these formations. The distribution of major biomes is climate dependent and the formations are primarily under the influence of the effects of various landforms and soils on vegetation (Strahler & Strahler 1987).

In Strahler & Strahler (1987), these local associations of interdependent, co-occuring plants and animals are called biotic communities. They state that the total biotic cover of a region is actually a mosaic of small community types that recur in different places on the landscape. Habitat, according to them, refers to a type of physical environment that has a characteristic biotic community. Precise location of each habitat and it's extent depend largely on factors of soil and landform.

Comparison of different maps of the natural vegetation regions of the world reveal that the study area seems to be located within either **savanna** or ***grassland*** or ***<u>across both</u>*** depending on scale and biome parameters (Keeton 1967; Mitchell 1982; Strahler & Strahler 1987).

Vegetation of the **savanna** biome consists of a combination of trees and grassland in various proportions. The appearance of the vegetation can be described as parklike, with trees spaced singly or in small groups and surrounded by, or interspersed with, surfaces covered by grasses or some other plant life form, such as shrubs or annuals in a low layer. Savanna is closely associated with warm climates having alternate wet and dry seasons. The most widespread areas of savanna are identified with the wet-dry tropical climate and with the semiarid subtype of the dry tropical climate. The latter climate shows a brief, but often intense, rainy season (Strahler & Strahler 1987).

The ***grassland*** biome consists largely or entirely of herbs, which may include grasses, grasslike plants, and forbs (broadleaf herbs). Degree of coverage may range from continuous to discontinuous and there may be stratification. Grassland can include some trees in moister habitats of valley floors and along stream courses where ground water is within reach of tree roots. This biome is closely associated with both the semiarid subtype of the dry midlatitude climate and the subhumid subtypes of the moist subtropical climate and the moist continental climate. Soil-water deficit ranges from zero to 200 mm or greater, and there is little or no water surplus. Thus soil-water storage is well below the storage capacity throughout most of the year (Strahler & Strahler 1987).

A. Savanna biome

Mitchell (1982) also distinguishes between grassland and savanna, but discusses only the savanna grassland of Africa. Savanna grassland covers much of Africa from the Sahara to the Cape. Only in the west does it give way to dense tropical forest of the Zaire River basin and the West African coast and to the Namibia Desert. The grassland is not a uniform area, but ranges from dry steppe and sub-desert in the north and southwest (on the fringes of the Sahara and Kalahari deserts) through thorn scrub to open savanna woodland in the equatorial region. Watercourses and granite hills bisect the landscape, and farming has modified much of the southern area.

The transitions between the various types of savanna are distinct and each type has its own characteristic fauna and flora. The open woodlands are characterised by fire-resistant trees such as *Brachystegia* and *Isoberlinia*, which are replaced in drier areas by acacias (thorn-scrub) and baobabs. The vegetation of the open areas is a mixture of grasses and herbs with occasional acacias.

Strahler & Strahler (1987) describe the savanna woodland formation as follows: trees are spaced rather widely apart, permitting development of a dense lower layer, which usually consists of grasses. It has an open, parklike appearance. Associated with the wet-dry tropical climate of Africa and South America, it can be found in a wide range of latitudes. In the wet-dry tropical climate, the soil-water regime shows a seasonal decline in soil-water storage to an amount too small to sustain closed-canopy forest. Some species of trees are xerophytic forms with small leaves and thorns; others are broad-leaved deciduous species that shed their leaves in the dry season. In this respect savanna woodland is akin to monsoon forest, into which it grades in some places. Fire is a frequent occurrence in savanna woodland during the dry season. The view is held that the periodic burning of the savanna grasses is responsible for the maintenance of the grassland against the invasion of forest. Many rainforest tree species that might otherwise grow in the wet-dry climate regime are prevented by fire from invading.

Another formation of the savanna biome is the thorntree-tall grass savanna of Africa, which forms a transitional class into the desert biome. The trees, largely of thorny species, are more widely scattered and the open grassland is more extensive than in the savanna woodland. Flat-topped acacias (*Acacia* species) are characteristic, as is the grotesque baobab (*Adansonia digitata*), with its barrel-shaped water-storing trunk. Strahler & Strahler (1987) reasons that because of the dominance of grassland over woodland, this formation class may equally well be placed in the grassland biome in terms of structure, **but because it is geographically and climatically intergradational with savanna woodland, inclusion in the savanna biome seems the more desirable alternative.** This thorntree-tall grass savanna is closely identified with the semiarid subtype of the dry tropical and subtropical climates and, in Africa, areas of semidesert subtypes as well. In the semiarid climate, soil-water storage is very low for 10 out of the 12 months. Only during the brief rainy seasons is soil water adequate for the needs of plants. Greening of the trees and grasses quickly follows onset of the rains. For this reason, vegetation of the savanna biome is described as "raingreen", an adjective that applies also to monsoon forest. Related soils of the savanna biome include Ustalfs, Ultisols, Oxisols, and Veritsols. The distribution of these orders varies according to parent matter of the soil and past climatic history (Strahler & Strahler 1987).

B. Grassland biome

Keeton (1967) does not describe a savanna biome and only distinguishes between three biomes on the Africa continent; tropical rain forest, grassland and desert. In this case the study area would be included in the grassland. He describes the grassland biome as typical of areas where either relatively low total annual rainfall (250 mm - 500 mm) or uneven seasonal occurrence of rainfall makes conditions inhospitable for forest but suitable for often luxurious growth of grasses. Strahler & Strahler (1987) stated that the only occurrence in the southern hemisphere of short-grass prairie or steppe formation, is the veldt of South Africa, developed on the highland surface in the Free State and former Transvaal. It consists of short grasses occurring in sparsely distributed clumps or bunches. Scattered shrubs and low trees may also be found in the steppe. Ground coverage is low and much bare soil is exposed. Many species of grasses and other herbs occur. Steppe grades into semidesert in dry environments and into prairie where rainfall is higher.

Under this system the study area would probably be considered prairie because of the subhumid province in which it occurs. The prairie consists of tall grasses, comprising the dominant herbs and subdominant forbs (broadleaf herbs). Trees and shrubs are almost totally absent but may occur as

forest or woodland patches in valley bottoms. The grasses are deeply rooted and form a continuous and dense sward. The grasses flower in spring and in early summer; the forbs in late summer.
In terms of climate and soil, these two grassland formations are associated with different climates and suborders of the same soil order. The steppe formation coincides quite closely with the semiarid subtype of the dry midlatitude climate. The soil-water budget shows a substantial soil-water deficiency, and there is no water surplus. Soil-water storage is far below the soil storage capacity in all months. During a spring period of soil-water recharge, a substantial amount of water is made available to grasses and results in rapid growth into early summer. By midsummer the grasses are usually dormant, although occasional summer rainstorms cause periods of revived growth. Soils of the steppe grasslands are associated with the Borolls suborder within the order of Mollisols. In contrast, tall-grass prairie is closely associated with the subhumid subtype of the moist continental climate and moist subtropical climate. Here the soil-water budget shows a moderate soil-water deficiency, ranging from 0 to 150 mm. Tall-grass prairie could also extend into the humid subtypes of the same climates. It is closely identified with Udolls, the udic-regime suborder of the Mollisols. These soils are exceptionally rich in base cations important to grasses (Strahler & Strahler 1987).

It would seem from all the global environmental factors influencing the region in which study area occurs and the global trend of vegetation according to these influences, that the study area should be representative of the savanna biome (Table 13). It is therefore concluded on a broad scale that the terrestrial ecosystem in which the study area is situated has the potential to maintain either forest or grassland. Local surface configurations and environmental conditions result in soil water shortages which prevent a closed canopy forest form developing, while sufficient water occurs to maintain grassland, resulting in a mosaic of tree and grass covered areas.

2.5.2. Aquatic ecosystem

The open water areas of freshwater ecosystems such as lakes, ponds and streams and their organisms are beyond the scope of this research project. This research project is concerned only with those areas which exclude open water, and which are defined in article 1.1 and included in article 2.1 of the Ramsar convention as wetlands, i.e. areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. These areas may also include adjacent riparian and coastal zones (Cowan 1995). The study area is situated away from the coast of South Africa, and all marine environments are therefore automatically excluded. For the purpose of this study the aquatic ecosystem is divided into open water and wetlands.

Table 13: Different global environmental factors and their associated global vegetation types.

Environmental factor	Classification category		Associated vegetation type
	Soil-water balance type	Köppen type	
Climate	Wet-dry tropical	Warm temperate (Cwb)	Forest
		Tropical savanna (Aw)	Open grassland with scattered trees
Precipitation	Subhumid humidity province		Grassland
Pedological	Suborders of the Marbut system		
	Light coloured podzolized and lateric soils		Forest
	Dark coloured soils		Grassland
	Alfisol suborders of the Comprehensive Soil Classification System		
	Udalfs		Deciduous forest
	Ustalfs		Grassland
	Mollisol suborders of the Comprehensive Soil Classification System		
	Borolls		Steppe (short grassland)
	Ustolls		Prairie (tall grassland)

Within the African continent, eight major wetland types and five major wetland plant communities can be recognised (Denny 1985). The eight major wetland types are divided into two main categories and sub-categories:

1. Freshwater herbaceous wetlands
1.1. Permanent
1.1.1. Reedswamps
1.1.2. Bog, fen and moorland
1.2. Seasonal
1.2.1. Black clays, pans and dambos
1.2.2. Floodplains and valley grasslands
1.2.3. Alkaline grasslands
2. Freshwater swamp forests
2.1. Permanent
2.2. Seasonal
2.2.1. Floodplain forests
2.2.2. Riverine and gallery forests.

The five major wetland plant communities are a) floating sudd communities; b) permanent reed swamps; c) seasonal herbaceous swamps (edaphic grasslands); d) swamp (edaphic) forests; e) montane wetland communities. Floating sudd communities are excluded from this research project, as they are associated with the open waters of lacustrine environments.

2.6. Fauna

Africa, south of the Sahara represents the Ethiopian zoogeographical region of the world (Burn 1980; Keeton 1967; Mitchell 1982). This region is mostly tropical and typified by dry, highly seasonal grassland. Much of west and central Africa is covered by tropical rain forest and inhabited by essentially arboreal species such as gorillas, monkeys and lorises (Thick-tailed and Lesser bushbabies). Of these, monkeys and lorises occur in the study area (Smithers 1983). The grasslands support huge herds of grazing and browsing herbivores and their predators (Mitchell 1982). In his description of the savanna grassland of Africa, he states that ecologically, the savanna is a highly complex system of interdependent components.

The food of the grazing animals - grasses and herbs - is resistant to drought, fire and grazing and quickly recovers from its effects. A bewildering number of savanna animals exploits their environment in a variety of different ways. Among the browsers there is a vertical zoning of feeding habits regarding the woody species component, with some animals utilising the trees and others the shrubs and the lower branches. Also within the grass layer different parts are utilised by different animals. Numerous smaller animals and birds form part of the delicate balance of the savanna ecosystem, which is easily upset, especially by man (Mitchell 1982).

Both these animals and their habitats are under constant pressure from bad management and overpopulation by humans. There is a corresponding gradation of plant resources and the ways in which it is used to support human life because the savanna environment in Africa is a transition zone between rainforest and desert environments. Moister regions are used for cropping and drier regions for grazing, with trees being felled for agricultural land, firewood and dwellings (Strahler & Strahler 1987). In some areas exotic trees are planted to provide pulpwood. Large numbers of game or cattle are restricted to small areas and overpopulation results in desertification through the destruction of grasses, shrubs, and trees. The effects of accelerated soil erosion, such as rilling and gullying of slopes and accumulations of sediment in stream channels, are also visible (Strahler & Strahler 1987).

Thus, humans and their animals change the appearance of the natural environment, through poor management from tree-dominated to grass-dominated, changing savanna into grassland and eventually grassland into desert (Strahler & Strahler 1987). This results in the loss of a highly productive environment and the expansion of a low productive environment in spite of the potential of the climate and soil to support a well adapted and highly productive environment consisting of trees, grasses and forbs.

3. Local perspective

From a global perspective, it is known that geology, forms an important part of the abiotic environment. Together with climate, it shapes the local surface configuration and eventually the composition and depth of local soils.

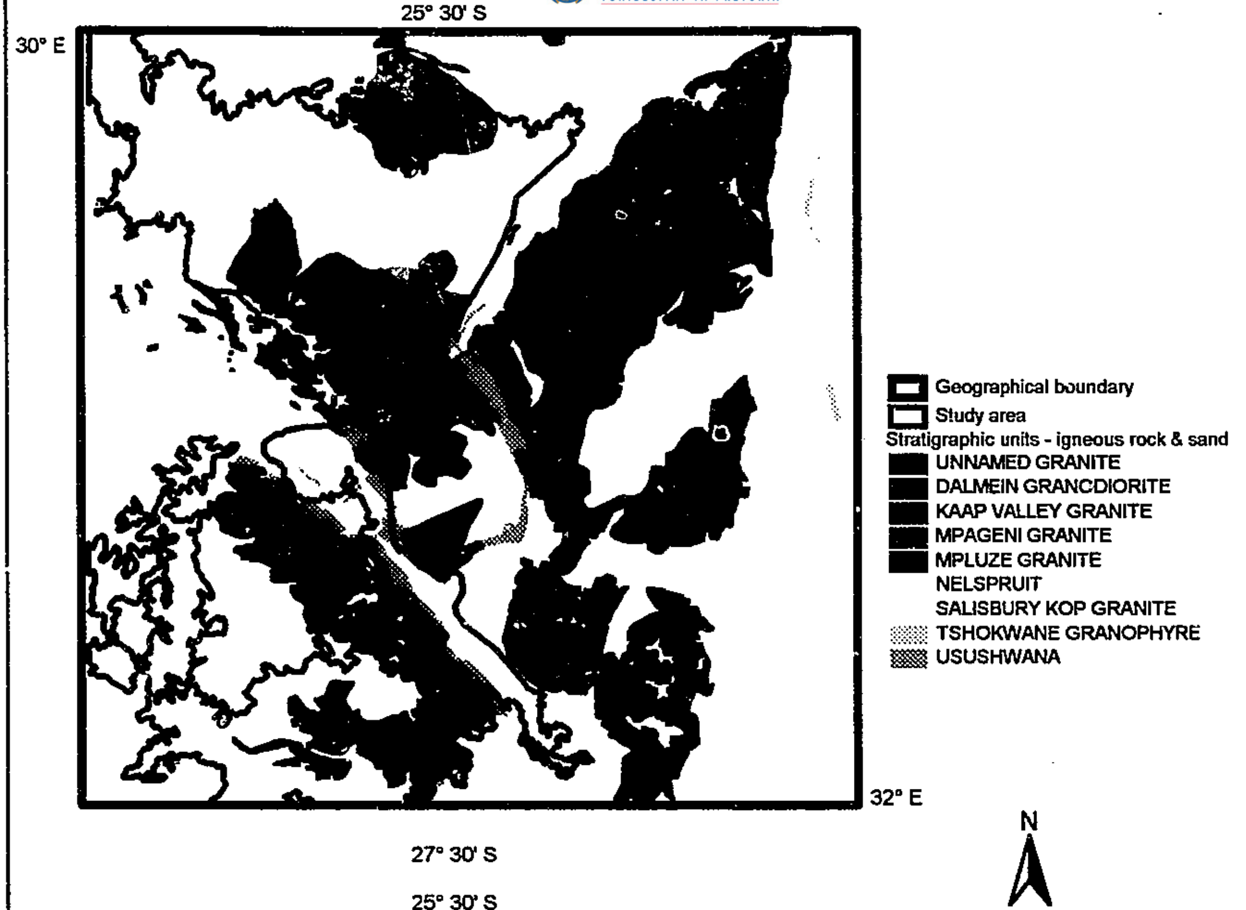
3.1. Geological environment

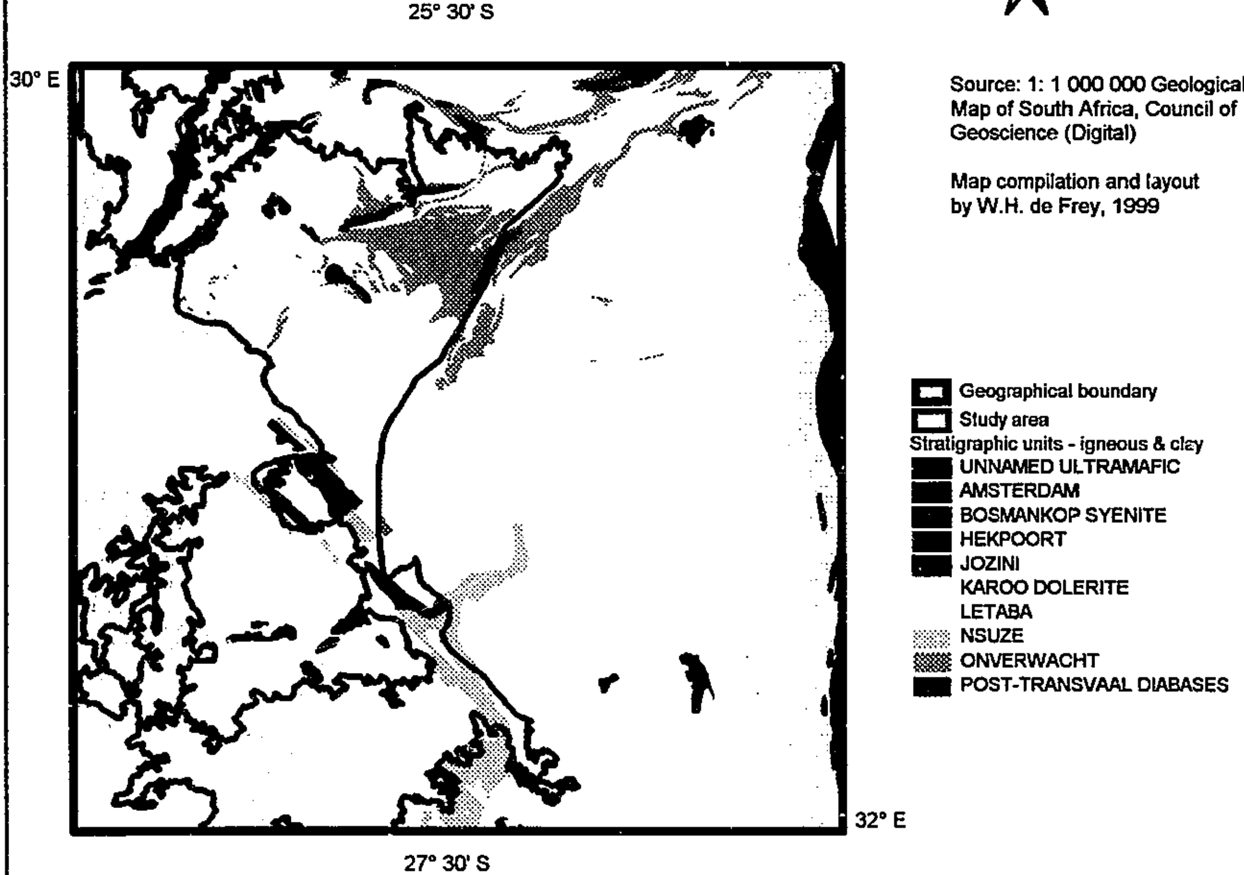
Within the boundary rectangle of the study area, lithological units of the different petrological units occur associated with different stratigraphic units (Table 14 & Figure 17.a, b & c). These stratigraphic units are members of larger *stratigraphic groups* and representative of different **chronostratigraphic units.** Only certain of these stratigraphic units are associated with the soil patterns, which form the boundary of the study area.

Walraven (1989a) describes the geology of the area between 25 and 26 degrees southern latitude and 30 degrees eastern longitude and Mozambique as follows: it includes rocks from a wide variety of lithological units ranging in age from Swazian to Recent. Included in these are the granite-gneiss and

Table 14: Different lithological units and their expected soil textures.

Shield	Petrological unit	Lithological unit	Stratigraphic unit	Expected soil texture
Covered	**International erathem: Mesozoic** – *Unnamed stratigraphc unit*			
	Igneous	Dolerite	Karoo dolerite	Clay
	International erathem: Palaeozoic – *Karoo Sequence/ Ecca Group*			
	Sedimentary	Shale	Pietermaritzburg	Clay
			Volkrust	
		Mudstone	Beaufort	
		Tillite	Dwyka	
		Arenite	Vryheid	Sand
Exposed	**National erathem: Vaallaan** – *Transvaal Sequence/ Pretoria Group*			
	Igneous	Andesite	Hekpoort	Clay
	Sedimentary	Shale	Timeball Hill	
			Silverton	
		Arenite	Pretoria	Sand
	National erathem: Randian – *Pongola Sequence*			
	Igneous	Basalt	Nsuze	Clay
	Sedimentary	Quartzite	Mozaan	Sand
	National erathem: Randian – *Unnamed stratigraphic unit*			
	Igneous	Tuff	Amsterdam	Clay
		Gabbro	Usushwana	Sand
		Quarts monozite	Mpluze Granite	
	National erathem: Swazian – *Unnamed stratigraphic unit*			
	Igneous	Granite	Unnamed	Sand
	Metamorphic	Gneiss		
	National erathem: Swazian – *Barberton Sequence*			
	Igneous	Lava	Onverwacht	Clay
	Sedimentary	Arenite	Moodies	Sand
	National erathem: Archaean – *Unnamed stratigraphic unit*			
	Igneous	Ultramafic	Unnamed	Clay





Source: 1: 1 000 000 Geological Map of South Africa, Council of Geoscience (Digital)

Map compilation and layout by W.H. de Frey, 1999

Figure 17.a: Igneous stratigraphic units which result in either predominantely sandy or clayey soil textures

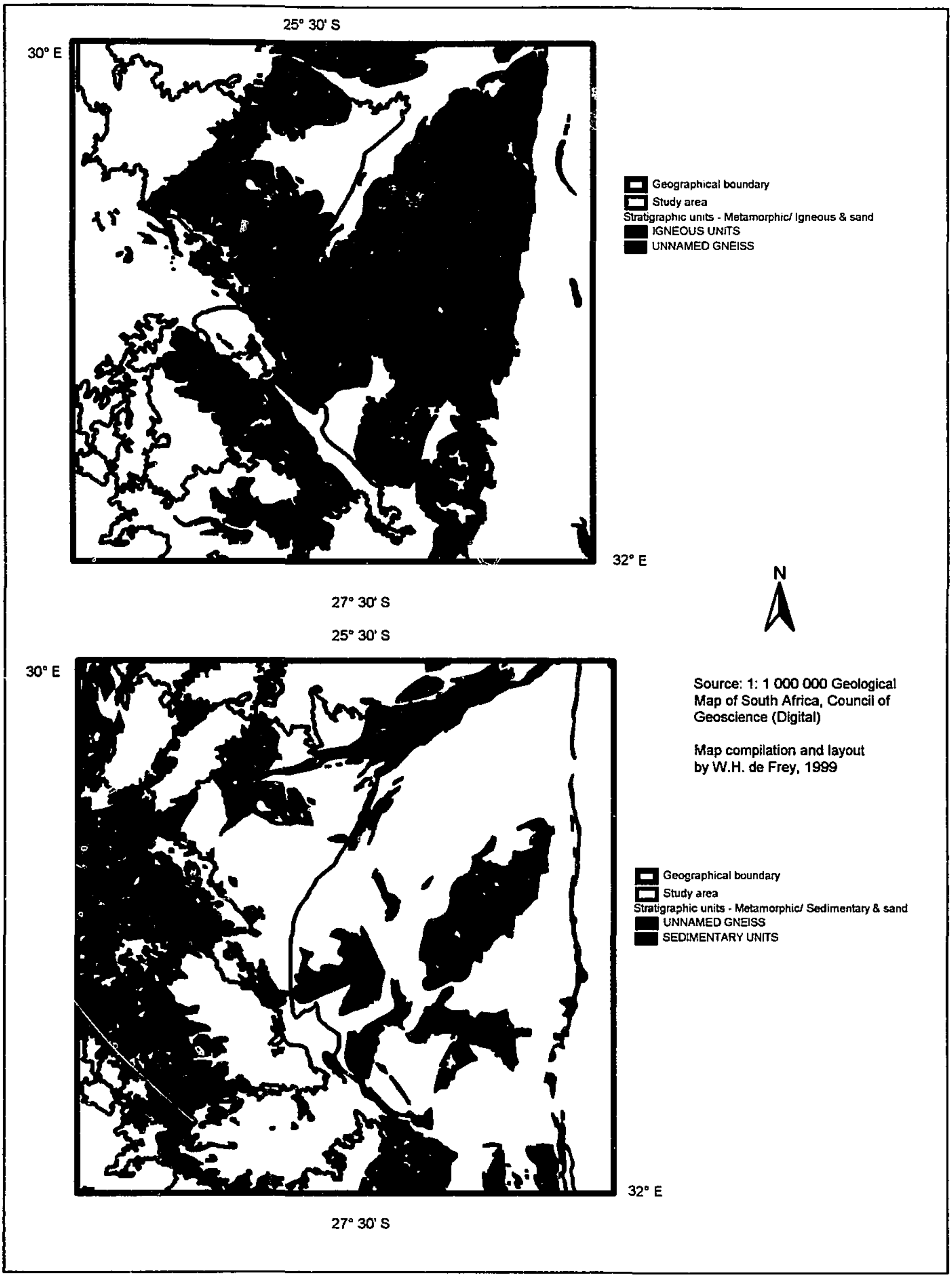


Figure 17.b: Stratigraphic units of the metamorphic rock and the general distribution of sandy soil textures across the study area

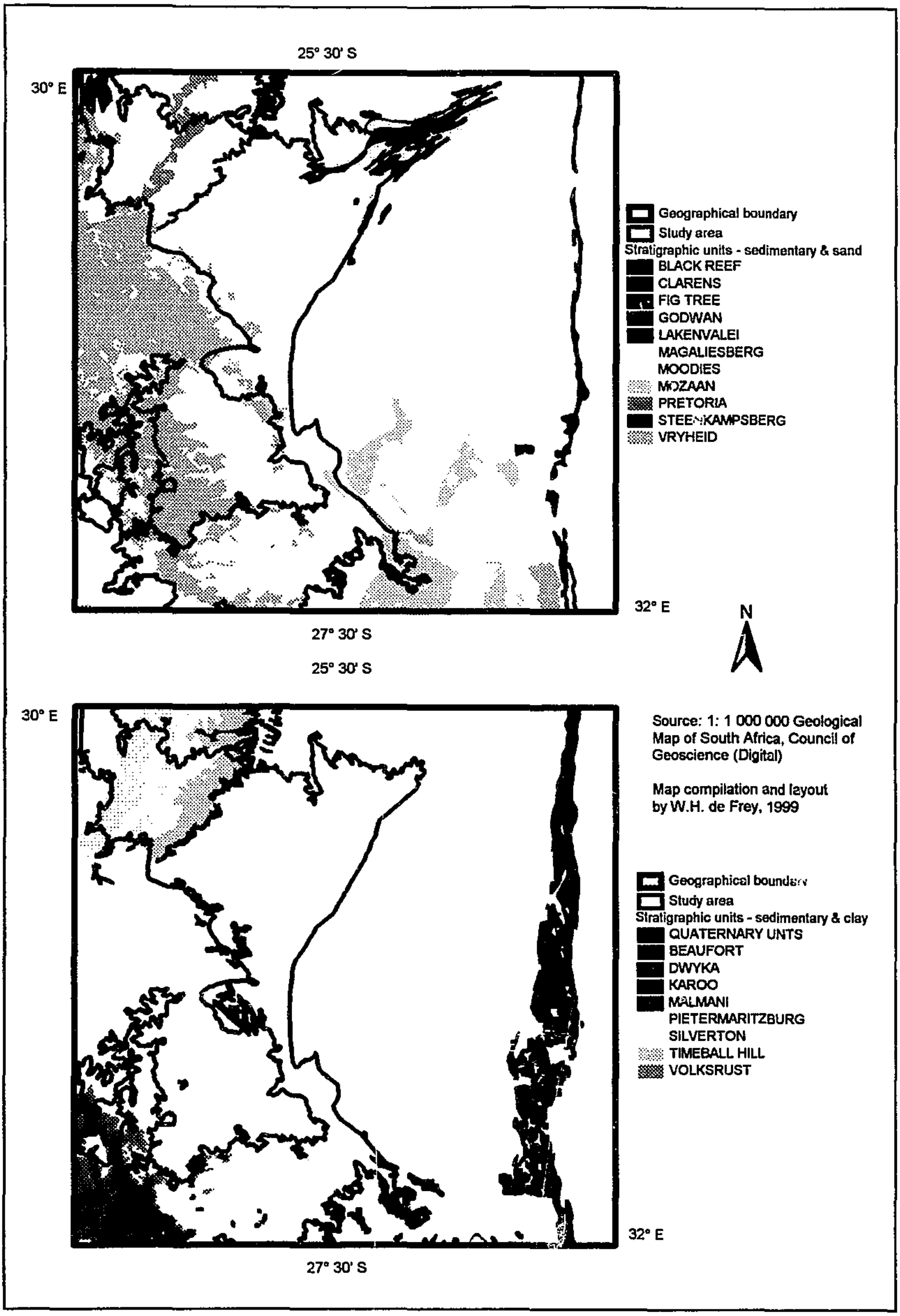


Figure 17.c: Sedimentary stratigraphic units which result in either predominantely sandy or clayey soil textures

migmatite of the Swazian basement complex, the rocks of the Barberton Sequence, clastic and chemical sediments and volcanic rocks of the Transvaal Sequence, intrusive igneous rocks of the Bushveld Complex, and sedimentary and volcanic rocks of the Karoo Sequence and Recent sediments.

The central area, between 26 and 27 degrees southern latitude and 30 and 32 degrees eastern longitude, is described by Walraven (1989b): rock types ranging in age from Swazian to the Recent are found. Included in these are the granite-gneiss and migmatite of the Swazian basement complex, the rocks of the Barberton and Pongola Sequence, the Usushwana Complex and the Amsterdam Formation, clastic and chemical sediments and volcanic rocks of the Transvaal Sequence, and sedimentary rocks of the Karoo Sequence and Quaternary sediments.

To the south of the above area, Linström (1987) describes the 1: 250 000 geological sheet area 2730 (Vryheid) as underlain by rocks varying in age from Swazian to Quaternary. The oldest rocks are the metavolcanic and metasedimentary xenoliths of varying size occurring in the Archaean granite and these rocks are thus older than 3 230 Ma. Rocks of the Pongola Sequence discordantly overlie Archaean granite. The Nsuze and Mozaan Groups, both of which crop out separately in four areas represent this sequence. The Nsuze Group comprises mainly volcanic rocks whilst the overlying Mozaan Group consists of rocks having a preponderantly sedimentary origin. The Pongola Sequence is intruded by various rocks, of which the Usushwana Complex (approximately 2 931 Ma in age) is the most important. This complex comprises basic as well as acid rocks. Post-Pongola granites of three ages are recognised (approximately 2 500 Ma in age).

Karoo Sequence rocks are well represented in the area, with all the formations from the Late Carboniferous - Early Permian Dwyka Formation to the Jurassic Jozini Formation being present. The rocks of the stratigraphically higher formations of the sequence crop out in separated easterly and westerly areas. Cretaceous-age rocks are not present in the area and the Masotcheni Formation and alluvium represent Quaternary rocks.

A large variety of minerals of possible economic importance occur in the area from north to south, especially gold and coal (Linström 1987, Walraven 1989a & 1989b). Walraven (1989a & b) describes the area in terms of structure and metamorphism as being divided into two regions: a western, structurally very simple region consisting of rocks of the Transvaal Sequence, and an eastern region underlain by rocks of the basement complex and the Barberton Sequence as a complex structure.

The rocks of the Transvaal Sequence have a regional westward dip of between seven and ten degrees. Local disturbances have resulted in increased dips in places. The emplacement of the Bushveld Complex gave rise to the formation of domal structures in the floor rocks. Local steeper dips of the contact between the Bushveld Complex and the Transvaal strata are probably due to isostatic equilibration. Metamorphic effects in the rocks of the Transvaal Sequence are due to the intrusion of the Bushveld Complex and the emplacement of basic sills of various ages.

Considerable structural deformation can be seen in the rocks of the Barberton Sequence. Large-scale upright folds and structural dislocation appear to dominate the mountain land. These structural and metamorphic attributes are associated with the exposed shield, recognised in the global geological environment (Chapter III, paragraph 2.1).

Linström (1987) describes the structural characteristic of the post-Pongola rocks in terms of folds and faults. They represent the covered shield of Karoo rock in the western region. It is relatively undisturbed, as indicated by the slopes of horizontal to seven degrees. It is quite often associated with local dolerite intrusions.

Most of the faults occur in the eastern region. They stretch from north to south, with the downfault (hanging wall) to the east. Transcurrent and tension faults also occur, the latter being associated with the Rooi Rante dolerite dyke swarm.

The Rooi Rante dolerite dyke swarm is an outcrop in the east in a sequence of ridges stretching from north to south, where it forms a prominent topographic and geological phenomenon.

Except for its role in global and local physiography, the geological environment is the source of soil texture. Different lithological units are the source of different soil textures. Soil texture is largely an inherited feature of a given soil and depends on the composition of the parent matter. Some kinds of parent matter furnish a large spread in particle sizes; others yield mostly sand or mostly clay (Strahler & Strahler 1987). Soils developed from granite are therefore usually higher in quartz grains (sand and silt size) than those developed from basalt (White 1987). Rock rich in coarse quartz granules (e.g. granodiorite, gneisses and quartzite) are a source of coarse textured soils, while red clay soils originate from basic rocks (Snyman 1989). Thus, the texture of the parent rock determines the texture of the soil (Table 14).

Igneous rock textures range from coarse grained intrusive rock (batholiths, dykes, sills, veins), to medium grained extrusive igneous rock (lava, obsidian) to fine grained volcanic ash (Strahler & Strahler 1987). Sedimentary texture classes for detrial rocks are a) coarse: psephites (pebbly) - gravel, conglomerate, breccia; b) medium: psammites (sandy) - sand, sandstone, greywacke, arkose and c) fine: pelites (clayey) - mud, clay, shale. In the case of metamorphic rock, texture or grain-size is influenced by many factors. In the finest-grained rocks such as slates, the individual minerals can hardly be distinguished even with the aid of a microscope; in the coarsest-grained the larger minerals may be many centimetres across (Read & Watson 1968).

Walraven (1989a & b) explained that Quaternary deposits in the area include residual soils, alluvial deposits and scree deposits. Outcrops in the area, especially on the granites and gneisses of the lowveld and also the rock of the Karoo Sequence are poor and many of these areas are covered by residual soils. On the granites and gneiss the residual soils are predominantly sandy and consist of quartz and feldspar. In other parts, silty and clayey soils are more abundant.

Alluvial deposits are found along most of the streams. The actual deposits vary according to the geology of the region. Prominent scree deposits and very thick alluvial fans adjoin the Drakensberg escarpment. The material in these deposits varies from very coarse and conglomeratic to fine grained and clayey (Walraven 1989a & b).

3.2. Climatic environment - microclimate

3.2.1. Introduction

In terms of microclimatology, the climate of the study area can be interpreted at a large and very large scale. The large scale is concerned with climate region as classified by local meteorologists using the empirical classification approach. The very large scale weather phenomena or local climatology[10] deals with the effect of topography on the three major climatic factors: heat, precipitation and moisture using applied classification techniques.

3.2.2. Empirical classification

Based on a map provided by the weather bureau of the climate regions of southern Africa, the study area is situated in the Highveld region. It was derived from Köppen's classification, with consideration of conventional geographical and other climate and agricultural boundaries. The region experiences a warm temperate climate with summer rainfall (Cwb), which is the same as the climate type classified on global scale (Chapter III, paragraph 2.2.2), using the Walter diagrams (Figure 8).

Average daily maximum temperature is roughly 27°C in January and 17°C in July but in extreme cases it may rise to 38°C and 26°C respectively. Average daily minima range from about 13°C in January to 0°C in July, whereas extremes can decrease to 1°C and –13°C respectively. The period during which frost is likely to occur, generally lasts on the average for about 120 days from May to September,

[10]Microclimatology covers a wide spectrum but can be separated into local, micro and boundary layer climates, although there are no clearcut divides.

though this period is longer in the southern highlands. Sunshine duration in summer is about 60% and in winter about 80% of the possible maxima.

On the whole winds are light except for short periods during thunderstorms. Occasional tornadoes do occur. Generally two types of wind occur in any region: **local winds** associated with special atmospheric conditions, sometimes combined with unusual topography; and winds of the **regular daily wind systems** (Buckle 1996). In South Africa, "Berg" (Mountain) winds are **local winds**, consisting of short spells of hot and dry turbulent winds. Originating from the interior plateau of southern Africa, they blow down the Great Escarpment, sometimes gusting at gale force, to reach the coast as a dry, scorching blast.

As part of the **regular daily wind systems**, valley and mountain winds occur in mountainous regions. Warm valley winds blow upslope during the day and cool mountain winds blow downslope overnight, thereby creating a pattern of daily reversal, although their speeds rarely exceed 3 m/s. Their direction, intensity and speed vary with slope, configuration and orientation of the valleys. Winds in east-west valleys are different from those in north-south valleys where slopes record marked contrasts in radiation heating and cooling. Mountain winds develop in many of the valleys that scar the eastern face of the Drakensberg Mountains. Lowest temperatures occur in the valley floor and, as the cool air moves down valley, so the inversion deepens. Maximum wind speeds are recorded about 150 m above the floor on a level with the adjacent ridgetops, while at the wind's upper limit a sharp temperature reversal creates considerable shearing. Towards dawn the mountain winds decay, while valley winds reach maximum depth soon after midday and are strongest in the mid-afternoon.

The average annual precipitation varies from about 900 mm on the eastern border of the study area to about 650 mm in the west. This is within the range of the subhumid annual precipitation level on global scale. The rainfall is almost exclusively due to showers and thunderstorms and falls mainly in summer, from October to March, the maximum fall occurring in January. The winter months are normally dry and about 85% of the annual rainfall falls in the summer months; heavy falls of 125 to 150 mm occasionally fall in a single day. Thunderstorms are often violent with severe lightning and strong (but short-lived) gusty southwesterly winds and are sometimes accompanied by hail. This region has the highest hail frequency in South Africa; about 4 to 7 occurrences (depending mainly on altitude) may be expected annually at any one spot. Snow occurs about eight times annually (mainly in midwinter) in Lesotho; the frequency decreases rapidly northwards across the study area.

This classification by a meteorologist of the weather bureau was further divided by the Land Type Survey Staff into a number of climate zones. Climate boundaries were based on climate measurements as well as natural vegetation, soils, crop performance, altitude and topography, because meteorological stations are widely scattered and in most cases record only a few climate parameters. Some climate zones cover no more than a terrain unit (e.g. a plateau, a flood plain), some a single crest-valley bottom sequence, while many cover a large number of crest to valley bottom sequences that repeat themselves three-dimensionally (e.g. a large undulating plain). Certain zones, for example some plateaux, display a greater uniformity of climate than others, for instance rolling hills or an escarpment.

The study area includes 64 climate zones (Figure 18), ranging from altitudes of 350 to 2040 m above sea level with most occurring at an altitude of 1700 m. Temperature measurements were incomplete for individual climate zones, but mean annual precipitation was available (Figure 19). Values ranged from 580 to 1505.5 mm, with a mean annual precipitation value of 850 mm. These values are also within the range of the subhumid level of mean annual precipitation in the macroclimate.

3.2.3. Applied classification

The soil-water balance classifications for Carolina and Piet Retief have changed due to higher actual evapotranspiration values. Louw and Kruger (1968) recommended that a ratio of 0.84 instead of 0.5 should be used for calculating actual evapotranspiration from American Class A pan data under South African conditions. This resulted in Carolina being classified within the subhumid subtype of the moist tropical climate type and Piet Retief within the desert subtype of the dry tropical climate type for local conditions (Figure 20).

A. Soil-water balance differences

On local scale, Piet Retief's soil-water balance climate classification has changed from a wet-dry tropical climate at global scale (Chapter III, paragraph 2.2.4) to a dry tropical climate, desert subtype, and that of Carolina from a dry tropical, desert subtype climate to a moist subtropical climate, subhumid subtype at local scale. Water shortage is less than 150 mm in the **moist subtropical climate, subhumid subtype**. Water surplus equals zero and potential evapotranspiration is greater and equal to 8 mm per month, for the subhumid subtype. Water shortage should be between 0 and 150 mm if water surplus equals zero or water shortage should be larger than water surplus if water surplus is greater than zero (Strahler & Strahler 1987). This is a moist climate type of the midlatitude group. Subtropical eastern continental margins are dominated by a maritime tropical air mass, flowing out from the moist western sides of the oceanic high-pressure cells. This air mass brings copious summer rainfall, much of it convectional. An occasional tropical storm brings heavy rainfall. Winter precipitation is also copious, produced in midlatitude cyclones. Invasions of continental polar air mass are frequent in winter, bringing spells of subfreezing weather. Summers are warm, with persistent high humidity. No winter month has a mean temperature lower than 0°C (Strahler & Strahler 1987). The climate type is characterised by a moderate to large water surplus, and a small seasonal soil-water shortage (Strahler & Strahler 1987). The Köppen classification equivalent of this climate type is temperate rainy (Cfa) with hot summers (Strahler & Strahler 1987).

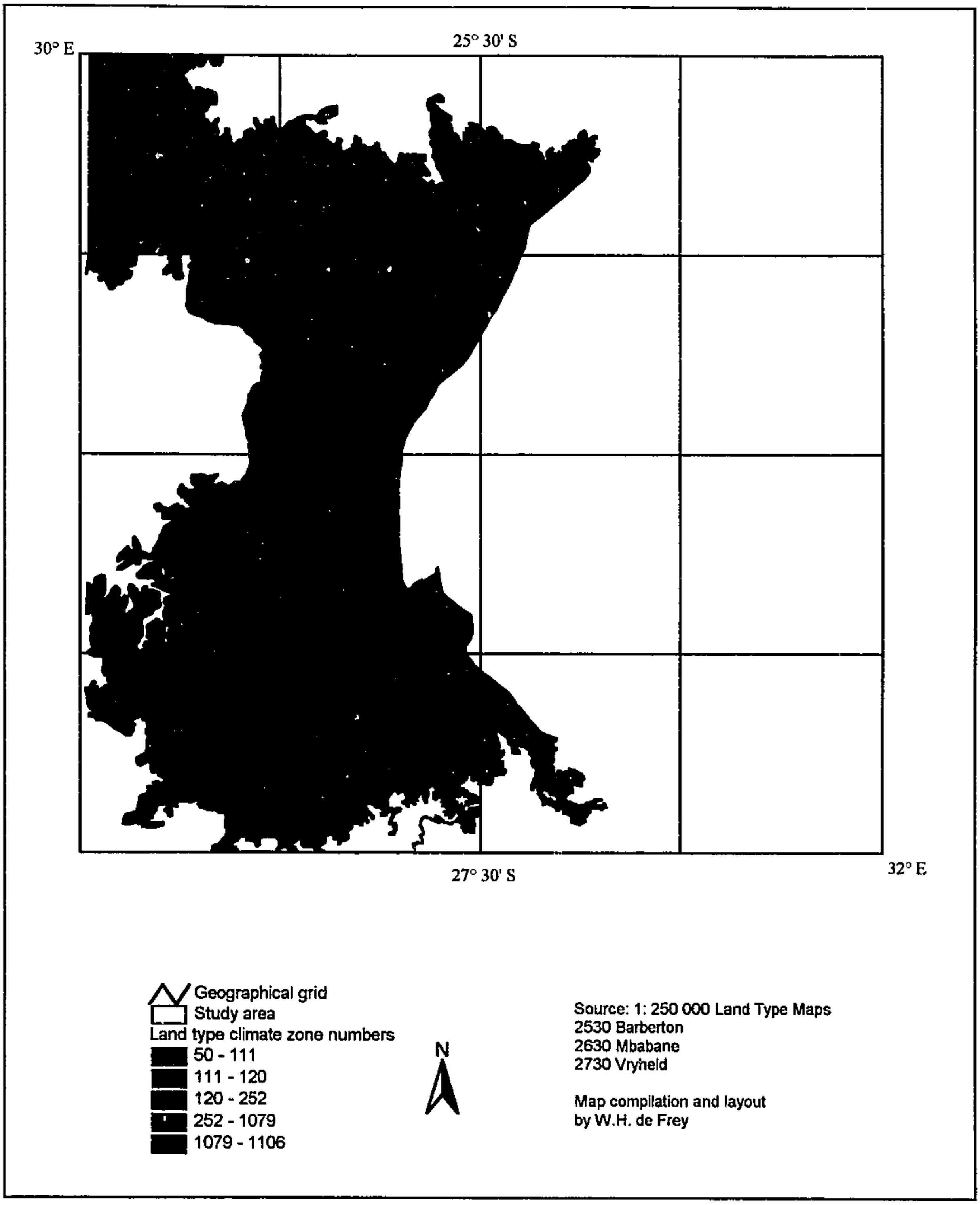


Figure 18: Land type climate zones within the study area, categorised in five classes to indicate distribution (Digitized from 1: 250 000 Land type maps Barberton, Mbabane, Vryheid by W.H. de Frey)

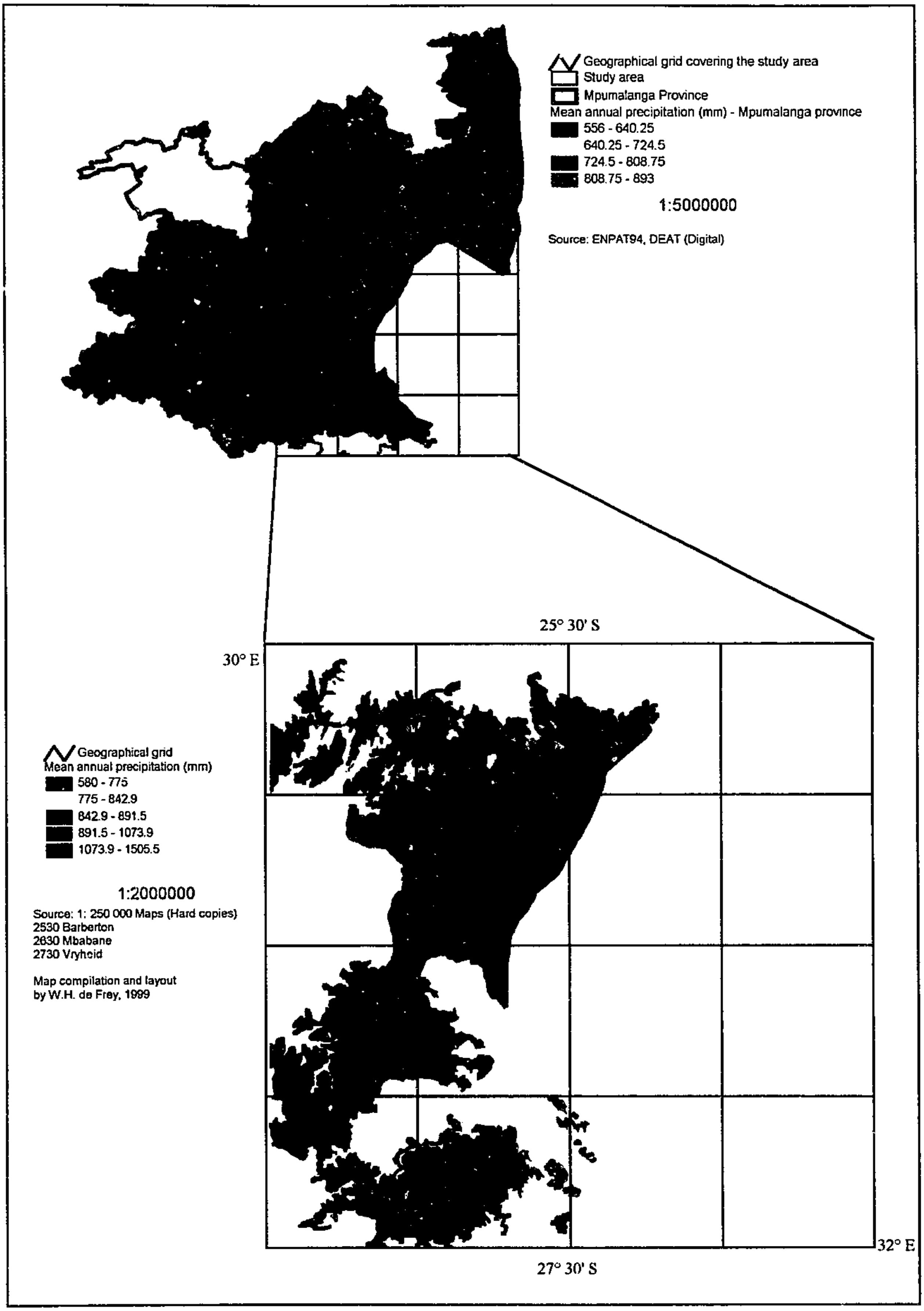


Figure 19: Mean annual precipitation (mm) of Mpumalanga Province and the study area based on ENPAT 94 and land type climate zones respectively

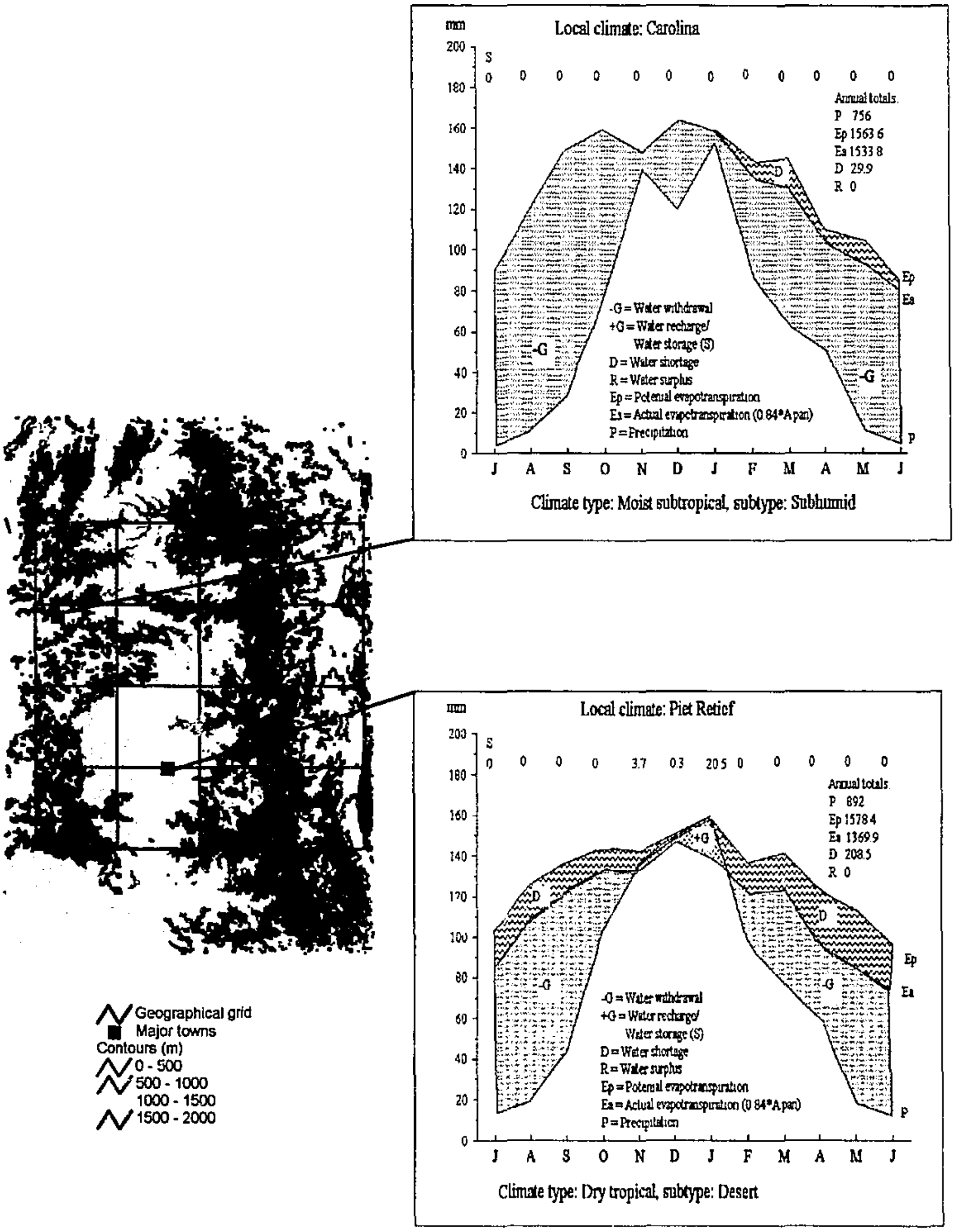


Figure 20: Soil water balance diagrams for two weather stations with complete climatic data sets, reflecting local conditions.

These soil-water balance differences and shifts in climate types at both global and local scale can be attributed to the influence of geomorphology on weather. **Differences in precipitation** are related to orographic precipitation within mountainous areas. Two conditions are associated with orographic precipitation, an approach effect of higher rainfall in front of a noticeable increase in altitude in the windward direction, and a rain shadow on the lee side of the mountain. This is related to the canyon effect of higher precipitation in valleys of mountainous areas at the same altitude as nearby plains, due to the stimulation of surrounding heights, distance from the oceans and landward movement of air masses, with inland areas becoming increasingl[illegible]y.

Differences in temperature are related to thermal belts of higher temperature due to temperature inversions, up to 300 m along the altitudinal range, because of heat lost from the earth's surface. Cold air drains down slopes to valley floors and frost pockets form behind obstructions in the path of this cold air movement. At the same altitude in sunny climates, the climate of wide mountain valleys are distinctly hotter and drier than the average local climate while the climate of narrow valleys are distinctly cooler and more moist than that of the average local climate. Temperature and precipitation decreases with an increase in latitude, while larger and higher mountain masses cause warmer temperatures at a given altitude (Daubenmire 1974).

On local scale, Piet Retief's soil-water balance climate classification within the desert subtype of the dry tropical climate has a larger soil water deficiency than on global scale and Carolina's subhumid subtype of the moist subtropical climate has a lower soil water deficiency than on global scale. Piet Retief is closer to the ocean than Carolina, resulting in a higher mean annual precipitation in spite of Carolina's higher altitude and closer vicinity to the mountains. On the other hand, mean monthly temperatures of Carolina are lower due to altitudinal difference which result in more effective evapotranspiration rates and smaller soil-water shortages. All these influences, and others, result in a mosaic of local climates within and across landforms in the region, creating conditions suitable for either trees or grasses, depending on sufficient soil water availability and temperatures.

B. Insolation attitude

Landform configuration, which includes slope gradient and aspect, influences the local climate in terms of intensity and duration of exposure to insolation (Barbour *et al.* 1980; Daubenmire 1974; Strahler & Strahler 1987). This in turn affects soil temperature and moisture content (Daubenmire 1974).

At any particular place on the earth, insolation received in one day will depend on two factors: (1) the angle at which the sun's rays strikes the earth and (2) the duration of exposure to the rays. These factors vary with changes in latitude and seasonal changes in the path of the sun in the sky. Intensity of insolation is greatest where the sun's rays strike vertically, as they do at noon at some parallel between the tropic of Cancer and the tropic of Capricorn. With diminishing angle, the same amount of solar energy spreads over a greater area of ground surface (Strahler & Strahler 1987). Thus radiation is most concentrated and effective on surfaces forming a right angle to the path of the rays. A slope of as little as 5° toward the pole reduces soil temperature to approximately the same extent as 185 km of latitude in the same direction (Daubenmire 1974).

Due to the inclination of the sun, a north-facing slope in southern temperate latitudes will always experience greater total insolation than will the south-facing slope of the same region. Thus there will be warmer air and soil, less moisture, and sparser vegetation (Barbour *et al.* 1980). Strahler & Strahler (1987) describe it as follows: slope aspect has a direct influence on plants by increasing or decreasing the exposure to sunlight and prevailing winds. Slopes facing the sun have a warmer, drier environment than slopes facing away from the sun and therefore lying in shade for much longer periods of the day. At the season when the sun's path is highest in the sky, the length of time it is above the horizon is correspondingly greater (Strahler & Strahler 1987).

At the equinox, the sun rises at a point due east on the horizon and sets at a point due west on the horizon. This fact holds true at all latitudes except at the two poles. Consequently, day and night are of exactly equal length, 12 hours each, at all latitudes. During winter solstices, at all latitudes between the arctic and antarctic circles, the sun rises on the northeastern horizon and sets on the northwestern horizon. It likewise rises on the southeastern horizon and sets on the southwestern horizon for the summer of that specific hemisphere.

Thus, at corresponding latitudes north and south of the equator, the relative lengths of day and night are in exact opposite relation (Strahler & Strahler 1987). At dawn, at sunset, and in winter, light intensity is weak because the waves are travelling a long distance through the atmosphere. Most of the light (especially the shorter wavelengths), is absorbed (Daubenmire 1974). Temperature rises sharply in the morning hours and continues to rise long after the noon peak of net radiation. Mixing of the lower air by eddies distributes sensible heat upward, offsetting the temperature rise and setting back the temperature peak to about 3 p.m. (The time of daily maximum varies usually between 2 and 4 p.m. according to local climatic conditions) (Strahler & Strahler 1987). On steep poleward slopes direct sunlight may be completely lacking at noon so that plants must rely heavily on skylight (Daubenmire 1974).

Directly or indirectly as a result of this slope-insolation relationship, plants adapted to warm dry lowlands extend highest up the mountains on those slopes and ridges so oriented that they receive the maximum insolation. Plants adapted to a cool moist environment of high altitude reach their lowest limits in protected ravines and on poleward slopes. Plants characteristic of intermediate elevations in mountains characteristically occupy exactly reversed habitats along their upper and lower altitudinal limits (Daubenmire 1974). Slope steepness acts indirectly by influencing the rate at which precipitation is drained from the surface. More rapid erosion on steep slopes may result in thin soil whereas that on gentle slopes is thicker (Strahler & Strahler 1987). Thin soils receiving perpendicular insolation will experience higher soil water deficiencies than thicker soils in flat areas.

In regard to these topographic influences, hundred metre contours were used to create a digital terrain model. The distribution of these insolation attitudes within the study area was modelled using the digital terrain model (Chapter II, paragraph 2.2.2.B). A possible 28 insolation attitudes could exist based on the slope angle for perpendicular insolation, aspect of maximum exposure and seasonal variation within the region. Due to the configuration of the landforms within the study area, only 15 insolation attitudes were realised (Table 15 & Figure 4).

From the table it is possible to conclude that northeast to north to northwest facing slopes in the southern hemisphere experience exposure throughout the year. South facing slopes seldom experience exposure and never perpendicular insolation, east to west facing slopes experience exposure during summer and the equinox (spring & autumn) while southeast to southwest facing slopes only experience exposure during the summer. In terms of insolation the northeast to north to northwest facing slopes should experience the most insolation, the east to west facing slopes the second most, the southeast to southwest facing slopes the third most and the south facing slopes the least.

Areas of no aspect should experience more insolation than south facing slopes, but less than areas with slopes more than 2° in the different aspect categories because they never experience perpendicular insolation. Slopes with angles between 2 and 25° experience perpendicular insolation, but mainly during summer, while slopes of 25 to 49° experience perpendicular insolation in all seasons except winter. Slopes of more than 49° experience perpendicular insolation right through the year, but mainly during dawn and early morning or late afternoon and dusk, when insolation is less intense. The areas with slopes between 2 and 25° degrees experience perpendicular insolation when the sun is in its highest position and the days are longest and insolation most intense. Those with slopes between 25 and 49° experience perpendicular insolation during summer mornings and afternoons and over midday at equinox, when insolation intensity is moderate. Slopes, which receive insolation in the afternoon, experience higher air temperatures than those of the morning due to the accumulation of heat during the day.

Slope angles also influence depth of soil, which in turn influences water availability. Slopes of more than 49° have very shallow soils and much bare rock, with no moisture or would reach permanent wilting point very easily because of low infiltration and high runoff rates. Slopes between 25 and 49° have shallow to very shallow soil, with moisture content varying between permanent wilting point and field capacity depending on the amount of precipitation and the time of year. At slope angles of 2 to 25° soils are shallow to deep, with infiltration increasing and runoff decreasing, and here soil moisture could range from field capacity to oversaturation. On deep to very deep soils at slope angles of 0 to 2°, soil moisture could range between oversaturation to standing surface water due to high infiltration, very

Table 15: Modelled insolation attitudes and their environmental attributes.

Insolation attitude	Topography		Seasonal variation		Soil attributes	
	Slope (°)	Aspect (Azimuths)	Exposure	Perpendicular insolation	Depth	Moisture
Flat, no aspect (8)	0-2		All seasons	No	Deep to very deep	Oversaturated to surface water
Flat, south facing (16)	0-2	135-225	No	No	Deep to very deep	Oversaturated to surface water
Gentle, south facing (18)	2-25	135-225	No	No	Shallow to deep	Field capacity to oversaturated
Flat, south east facing (24)	0-2	90-135	Summer mornings	No	Deep to very deep	Oversaturated to surface water
Gentle, south east facing (27)	2-25	90-135	Summer mornings	Yes, summer solictice	Shallow to deep	Field capacity to oversaturated
Steep, south east facing (30)	25-49	90-135	Summer mornings	Yes, summer solictice	Very shallow to deep	Permanent wilting point to field capacity
Flat, south west facing (32)	0-2	225-270	Summer afternoons	No	Deep to very deep	Oversaturated to surface water
Gentle, south west facing (36)	2-25	225-270	Summer afternoon	Yes, summer solictice	Shallow to deep	Field capacity to oversaturated
Flat, east facing (40)	0-2	45-90	Equinox mornings	No	Deep to very deep	Oversaturated to surface water
Gentle, east facing (45)	2-25	45-90	Equinox mornings	Yes, summer solictice	Shallow to deep	Field capacity to oversaturated
Flat, west facing (48)	0-2	270-315	Equinox afternoons	No	Deep to very deep	Oversaturated to surface water
Gentle, west facing (54)	2-25	270-315	Equinox afternoon	Yes, summer solictice	Shallow to deep	Field capacity to oversaturated
Flat, north facing (56)	0-2	315-360, 0-45	All seasons midday	No	Deep to very deep	Oversaturated to surface water
Gentle, north facing (63)	2-25	315-360, 0-45	All seasons midday	Yes, summer solictice	Shallow to deep	Field capacity to oversaturated
Steep, north facing (70)	25-49	315-360, 0-45	All seasons midday	Yes, summer solictice & equinox	Very shallow to shallow	Permanent wilting point to field capacity

little runoff and high water tables. Normally in a single dry season only the upper 300 mm of soil is dried by evaporation, but depth increases during prolonged droughts (Strahler & Strahler 1987).

It would therefore be expected that areas of 49° and steeper would be sparsely vegetated or not vegetated at all irrespective of aspect, while slopes ranging from 25 to 49° would be vegetated to an intermediate extent. Those of 2 to 25° would be well vegetated and below 2° also well vegetated, depending on the amount of surface water present. Vegetation of steep north facing slopes could be expected to be adapted to warm and dry conditions and those of gentle south facing slopes or flat areas to cool, moist or surface water conditions.

3.2.4. Summary

On local scale the study area is situated within the Highveld region or warm temperate climate with summer rainfall (Cwb). Due to the range in mean annual precipitation through the region, it qualifies for inclusion within the subhumid level of mean annual precipitation classification. This level is higher than for most of the country and excludes it from the arid region (Bothma 1989; Cowan 1995). It has been divided into a number of climate zones by the Land Type Survey Staff, of which 64 are included in the study area. Average daily maximum temperatures range from 27°C in January to 17°C in July, while average daily minima extremes can be as low as 1°C and –13°C respectively. Mean annual precipitation values of individual climate zones ranged from 580 to 1505.5 mm, with most having a value of 850 mm.

The mean annual precipitation (precipitation occurs during summer) on the Highveld plateau varies from 720 mm in the west to 900 mm on the eastern outliers. The middleveld valleys receive between 630 mm (Badfontein) and 890 mm (Badplaas). In the Great Escarpment, the rainfall varies from over 1 500 mm at Sabie and Kaapsehoop to roughly 570 mm at Kaapmuiden. Large variations due to locality are frequent and can be attributed to differences in orientation with respect to moisture-laden airmasses, rain shadows, altitude and aspect. The Lowveld receives between 600 and 700 mm of rainfall annually.

Due to topographical influences associated with landforms, large scale climate varies from dry tropical, desert subtype to moist subtropical, subhumid subtype or Köppen equivalents; steppe (BSh) and temperate rainy with hot summer (Cfa) respectively. On very large scale, landform configurations such as slope and aspect resulted in a number of insolation attitudes, each with its own characteristic slope of perpendicular insolation and insolation exposure ranges as well as associated soil depth and moisture attributes. In the study area the 15 insolation attitudes form a mosaic, representing cool-moist to hot-dry areas with plants adapted to these conditions.

3.3. Geomorphological environment

From the global geological environment, it is known that the area consists of mountains, hills and plains. Walraven (1989a & b) states: "a general relationship exists between the underlying geology and the topographic expression". He, together with Linström (1987), described the geomorphology of the area in which the study area occurs in relation to the underlying geology.

To the north between 25 and 26 degrees southern latitude, Swazian granite-gneiss and younger granite plutons underlie the Lowveld at an average altitude of 600 m. In contrast, the Transvaal Sequence in the western region forms the Highveld at an average altitude of between 1 300 and 2 000 m. A prominent and steep Drakensberg scarp separates these two physiographic regions The exposed and deeply incised Barberton Sequence formed a mountainous area. Important rivers that flow from west to east down the escarpment, are the Krokodil, Olifants, Sabie en Komati Rivers.

In the centre between 26 and 27 degrees southern latitude, the Karoo rocks in the extreme western part form a moderately flat topography at an elevation of 2 000 m and higher. A more rugged topography has developed on the Pongola Sequence, Usushwana Complex and the gneiss and granitoid rocks to the east as well as the Barberton Mountain Land (Walraven 1989a & b).

Towards the southern boundary, Linström (1987) states that the western area physiography is quite different from that of the east. The western area is accessible, grass covered, plateau type landscape with inselbergs at an altitude above 1 000 m. Rocks of the Pongola Sequence, with deeply incised valleys underlie the central area, which is relatively inaccessible. The relatively accessible eastern region is below 1 000 m with grassland destroyed by bush encroachment.

A. Terrain groups

The Interior Plateau, Great Escarpment and Coastal Borderland major physiographic regions, regions and subregions of southern Africa (Visser 1989) were further classified on a larger scale by Kruger (1983) into ***terrain groups*** and terrain types based on landforms and their surface configuration (Figure 21). The following ***terrain groups*** occur in the study area:

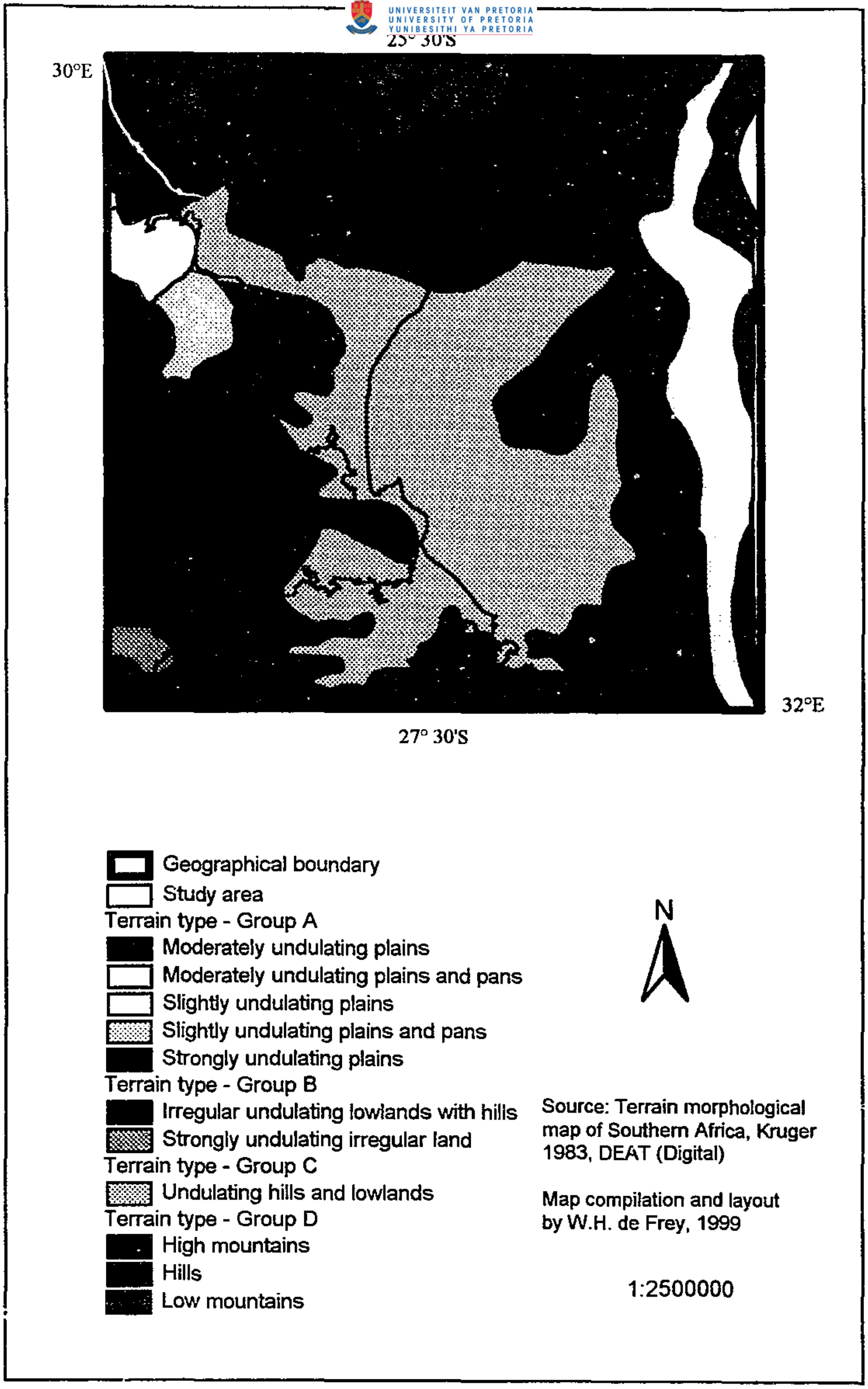


Figure 21: Terrain types found within and along the boundaries of the study area

A. Plains with low to moderate relief are associated with surface configurations of which 80% or more of the area have slopes of less than 5° (8%).

B. Lowlands, hills and mountains with moderate and high relief are associated with areas in which 50-80% is level land and 20-50% sloped land, with more than 50% of the level land in the lower elevation.

C. Open hills, lowlands and mountains with moderate to high relief have a surface configuration in which 20-50% of the area is associated with level land and 50-80% is sloped.

D. Closed hills and mountains with moderate and high relief are associated with areas in which more than 80% of the land has slopes of more than 5° (8%) (Snyman 1989).

Each of these ***terrain groups*** is divided into terrain types according to the slope and relief of the relevant landforms (Table 16), these terrain types representing different stages of landmass rejuvenation on a global scale. The stages do not occur in a chronological sequence from west to east (Figure 22) but in a mosaic at different altitudes due to alternating coastal transgression and regressions during the Cainozoic Erathem.

On a larger scale, the **nature of the terrain type** within each land type is described in terms of percentage level land and local relief. Four level land classes are defined by the Land Type Survey Staff (1985; 1986; 1989): in level land class A, more than 80% of the area has slopes of less than 8%. In level land class B, 50-80% of the area has slopes of less than 8%, in level land class C, 20-50% of the area has slopes of less than 8% and in level land class D, less than 20% of the area has slopes of less than 8%. Six relief classes were also defined, class one ranging from 0 - 30 m, class two from 30 - 90 m, class three from 90 - 150 m, class four from 150 - 300 m, class five from 300 - 900 m and class six from 900 m upwards. Together they represent the nature of terrain type symbol (e.g. A1, B2, C3 and D4), provided on the land type inventory of each land type (Land Type Survey Staff 1985; 1986; 1989). Table 17 shows the relationship between ***terrain groups*** and the **nature of the terrain types**.

B. Terrain morphological unit

Terrain morphological units or terrain units are any part of the land surface with homogenous form and slope: the highest point of relief is known as the crest, followed on its way to the lowest point, by the scarp, midslope, footslope and valley bottom. Midslopes always follow crests or scarps, while scarps are associated with slopes steeper than 70° or 100% (45°) (Land Type Survey Staff 1985; 1986; 1989). In upper course areas or mountains, scarps are more frequent and footslopes less frequent, while in the lower course areas or plains, footslopes are more frequent than scarps.

Table 16: Terrain groups and terrain type of the Highveld physiographic region.

Terrain group	Terrain type	Slope shape	Relief (m)	Drainage density	Streams/km²	Landmass rejuvenation stage
A.1. Plains with low relief	Slightly undulating plains	Concave/ convex	0-130	Low – medium	0-6	Stage A
	Slightly undulating plains and pans					
A.2. Plains with moderate relief	Moderately undulating plains	Concave/ convex	30-120	Low - medium	0-6	Stage E
	Moderately undulating plains and pans					
	Strongly undulating plains					
B. Lowlands, hills and mountains with moderate and nigh relief	rregular undulating lowlands with hills	Concave/ convex	30-450	Low - medium	0-6	Stage D
	Strongly undulating irregular land		450+			
C. Open hills, lowlands and mountains with moderate to high relief	Undulating hills and lowlands	Concave/ convex	130-450	Medium	0-6	
D. Closed hills and mountains with moderate and high relief	Hills	Concave/ straight	130-450	Medium	1.5-10.5	
	Low mountains	Convex/ concave/ straight	450-900			Stage B
	High mountains		900+			Stage C

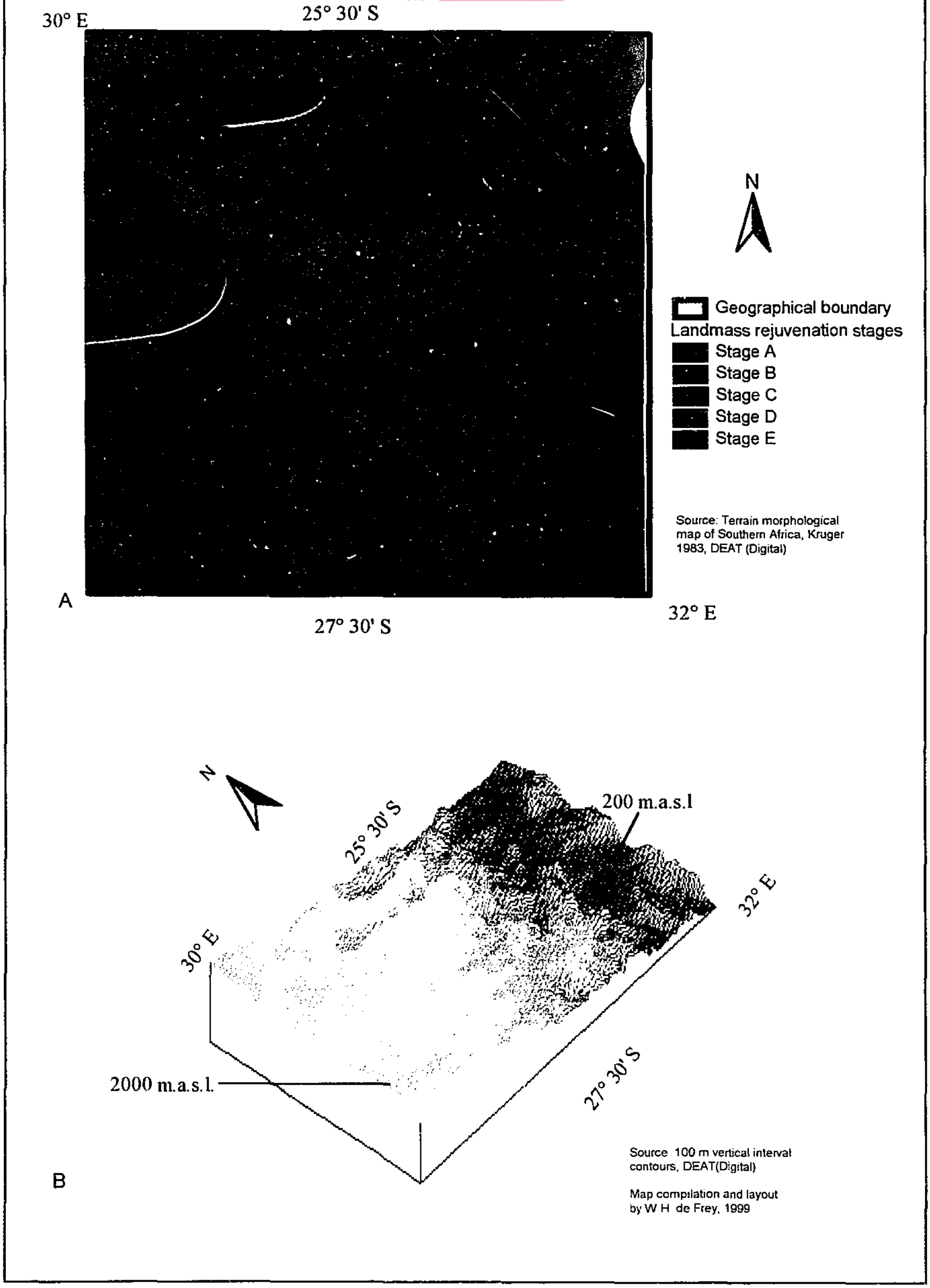


Figure 22: The mosaic distribution of the landmass rejuvenation stages (A) at different altitudes (B). (Letters refer to Table 16 & Figure 13)

Table 17: Terrain groups and their equivalent pe symbols.

Terrain group	Relief (m)	**Nature of terrain type** symbol
A. Plains with low to moderate relief are associated with surface configurations of which 80% or more of the area has slopes of less than 5° (8%)	0 - 130	A1 - 3
B. Lowlands, hills and mountains with moderate and high relief are associated with areas in which 50-80% is level land and 20-50% sloped land, with more than 50% of the level land in the lower elevation	30 - 450+	B2 - 4
C. Open hills, lowlands and mountains with moderate to high relief has surface configuration in which 20-50% of the area is associated with level land and 50-80% is sloped	130 - 450+	C2 - 4
D. Closed hills and mountains with moderate and high relief are associated with areas in which more than 80% of the land as slopes of more than 5° (8%).	450 - 900+	D4 - 6

Based on the modal interval of percentage [illegible]e different terrain morphological units within the individual land types involved in the survey, the following percentage slope ranges represent the different terrain morphological units:

Footslopes and valley bottoms	[0; 12%) (7°)
Crest and midslopes	[12; 100%) (45°)
Scarps	[100% +)

These three categories were used to classify a slope image created from the surface model.

It would therefore seem as if the ability to differentiate between these terrain morphological units would closely relate to an increase in relief. It would thus be easier to differentiate between these terrain morphological units in mountainous areas than on plains.

Associated with an increase in relief, from plains to mountains, is an increase in drainage line density. Terrain morphological units separate drainage lines. Drainage lines consist of an upper course and lower course (Buckle 1978). Upper course areas or streams are narrow and V-shaped while lower course areas or rivers are usually broad and flat-floored, while the gradient of the valley is gentle. This trend could be upset or reset by rejuvenation of either the landmass or the river due to upwarping or lowering sealevel, in which case steep valleys may occur within lower course areas. The average speed of water in a river tends to increase from source to mouth. Most African rivers are dry for much of the year and in flood when the rains come (Buckle 1978). Different drainage patterns are associated with differences in slope, rock hardness and rock structure: dendritic patterns with slopes, trellis patterns with structure and hardness, radial pattern with slope of cone-shaped upland, rectangular pattern with joints and faults and annular patterns with slope of basins (Buckle 1978; Strahler & Strahler 1987). From the 1: 250 000 Topo-cadastral maps 2530 Barberton, 2630 Mbabane and 2730 Vryheid, the dominant drainage pattern appears to be the dendritic pattern. It is shaped like the trunk and branches of a tree, the tributaries converging on the main stream from many directions and usually joining at acute angles. This is the most common type and is not related to structure or differences in rock hardness, but tends to form on massive crystalline rocks, like granite, or horizontal to gently dipping sedimentary strata (Buckle 1978).

3.4. Pedological environment

In support of the theories, concepts and trends mentioned in the global perspective (Chapter III, paragraph 2), the Land Type Survey Staff (1985, 1986 and 1989) describe the soils occurring in the area associated with the study area from north to south in relation to the geology, geomorphology and climate.

In the north between 25 and 26 degrees southern latitude and 30 to 32 degrees eastern longitude (Land Type Survey Staff 1989), the area topographically comprises four broad zones. These are 1) the eastern Highveld Plateau with its outliers, 2) the middleveld valleys of Lydenburg, Badfontein, Badplaas and Barberton, 3) the Great Escarpment and 4) the Lowveld.

The Highveld Plateau, at altitudes of 1 600 to 2 000 m above sea level, is composed of strongly undulating plains underlain by sandstone, shale, quartzite and diabase (Ecca and Pretoria Groups). Shallow to deep, yellow-brown and red dystrophic, sandy loam to sandy clay soils are predominant. Prominent outliers of the plateau, with similar topography and soil, occur as erosional remnants between the incised headwaters of the Komati, Elands and Crocodile Rivers.

The prominent, strongly undulating valleys of Lydenburg, Badfontein, Badplaas and Barberton are incised into relatively soft geological materials (shale, gneiss and granite) partly surrounded by hills containing quartzite. On shale (Lydenburg and Badfontein), mesotrophic or dystrophic, red and yellow-brown sandy clay loam or sandy clay soils are dominant. On gneiss and granite (Badplaas and Barberton), relatively shallow grey and red mesotrophic to eutrophic sandy clay loam soils dominate.

The Great Escarpment (comprising the area between Long Tom Pass and Hazyview and between Machadodorp and Kaapmuiden) is a more or less mountainous zone, 50 to 100 km wide. The landscape consists of series of step-like terraces, hill slopes and incised river valleys at altitudes of 400 to 2 000 m above sea level. Deep weathering associated with dystrophic red sandy clay or clay soils is widespread. At altitudes greater than 1 300 m, yellow-brown apedal sandy clay to clays soils are frequent. Lithosols are dominant north west of the Swaziland border where slopes are very steep and outcrops of hard rock (quartzite, chert) are frequent.

East of the Great Escarpment, the undulating to flat Lowveld plain stretches to the Mozambique border at altitudes of 150 m (Komatipoort) to roughly 600 m (Hazyview). The Lowveld is mostly underlain by Archaean gneiss, where stony grey sandy loam soils predominate.

In the central area between 26 and 27 degrees southern latitude (Land Type Survey Staff 1985), the topography is characterised by plains with low to moderate relief, broken by hills in the west and mountainous land in the northeast. The range in altitude is 700 - 1900 m.

The geology of the greater part is Ecca shale and sandstone, with dolerite intrusions. Migmatite, gneiss and other metamorphic rocks of the Archaean and Usushwana Complexes and Pongola and Barberton Sequences occur in the east. In the west, dolomite, shale, quartzite and diabase of the Transvaal Sequence occupy significant areas.

Highly weathered, dystrophic, red and yellow non-plinthic soils occur on high-lying, moist sites in the east. Black clays, with dolerite as a major component of the parent material, and duplex soils derived from shale and sandstone, dominate the area [illegible] between Devon in the west and Ermelo in the east. The remainder of the area is characterised by a Hutton-Avalon-Longlands catena, in which Glencoe and Wasbank forms may occur. East of 30° longitude these catenary soils are dystrophic, while to the west they are either dystrophic or mesotrophic.

Southward, between 27 and 28 degrees southern latitude (Land Type Survey Staff 1986), the topography is described as similar to many parts of Africa; this area underwent marked planation during the Tertiary. In the Pliocene, some 5-7 million years B.P., a major uplift of the eastern continental margin occurred inland of a hinge-line near the coastline. Eastward towards the sea the sloping, mature, Tertiary landscape suffered erosion and incision by eastward flowing rivers. The rejuvenation gave rise to the complex pattern of the natural resources which we see in this area today. It comprises landscape which descends from the South African Highveld at 1 700 m in the northwest via a series of steps (which form part of the Great Escarpment), plains and steep-sided valleys to the Lowveld at 175 m in the east. Highly weathered soils are found on the old residual highlands, spurs and outliers (as low as 870 m in the east) of Tertiary planation. Soils of intermediate to young age are found at progressively lower altitudes.

At 1700 - 1850 metres above sea level (m.a.s.l.) with mountains rising to 2226 m.a.s.l., the Highveld plain, which occupies the northwest corner of the area, consists of Beaufort Group sandstones and shales with dolerite. Duplex soils, plinthic soils, and porous dystrophic and mesotrophic yellow soils predominate.

The ferralitic highlands comprise the eastward-jutting spurs of the Highveld and their associated foothills and valley basins. The area is underlain by sandstones and mudstones of the Adelaide Formation of the Beaufort Group, and shales and sandstones of the Volksrust and Vryheid Formations of the Ecca Group, with dolerite intrusions, and Swazian granites. Apart from outcrops of rock and shallow soils, porous, dystrophic red and yellow soils of Hutton, Griffin and Clovely forms predominate.

Alcockspruit-Hlobane and Dirkiesdorp-Piet Retief are the two major occurrences of plinthic plains (1200-1400 m) which are underlain by sandstones and shales of the Vryheid Formation, with dolerite intrusions. Plinthic soils (with a small but significant proportion of hard plinthite) and duplex soils predominate. Red and black clays are found on dolerite.

This wide spectrum of soils and terrain types was classified into pedosystems, and the pedosystems and climate zones combined to form land types. The land types were grouped together into soil patterns to improve readability of the maps and to give an indication of the soils of the area (Land Type Survey Staff 1985, 1986, 1989). Nine soil patterns with or without further division exist; four of the broad division or eight of the finer division were included in the study.

The eight soil patterns are Ab, Ac, Ad, Ae, Ea, Fa, Fb and Ib (Figure 23). The Aa to Ae soil patterns are included under the heading: red-yellow apedal, freely drained soils. These soil patterns refer to yellow and red soils without water tables, which belong to one or more of the following soil forms: Inanda, Kranskop, Magwa, Hutton, Griffin, Clovelly. It includes land which does not qualify as a plinthic catena and in which one or more of the above soil forms occupy at least 40% of the area. The first three soil forms are associated with the Aa soil pattern and has humic A horizons.

The Aa soil pattern does not occur in the study area.

Ab soil pattern: dystrophic and/or mesotrophic Huttons (orthic A, red apedal B horizons) are dominant.

Ac soil pattern: dystrophic and/or mesotrophic Huttons and Clovelly (orthic A, yellow-brown apedal B horizons) are dominant.

Ad soil pattern: dystrophic and/or mesotrophic Clovelly is dominant.

Ae soil pattern: eutrophic Huttons of more than 300 mm deep in an area without dunes are dominant.

The Ea soil pattern has no subdivisions and is defined under the heading: one or more of vertic, melanic, red structured diagnostic horizons. This unit indicates land with a high base status (eutrophic), dark coloured and/or red soils, usually clayey, associated with basic parent materials. A soil pattern of which more than half is covered by soil forms with vertic or melanic A horizon or red structured B horizons, qualifies for inclusion in this unit, provided it does not qualify for inclusion in units A, B or C. Soil patterns in which these soils cover less than half of the area may also qualify for inclusion, if 1) duplex soils occur in the non-rock land but unit Ea soils cover a larger area than the duplex soils, or 2) if exposed rock covers more than half the land type.

Glenrosa and/or Mispah forms (other soils may occur) are the headings for the soils occurring in soil patterns Fa and Fb. These soil patterns accommodate pedologically young landscapes that are not predominantly rock and not predominantly alluvial or aeolian and in which the dominant soil forming processes have been rock weathering, the formation of orthic topsoil horizons and commonly clay illuviation, giving rise typically to lithocutanic horizons. The soil forms which epitomise these processes are Glenrosa (orthic A horizon, lithocutanic B horizon) and Mispah (orthic A horizon, hard rock diagnostic horizon). Exposed rock and other soil forms are included in this soil pattern, as long as they do not qualify for inclusion in the other soil patterns. Shallow and deep soils of the Oakleaf form (orthic A horizon, neocutanic B horizon, non-specified) (usually on upland sites) developed by rock weathering (e.g. gneiss, aeolianite etc.) are accommodated here.

Fa soil pattern: has no regular lime in any of the horizons within the landscape.

Fb soil pattern: lime occurs within the horizons in the lower lying areas of the landscape, e.g. valley bottoms.

The lime indicates to what extent the soils have been leached.

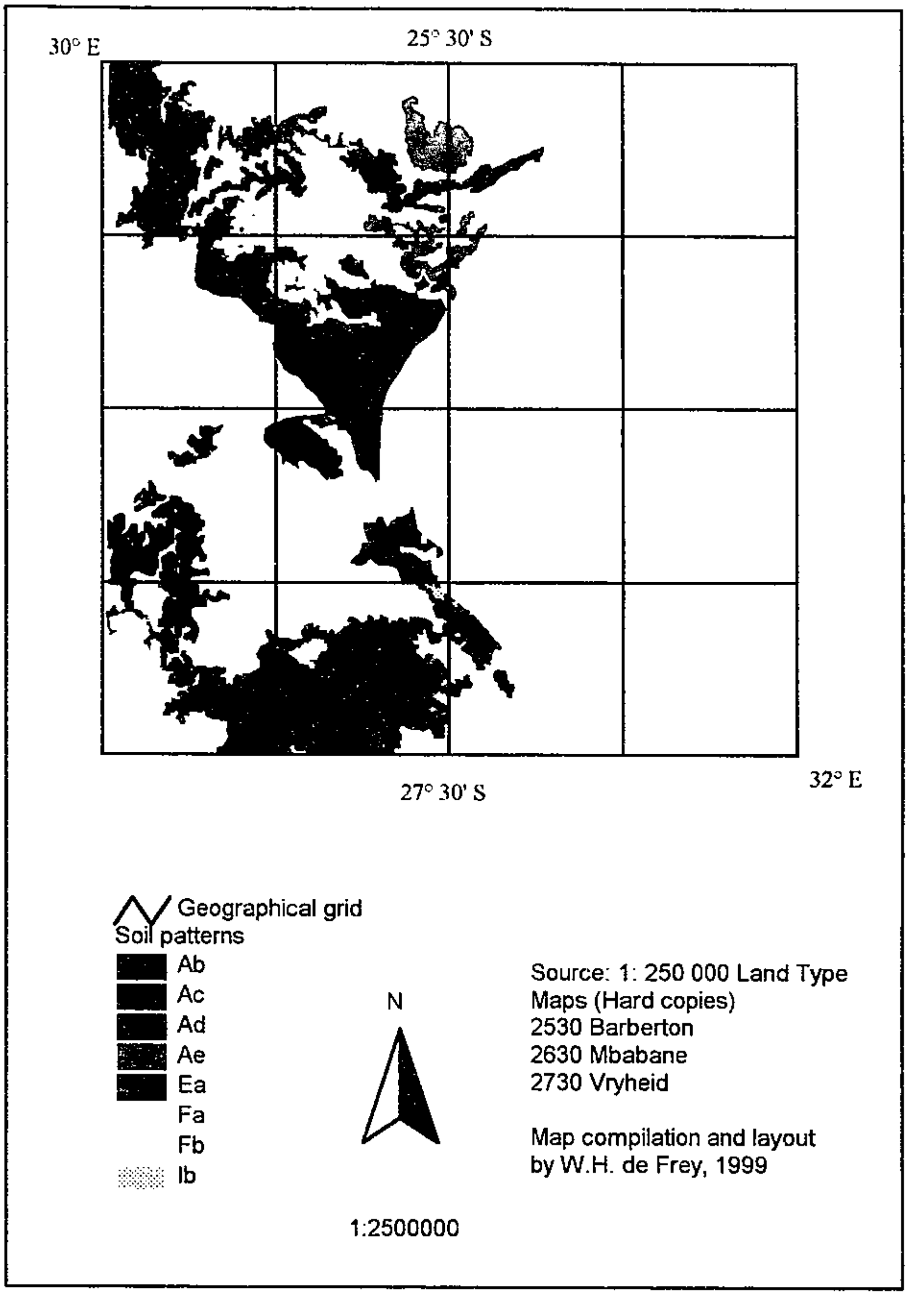


Figure 23: The eight soil patterns used during the vegetation survey

Ib is one of the soil patterns in the major soil pattern associated with miscellaneous land classes. Landscapes which qualify for inclusion in this soil pattern have exposed rock (exposed country rock, stones or boulders) covering 60 - 80% of the area.

These soil patterns and their dominant soil forms or associated diagnostic horizons give an indication of certain environmental variables (White 1987; Soil Classification Workgroup 1991).

Vertic A horizon: has high base status associated with a high pH due to little leaching, a high clay content and the ability to swell and shrink. They occur generally on basic igneous rock or soil material with very strong structure.

Melanic A horizon: dark coloured topsoil, high base status and well developed structure. They develop in semi-arid to subhumid climate or even humid climates in geomorphological young landscapes where limited weathering has taken place. Parent material is either basic or intermediate igneous rock or sedimentary rock in landscape positions from where it could receive bases via lateral drainage of water.

Orthic A horizon: is topsoil, which does not qualify for inclusion in any of the other topsoil diagnostic horizons. Normally there is a natural genetic relationship between topsoil and subsoils, for example the organic carbon content of a orthic A horizon in a dystrophic Hutton would be higher than that of a eutrophic one.

Red apedal B horizon: a reddish, structureless and non-calcareous horizon (Van der Watt & Van Rooyen 1990). It is associated with weathering taking place under well drained, oxidised conditions. It occurs widely under all climatic conditions in South Africa. Where it has developed on basic parent material (e.g. dolerite, basalt, norite, gabbro, diabase), it indicates an advanced stage of weathering and leaching. Red apedal B horizons develop relatively easily under the influence of a wide variety of climatic conditions on silica rich parent material such as granite, schist, gneiss, quartzite, sandstone and sandy deposits. Due to the high content of weathering resistant material, it has a low potential for clay developing. Base status varies widely.

Yellow-brown apedal B horizon: a yellowish, structureless and non-calcareous horizon (Van der Watt & Van Rooyen 1990). This horizon is only distinguished from the red apedal horizon on the basis of colour, as all other conditions are the same. The difference in colour is due to the difference in mineralogy and chemical composition of the layer which covers the individual particles. Either parent material with lower reserves of ferri iron or higher general water status within the horizon may be the cause. Sources of lower ferri iron are sand, sandstone, quartzite, shale and granite. Average higher water status is caused by shallow soils on aquilades or a fluctuating water table or by humid climates.

Red structured B horizon: a reddish horizon with strong structure. It develops in parent material rich in ferromagnesium and calcium-alumina-silicate minerals. Basic igneous rock (e.g. basalt, dolerite, norite, diabase, gabbro) and metamorphic rock (e.g. amphibolite, basic schist) are the source of these minerals. The horizon normally develops from residual rock, seldom from colluvium and very seldom in alluvium.

Lithocutanic B horizon: A horizon with distinct affinities with the underlying parent rock into which it merges. It has cutanic characteristics expressed usually as tongues or prominent colour variations (Van der Watt & Van Rooyen 1990). It is associated with *in situ* weathering of the parent material. Hard, impenetrable rock and horizontally orientated shales, without vertical cracks, are not associated with this horizon.

Neocutanic B horizon: A horizon that has developed in recent sediments and unconsolidated material (usually transported), showing little signs of pedogenesis and is non- calcareous (Van der Watt & Van Rooyen 1990). Material in which this horizon develops is normally of alluvial or colluvial origin, in certain but not all landscape positions e.g. river terraces and footslopes.

Hard rock: a continuous hard layer of parent rock or silcrete (Van der Walt & Van Rooyen 1990). This horizon is associated with shallow soils, and cannot be broken with a spade, but does not qualify as one of the other hard horizons such as lithocutanic or hard plinthic B horizons or hard pan carbonate horizon. An example is horizontal stratified sedimentary rocks without vertical cracks.

Under the influence of precipitation (available moisture) and physical composition, each of the diagnostic horizons has the ability to develop different chemical properties or potentials. Base status or base saturation percentage (Strahler & Strahler 1987; White 1987; Van der Watt & Van Rooyen 1990; Soil Classification Workgroup 1991) relates to the degree of leaching undergone by a specific soil. Base status is a qualitative expression of base saturation, determined by the following equitation: Σ exchangeable cations (Ca, Mg, K and Na) [cmol(+)/kg soil]*100/ % clay, where values of less than five are associated with dystrophic soil of low pH, highly leached and with low base status, values between 5-15 denote mesotrophic soils of intermediate pH, moderately leached and with medium base status and soils with values of 5 and more are eutrophic with high pH, little leached and with high base status. Percentage base saturation, on the other hand, is defined as the proportion of exchangeable base cations to the total cation exchange capacity of a soil. Soils of high base status (PBS greater than 35%) have high natural fertility and are nutrient rich compared to those of low base status. Eutrophic soils are non-calcareous.

Calcareous soils contain enough lime to bubble when treated with cold 10% hydrochloric acid, but are excluded from neocarbonate, soft carbonate and hardpan carbonate B horizons of arid and semiarid climates because they do not represent a physically distinguishable layer within the soil profile. Non-calcareous soils may contain discrete relics of lime nodules in a soil matrix which does not bubble when tested with cold 10% hydrochloric acid.

A detailed correlation between the South African soil classification system (Soil Classification Workgroup 1991) and Marbut and Comprehensive Soil Classification System (CSCS) of the United States (Chapter III, paragraphs 2.4.1 & 2.4.2) is not within the scope of this study. In general all the soil patterns involved qualify for inclusion in the Zonal order of the Marbut system. The Ab, Ac, Ad and Ae soil patterns qualify for inclusion in the light coloured podzolise soils of the forested region suborder while the Ea soil pattern can be included in the dark coloured soils of the semi-arid, subhumid and humid grasslands suborder. In terms of the Comprehensive Soil Classification System (CSCS), the eight soil patterns, based on their general top and subsoil diagnostic horizons, probably qualify for inclusion in the Alfisols and Mollisols orders. Mollisols are associated with grassland, while Alfisols have the potential to support either deciduous forest or grassland (Table 3).

To conclude, Table 18 is a generalised summary of the seven soil patterns and their attributes. The Ib soil pattern is associated with exposed surface rock and any of the possible soil forms and is therefore excluded. It should be kept in mind that all these soil patterns contain more than one land type with its own unique set of soil forms (Appendix B), of which those used in the table are dominant. Thus, a mosaic of dystrophic, mesotrophic and eutrophic soil forms exist within a landscape covered by a mosaic of grass and woodland.

Soil textures influence the rate of water infiltration and the water-holding capacity of soils (Daubenmire 1974). Rain falling on a coarse-textured soil penetrates almost immediately, so that almost none is lost as runoff. The fact that forest extends farthest into arid regions on coarse or stony soils can be explained in part by the rapid infiltration and deeper percolation of rain in such soils, as well as by the deeper root systems of woody plants (Daubenmire 1974). Water moves downward through a sandy soil so rapidly that most of it is soon beyond the reach of plants with shallow root systems. Consequently the most successful perennials on sandy soils (provided the water table is not near the surface) are almost invariably deep-rooted species. Where rainfall is low however and plants depend upon water rising by capillarity from levels below the reach of their roots the rate of rise may be rapid enough to satisfy plant demands only on sandy soils.

In fine-textured soils there are more aggregate surfaces to accommodate films, more angles to hold water, and more colloidal material, and consequently these can hold more water per unit volume of soil than coarser soils. In regions where there are pronounced dry seasons, plants are most favourably situated when their roots are in contact with a body of fine-textured soil. Fine soils absorb so much water during each rainy season that the supply is exhausted relatively late in the ensuing dry season, as compared to sandy soils. It is a general rule that the finer the texture of a soil the greater its fertility (Daubenmire 1974). Therefore, within the study area, sandy and clay soils have the potential to support forests in areas of adequate moisture or low soil-water deficiency. Areas of less adequate moisture or

Table 18: Seven soil patterns classified according to base status, with their attributes.

<table>
<tr><td colspan="2">Base status</td><td>Dys- or mesotrophic</td><td>Eutrophic</td></tr>
<tr><td colspan="2">Soil attributes</td><td>Leaching: High to moderate
Sandy texture
Substantial soil-water deficiency, no water surplus
(Ep-Ea large)</td><td>Leaching: Low
Clay texture
Moderate soil-water deficiency
(Ep-Ea moderate)</td></tr>
<tr><td colspan="2">Marbut soil classification suborder
Comprehensive Soil Classification Systems suborder</td><td>Light-coloured podzolized soils

Borolls, Ustalfs</td><td>Dark-coloured soils

Ustolls, Udalfs</td></tr>
<tr><td rowspan="2">Local climate type:</td><td>Empirical/ Generic</td><td colspan="2">Highveld (Warm temperate Cwb)/
Wet-dry tropical</td></tr>
<tr><td>Applied</td><td>Moist subtropical</td><td>Dry tropical</td></tr>
<tr><td colspan="2">South African soil pattern</td><td>Ab, Ac, Ad, Fa</td><td>Ae, Ea, Fb</td></tr>
<tr><td colspan="2">Diagnostic horizons</td><td>Orthic A horizon, red apedal -, yellow-brown apedal -, lithocutanic B horizon, hard rock</td><td>Orthic -, melanic - or vertic A horizon, red apedal -, red structured -, lithocutanic B horizon, hard rock</td></tr>
<tr><td colspan="2">Soil forms</td><td>Hutton, Clovelly, Glenrosa, Mispah</td><td>Shortlands, Hutton, Glenrosa, Mispah, Mayo, Milkwood, Arcadia</td></tr>
<tr><td colspan="2">Associated vegetation type</td><td>Short grassland or forest</td><td>Deciduous forest or tall grassland</td></tr>
</table>

higher soil-water deficiency sustain open or closed canopy woodlands on either sandy or clay soils while grasslands occur in areas of inadequate moisture or highest soil-water deficiency. In the grassland areas, tall grasses are associated with fine-textured, more fertile soils and short grasses with coarse textured soils.

Finally, the great soil group Latosols included in the Marbut soil classification on global scale, which represent the Oxisol order of the Comprehensive Soil Classification System, were surveyed by Coetzee *et al.* (1993a & b). They are the plinthic catena soils of the dys- or mesotrophic Ba & Bb soil patterns and the eutrophic Ca soil pattern in which upland duplex and margalitic soils are common. Soils with hard plinthite are particular common over sandstones in the moist climate zones in the eastern parts of the country, while duplex and margalitic soils have higher clay contents in the B and A horizons respectively (Land Type Survey Staff 1985, 1986, 1989; Van der Watt & Van Rooyen 1990).

3.5. Flora

3.5.1. Terrestrial ecosystem

On a global scale (Chapter III, paragraph 2.5.1), the study area appears to be within the savanna biome, but on local scale it is classified within the Grassland Biome (Rutherford & Westfall 1994). This classification is based on life forms and the following climate attributes: precipitation, seasonality and temperature, and therefore conforms with the general idea that biomes are distinguished by climate and classified according to vegetation life forms (Strahler & Strahler 1987). The grassland biome interfaces with the Nama-Karoo on its drier southwestern boundary and on the remaining boundary with the savanna biome (O'Connor & Bredenkamp 1997) (Figure 24). The boundaries between the grassland and other biomes can be determined by a water balance approach. Savannas, grassland and forest are distinguished from Nama-karoo by longer growing seasons and higher temperatures during the non-growing season. Forest receives higher seasonal rainfall than grassland or savanna. Savanna experiences higher temperatures during the non-growing season than grassland. Forest patches may occur within grassland, provided there are sufficient growing days, appropriate soils and protection from fire (O'Connor & Bredenkamp 1997). Thus, the same moisture gradient is supported between the biomes as suggested on global scale, but the difference between savanna and grassland is based on temperature instead of adequate moisture.

Table 19 is a generalised comparison between the geological, climatic and pedological environments for the grassland and savanna biomes, summarised from Rutherford & Westfall (1994), and the local scale attributes of the study area for the same environments. The Summer Aridity Index (SAI) is defined as the sum of the mean precipitation for the four hottest months of the year, taken as a natural

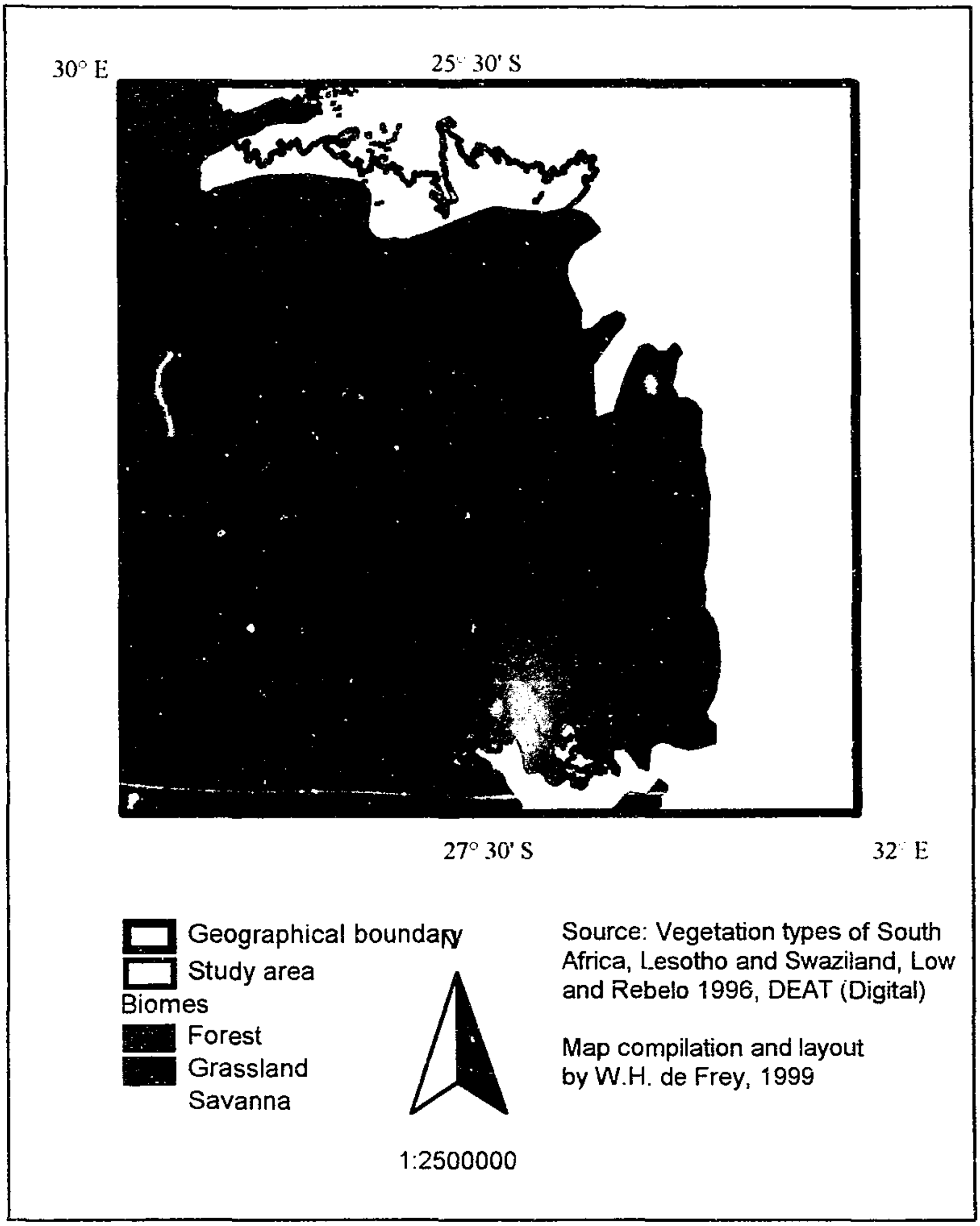


Figure 24: Biomes of South Africa found within the study area.

Table 19: A generalised summarised comparison of the geological, climatic and pedological environments between the grassland and savanna biomes of Rutherford and Westfall (1994) and the study area.

Area	Grassland Biome	Savanna Biome	Study area
Geological environment	Main units - Beaufort and Ecca Groups, Karoo Sequence, Phanerozoic erathem	Main units - Quaternary and Tertiary deposit, Phanerozoic erathem Basement complex, Swazian erathem	Main units - Quaternary deposits and Ecca Group, Karoo Sequence, Phanerozoic erathem Basement complex, Swazian erathem
Climatic environment	Warm temperate climate (Cwb) Summer and strong Inland Tropical Forest Types - summer rainfall areas with SAI between 2.0 and 3.9 Mean annual rainfall between 400 and 2 000 mm	Summer and strong summer rainfall areas with SAI less than 4.0 Lowest mean annual rainfall approximately 235 mm	Warm temperate climate (Cwb)/ Wet-dry tropical type Summer rainfall during periods of high sun - Hot Dry season during periods of low sun - Cool Mean annual rainfall between 580 and 1 505 mm
Geomorphological environment	Topography: mainly flat to rolling, also mountainous Altitude: 300 to 2 850 m a.b.s.l.	Topography: plains and more rugged areas Altitude: Coastal to 2 000 m a.b.s.l. up north	Topography: plains, hills and mountains Altitude: 600 m to 2 000 m a.b.s.l.
Pedological environment	The acid soils of the red-yellow-grey plinthic catena are better represented in the Grassland Biome than in the other biomes	The red clays and combinations of black and red clays are limited mainly to the Savanna Biome	Dys- and mesotrophic sandy texture: orthic, red - and yellow-brown apedal diagnostic horizons Eutrophic clay texture: vertic, red structured diagnostic horizons

logarithm for scaling purposes and subtracted from a constant to ensure ascending values with increasing aridity. This index reflects moisture at a physiologically important time of year and under conditions of high evaporative demand (Rutherford & Westfall 1994). **From the table, based on the environmental factors, it appears as if the study area could be associated with any of these two biomes or could represent a transitional zone.** The latter seems possible when the different veld types or vegetation types occuring in the study area are taken into consideration.

Veld types are associated with a classification of the vegetation of South Africa by Acocks (1988), who classified seventy veld types plus seventy-five variations. He defined the veld type as a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potentialities. Eight veld types (Figure 25) are found in the study area, under four main groupings or physiognomic types; namely:

Inland Tropical Forest Types -

- North-eastern Mountain Sourveld (Veld type 8)
- Lowveld Sour Bushveld (Veld type 9)

Tropical Bush and Savanna Types

- Lowveld (Veld type 10)

Pure Grassland Types -

- *Themeda* veld to Highland Sourveld transition (Veld type 54)
- North-eastern Sandy Highveld (Veld type 57)

False Grassland Types -

- Bankenveld to Sour Sandveld transition (Veld type 62)
- Piet Retief Sourveld (Veld type 63)
- Northern Tall Grassveld (Veld type 64)

Five vegetation types (Figure 26) described by Low & Rebelo (1996) occur in the study area. One is associated with the Forest Biome, another with the Savanna Biome and the rest with the Grassland Biome. Each Vegetation Type should be a coherent array of communities with shared common species (or abundance of species), possessing a similar vegetation structure (vertical profile), and sharing the same set of ecological processes. They would thus have similar uses, management programmes and conservation requirements (Low & Rebelo 1996). The five vegetation types are:

Forest biome -

- Afromontane Forest (Vegetation Type 2)

Savanna biome -

- Sour Lowveld Bushveld (Vegetation Type 21)

Grassland Biome -

- Moist Clay Highveld Grassland (Vegetation Type 35)
- Moist Sandy Highveld Grassland (Vegetation Type 38)
- North-eastern Mountain Grassland (Vegetation Type 43)

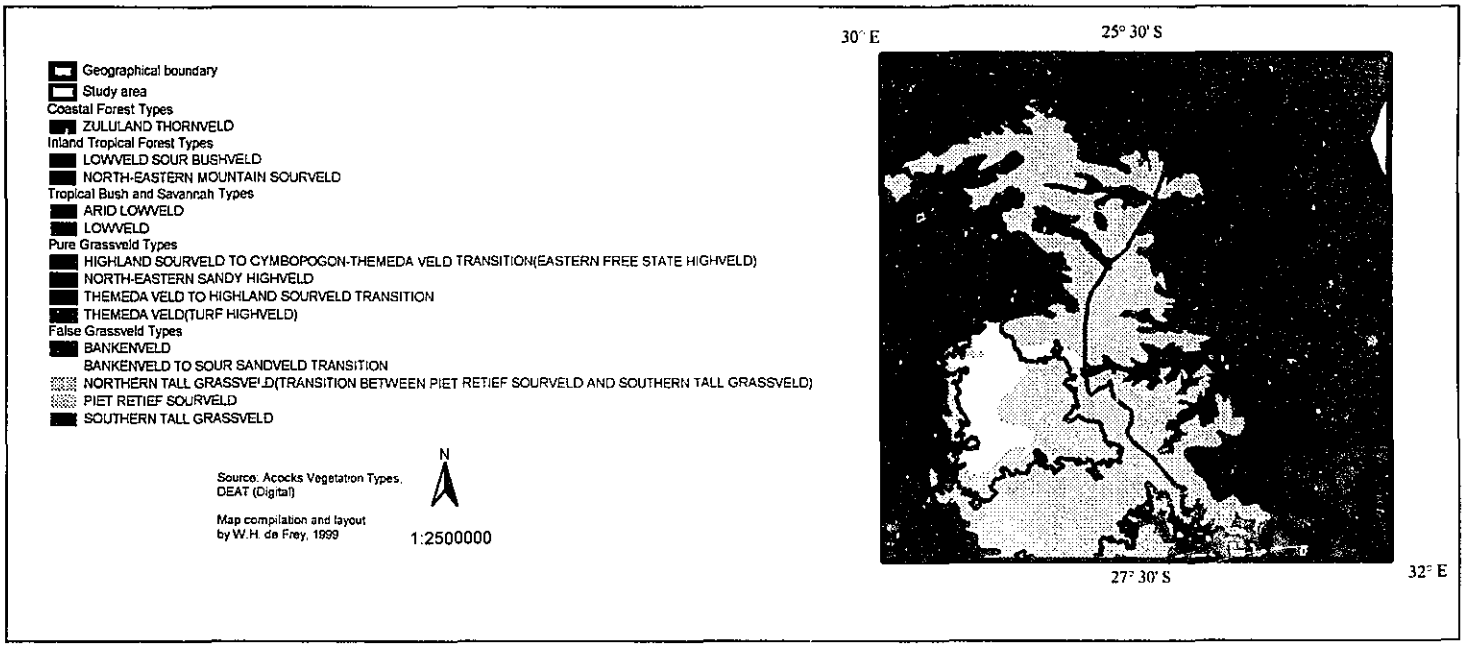


Figure 25: Acocks veld types found within and around the study area

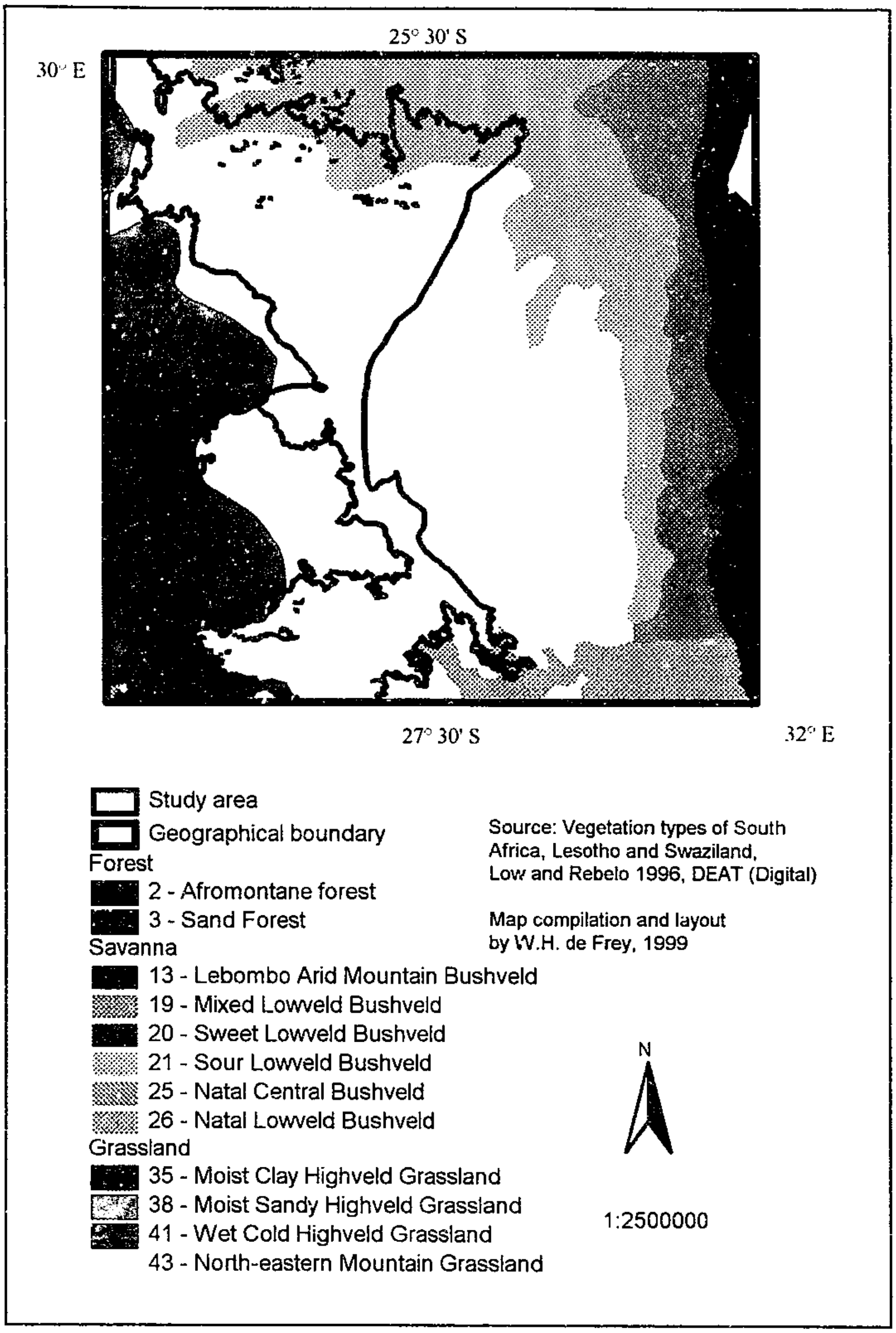


Figure 26: Vegetation types of Low and Rebelo (1996) found in and around the study area

O'Connor and Bredenkamp (1997) identified six main floristic regions in the grassland biome, with 14 main community types. Of these approximately two regions and two main community types are associated with the study area:

Eastern mountains and escarpment (E) -

Monocymbium ceresiiforme-Tristachya leucothrix grassland

Eastern lowlands (F) -

Hyparrhenia hirta tall grassland

The latter lies to the east of the former, while both the main floristic regions stretch in a north-south direction across the grassland biome. The *Hyparrhenia hirta* tall grassland forms the boundary with the savanna biome.

Within the study area, Coetzee *et al.* (1993a & b) classified the following vegetation units or plant communities associated with the undulating plains into the Ad, Ba, Bb and Ca soil patterns. He distinguished between the terrestrial communities and the wetland communities of these undulating plains. The terrestrial communities of these undulating plains are:

1. The *Acacia karroo-Diospyros lycioides* Vegetation unit
2. The *Themeda triandra-Eragrostis plana* Vegetation unit
3. The *Aristida junciformis-Panicum natalense* Vegetation unit
4. The *Digitaria tricholaenoides-Setaria nigrirostris* Vegetation unit
5. The *Themeda triandra-Trachypogon spicatus* Grassland

The wetland communities of the undulating plains are:

1. The *Cynodon dactylon-Cyperus marginatus* Pans
2. The *Sacciolepis typhura-Cyperus esculentus* Pans
3. The *Phragmites australis-Typha capensis* Wetland
4. The *Eleocharis palustris-Leersia hexandra* Wetland
5. The *Arundinella nepalensis-Rhus pyroides* Wetland
6. The *Arundinella nepalensis-Miscanthus junceus* Wetland
7. The *Arundinella nepalensis-Juncus effusus* Wetland
8. The *Cyperus fastigiatus-Polygonum salicifolium* Wetland
9. The *Imperata cylindrica-Kyllinga erecta* Wetland
10. The *Acacia mearnsii-Hyparrhenia tamba* Wetland

Within these terrestrial and wetland communities Coetzee identified a total of fourteen variations and described the vegetation as part of the grassland biome.

To the north of the study area, Matthews (1991) and Burgoyne (1995) described respectively the phytosociology of the northeastern Mountain Sourveld and the phytosociology of the northeastern Transvaal High Mountain Grasslands. To the far northwest, Myburgh (1993) classified the phytosociology of the sourveld of the southeastern Transvaal Highveld. On the eastern and southeastern borders of the study area, Turner (1989) and Smit (1992) described respectively the phytosociology of the southeastern Transvaal Highveld Grasslands and the phytosociology of the Newcastle-Memel-Chelmsford dam area.

Within these phytosociological classifications, the Grassland Biome of southeastern Mpumalanga is described as consisting of mountains, hills and plains covered with grasslands, woodlands or forest and alternating wetlands on different soil types (Table 20). This also corresponds to the global perspective that landforms and soils on local scale influence the mosaic of biotic communities within biomes.

With mountains, hills and plains occurring within the study area, it is expected that it would be covered with a mosaic of wetlands, woodlands and grasslands on a variety of soils which provide enough moisture and heat to maintain these life forms.

3.5.2. Wetlands

Wetlands are azonal, occurring across a wide range of geological formations and topographic regions (Buckle 1987, Strahler & Strahler 1987, Cowan 1995). In South Africa, wetlands are functionally classified between exorheic riparian wetlands and endorheic pans. Riparian wetlands are open-ended (exorheic) systems which occur adjacent to river and stream channels where plant species distribution and growth is determined by, at least, intermittent soil (root zone) saturation or inundation as a consequence of fluctuations in flow. Pans, on the other hand, are usually closed systems (Cowan 1995). During this study only riparian wetlands were sampled, within two of the twenty-six wetland regions of South Africa, the Eastern plateau, highveld region (PE.h) and the Northern escarpment, lowveld region (SNE.l). Riparian wetlands in South Africa can be classified into one of five categories (Cowan 1995):

1. Riparian fringes
2. Riparian swamp forest
3. Karoo salt flats
4. Floodplain vleis
5. Storage floodplains

The type of vegetation associated with these categories depends on the hydrological regime of the drainage line and its depth, and seasonal timing, frequency and duration of flooding.

In Table 21, a comparison is made between the wetlands classified on global (Chapter III, paragraph 2.5.2) and local scale, in order to highlight those environmental factors, which influence plant distribution and physiognomy. The principle environmental factor influencing plant distribution and physiognomy is the hydrological regime, distinguishing between areas permanently inundated and temporarily inundated within three physiognomic classes: forests, reeds and grasslands.

Table 20: An overview of the attributes of the plant communities of the southeastern Mpumalanga grassland from 1988 to 1997.

Regional Scale	Small scale			Large scale					
Authors	Acocks (1988)	Low & Rebelo (1996)	O'Connor & Bredenkamp (1997)	Turner (1989)	Matthews (1991)	Smit (1992)	Coetzee *et al.* (1993a & b)	Myburgh (1993)	Burgoyne (1995)
Topography/ land forms	Mountains, Foothills, Plains, Highveld	Mountains, Foothills	Eastern mountains and escarpment, Eastern lowlands	Low hills and mountains and shallow valleys	Mountainous	Mountains, Plainlands	Undulating plains	Plains with moderate relief, Closed hills and mountains with moderate to high relief	Mountainous, Gently sloping plains
Soils/ soil patterns	Sandy	Leached, Sandy, Sandy loam, Clayey	Leached, shallow, rocky	Ca, Ea, Fa, Ac	Shallow to deep and medium to highly leached depending on parent material,	Dystrophic, Ferrallitic soils, Fersiallitic soils, less leached, B land types	Ad, Ba, Bb, Ca	Ba, Bb, Bc, Ac, Ad, Ea, Ib	Fa, Ac
Physiognomic / vegetation units	Forest, Bushveld, Grassland	Forest, Savanna, Grassland	Grasslands, Shrublands, Forest patches	Open and closed grasslands	Forest, Grasslands, Woodlands,	Forests, Woodlands, Grasslands	Woodlands, Grasslands, Wetlands	Grasslands, Shrublands, Woodlands, Forb lands.	Wetlands, Boulders, Grasslands

Table 21: An overview of the wetland types and wetland plant communities found within Africa on a global scale and South Africa on a local scale.

<table>
<tr><th rowspan="3">Hydrological regime</th><th colspan="3">Global scale</th><th colspan="2">Local scale</th></tr>
<tr><th colspan="2">Wetland types</th><th rowspan="2">Wetland plant communities</th><th colspan="2">Systems</th></tr>
<tr><th>Freshwater herbaceous</th><th>Freshwater swamp forests</th><th>Exorheic</th><th>Endorheic</th></tr>
<tr><td rowspan="5">Permanent</td><td></td><td>Permanent</td><td></td><td>Riparian swamp forest</td><td></td></tr>
<tr><td rowspan="2">Reedswamps</td><td rowspan="2"></td><td>Floating sudd communities</td><td></td><td></td></tr>
<tr><td>Permanent reed swamps</td><td>Floodplain vleis</td><td>Pans</td></tr>
<tr><td rowspan="2">Bog, fen and moorland</td><td rowspan="2"></td><td rowspan="2">Montane wetland communities</td><td colspan="2">Mires</td></tr>
<tr><td>Fens</td><td>Bogs</td></tr>
<tr><td rowspan="4">Seasonal</td><td rowspan="2">Black clays, pans and dambos</td><td>Floodplain forests</td><td rowspan="2">Swamp (edaphic) forests</td><td rowspan="2">Riparian fringes</td><td rowspan="2"></td></tr>
<tr><td>Riverine and gallery forests</td></tr>
<tr><td>Floodplains and valley grasslands</td><td rowspan="2"></td><td rowspan="2">Seasonal herbaceous swamps (edaphic grasslands)</td><td>Storage floodplains</td><td>Pans</td></tr>
<tr><td>Alkaline grasslands</td><td>Karoo salt flats</td><td></td></tr>
</table>

This study did not survey any pans, as they occurr only within the soil patterns already studied by Coetzee (Coetzee *et al.* 1993b). Wetlands surveyed during the current study are associated either with riparian fringes or floodplain vleis and included both perennial and non-perennial streams and rivers, and potential drainage lines associated with erosion gullies and depressions.

3.6. Fauna

The herds of herbivores with their accompanying predators, associated with the savanna grasslands, have been replaced with cattle and sheep. Wildlife is restricted to provincial and private game reserves, where it provides opportunities for eco-tourism and hunting. These reserves also provide habitat for the less charismatic and/or conspicious animals (birds, reptiles, amphibians and insects), which are under constant threat from agriculture, forestry and mining (Turner 1989; Burgoyne 1995; Low & Rebelo 1996). Additional threats to habitat are alien plants and urbanisation (Myburgh 1993; Low & Rebelo 1996, O'Connor & Bredenkamp 1997).

Slopes of more than 15 % (8°) are recommended for utilisation by domestic and wild animals (game) as well as afforestation (Tainton 1981, Matthee 1984). This represents steep to very steep slopes, which are prone to erosion if mismanaged. The very steep slopes are especially difficult to transverse and are sparsely vegetated.

CHAPTER IV - IDENTIFICATION OF MAJOR VEGETATION TYPES OF THE SOUTHEASTERN MPUMALANGA HIGH ALTITUDES GRASSLANDS

1. Introduction

This chapter describes the result of the first step, the classification and identification of the major vegetation types. A numerical, hierarchical, polythetic, divisive TWINSPAN (Hill 1979a) classification of the **complete floristic data** set revealed three major vegetation types associated with three landforms: mountains, hills and plains. Each of these was divided between two ecosystems: the wetlands of the aquatic ecosystems, associated with footslopes and valley bottoms, and the terrestrial ecosystem associated with the crests, scarps and midslopes. A DECORANA (Hill 1979b) ordination confirmed this soil moisture gradient.

2. Results

2.1. TWINSPAN classification

It was expected that the clusters produced by the TWINSPAN (Hill 1979a) algorithm would reflect the soil patterns. When the TWINSPAN output and the environmental data were combined, it was discovered that the clusters contained mixed soil patterns throughout the TWINSPAN sequence. Therefore some factor other than soil pattern must control the distribution of the vegetation types at this hierachical level.

Traditionally, major physiognomic or floristic units within the TWINSPAN classification were identified and used as base for further classifications and Braun-Blanquet procedures. Using species as guidelines, the TWINSPAN sequence was interpreted as three broad physiognomic units: Woodlands, Grasslands and Wetlands on TWINSPAN levels one and two. The relevés related to these physiognomic units were then separated and each unit subjected to a second TWINSPAN classification.

Each of the classifications obtained was refined using Braun-Blanquet procedures. It was during these procedures that it was discovered that these divisions were also not satisfactory. The woodland unit contained clusters related to the grasslands, and the woodland communities were not well defined in terms of floristics or environmental factors. The grassland unit had to be divided further into a *Themeda triandra* grassland and a *Hyparrhenia hirta* grassland, but this separation could not be motivated in terms of environmental factors. Also, the different vegetation communities were not well defined. The wetland unit reflected a mixture of physiognomic units, with no clear division between the different vegetation communities. Applying statistical descriptive methods such as frequency polygons and mode merely confirmed the absence of clear boundaries between these units and their supposed vegetation communities (Table 22). In general the vegetation communities within the broader classifications could not be related to vegetation communities sampled in the survey. Secondly, the broad physiognomic units were not mappable at or between the biome scale of 1: 10 000 000 and the land type scale of 1: 250 000. This classification was therefore rejected.

Further literature studies revealed that climate types determine biome boundaries, but vegetation communities at the next level are determined either by landform or soil (Strahler & Strahler 1987). From the current results, it is known that in this case the soil patterns do not influence the vegetation distribution, while the soil forms are too diverse and their spatial distribution too limited to be used for mapping. Thus, landforms are the next option to be tested on the results of the TWINSPAN classification of the complete floristic data set. Making use of geographical information systems (GIS), data concerning the landforms were extracted for each relevé from the 1: 2 500 000 map of the terrain morphology of South Africa (Kruger 1983).

When this information was combined with the existing spreadsheet containing the floristic and environmental data along the TWINSPAN sequence (Appendix E), it was found that the TWINSPAN clusters reflected three broad landforms on levels one and two (Figure 27). Level one divides between aquatic and terrestrial ecosystems, while level two consists of the broad landforms mountains, hills and plains. These represent separable units (Table 16), mappable at a scales of between 1: 10 000 000 and 1: 250 000 (Figure 21), with information concerning their geological origin, microclimatology, topography and pedology (Table 23).

2.2. DECORANA ordination

An ordination DECORANA (Hill 1979b) was executed using the complete floristic data set. The output file was combined with the environmental data file, which included the TWINSPAN classification. In the scatter diagram (Figure 28), it is possible to see that there is an almost abrupt transition between the relevés associated with aquatic ecosystem and the terrestrial ecosystem. The scatter diagram only reflects those variables of the different environments of which the trends were statistically significant (P-value $< \alpha$ at $\alpha = 0.5$). The table associated with the figure reflects the parameters where the coefficients and P-value fields were of value. Only environmental variables with low P-value were included while the coefficients indicated whether a positive or negative correlation existed between the environmentally variable gradient and the floristic data.

Table 22: The broad physiognomic units and their environmental attributes deduced from the TWINSPAN classification of the complete data set.

Physiognomic unit	Woodland	Grassland		Wetland
Environmental factors		*Themeda triandra*	*Hypparhenia hirta*	
Sedimentary rock	Sandstone, grit, conglomerate	Shale, sandstone, chert	Shale	Shale, sandstone
Igneous/ Metamorphic rock	Magnetite, gneiss	Dolerite	Dolerite	Magnetite, gneiss
Stratigraphic unit	Archaean Complex	Karoo Sequence	Karoo Sequence	Karoo Sequence
Climate zone	118S	56S	253S	118S
Annual precipitation (mm)	894.1	733.4	1073	894.1
Land type height (m.a.s.l)	900	1650	900	900
GPS height (m.a.s.l.)	960	1680	1170	1080
Terrain nature classification	b4	c4	b3	a3
Land type	Fa166	Ac39	Ac106	Fa166
Soil form	Glenrosa	Hutton	Hutton	Katspruit
Soil texture (horizon: category)	A: coarse sand to sandy loam	A: fine sandy clay loam to sandy clay	B: sandy clay	A: coarse sandy to loamy sandy
Soil depth (mm)	300-400	200-400	900-1200+	300-600

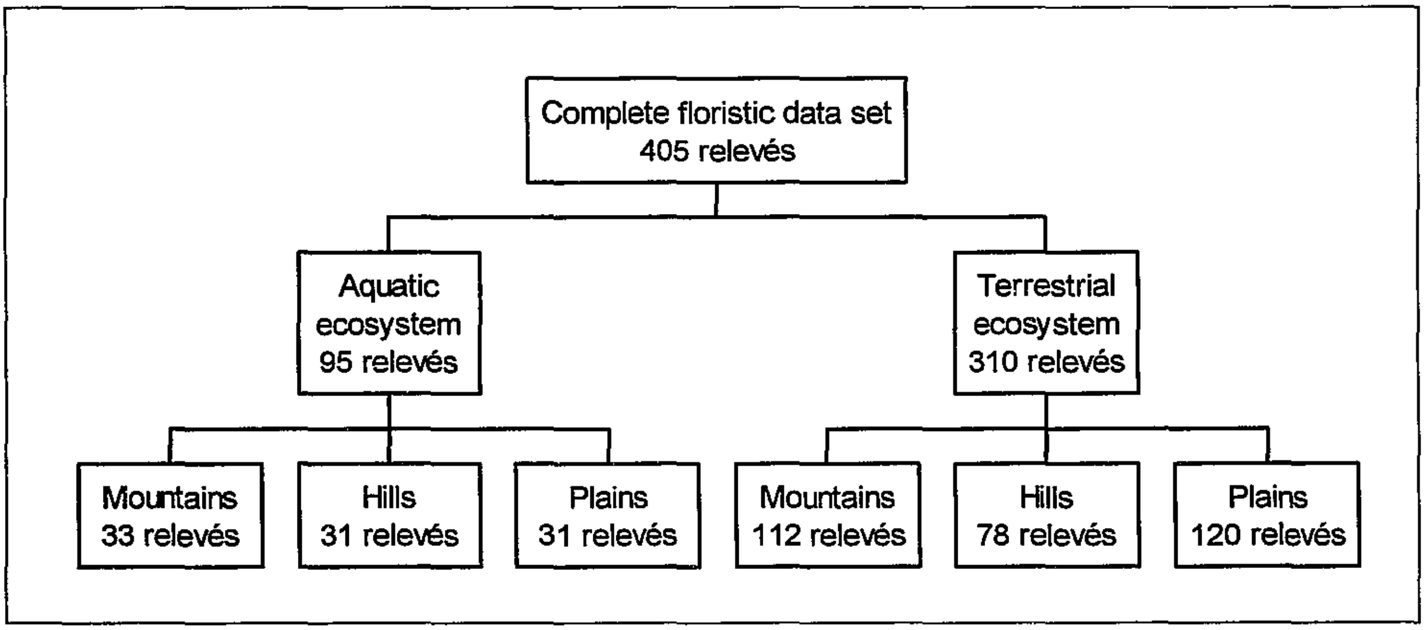
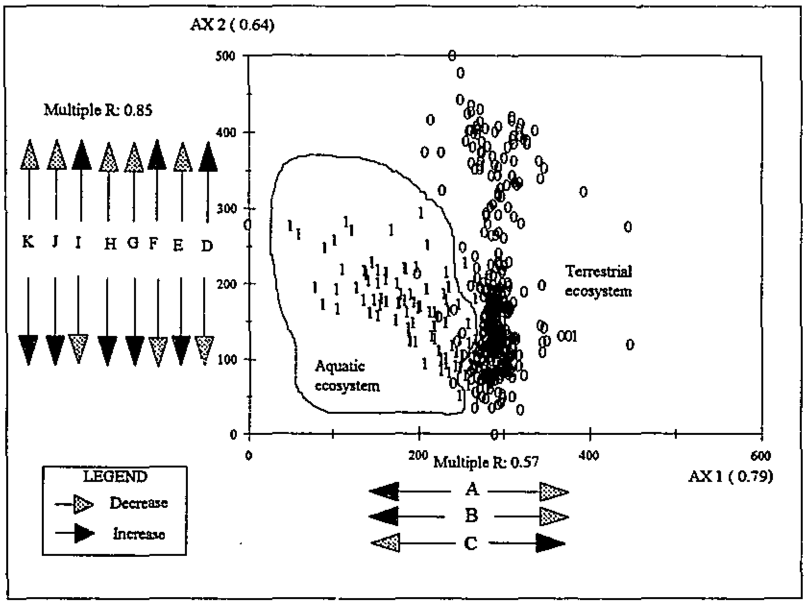


Figure 27: Twinspan classification dendrogram of the complete data set, showing the division between terrestrial and aquatic ecosystems on cutlevel one and between the different landforms on cutlevel two

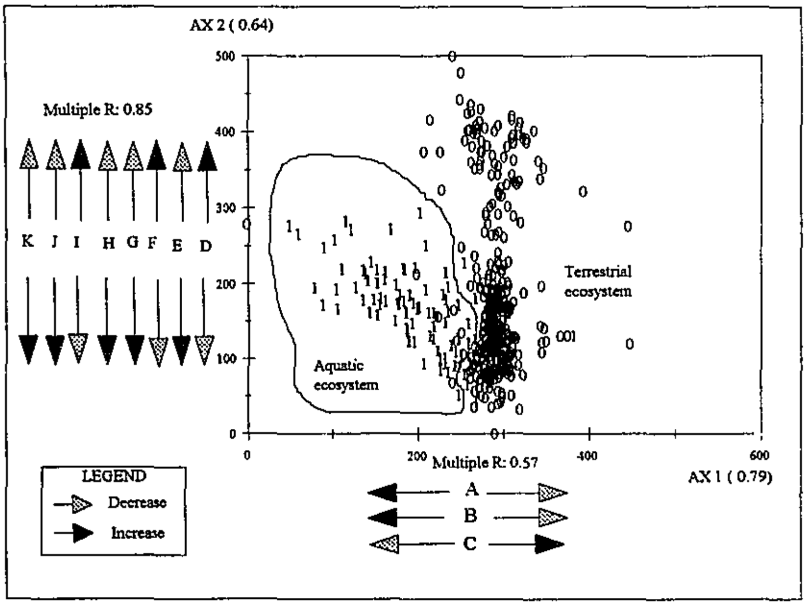
Table 23: Environmental attributes of the three broad landforms, separated by the TWINSPAN classification on the complete data set.

Landforms	Mountains	Hills	Plains
Origin	Tectonic and volcanic activity	Volcanic activity and pediplanation	Pediplanation
Landform category	Initial	Initial and sequential	Sequential
Petrological and structural units	Well exposed igneous batholiths and/or metamorphic rock and upwarped or faulted sedimentary rocks	Partially exposed igneous sills, dykes and metamorphic rocks	Easily weathered metamorphic and sedimentary rocks
Topography	Extremely complex	Complex	Simple
Microclimatology	Extremely variable	Variable	Conforming
Pedology	Thin, well drained, dystrophic soils	Medium, moderately drained, dystrophic to mesotrophic soils	Deep, moderately to poorly drained, mesotrophic to eutrophic soils



Symbol	Variable	Coefficients	Standard Err	t Statistic	P-value < Alpha @ 0.05	Lower 95.00%	Upper 95.00%
AX1	Intercept	0.0542545	0.0512368	1.0588959	0.2902799	-0.0465020	0.1550109
A	Soil water availability	-20.6817993	2.3413823	-8.8331579	0.0000000	-25.2860914	-16.0775071
B	Species per relevé	-2.6591162	0.8082865	-3.2898188	0.0010905	-4.2485992	-1.0696332
C	Chronostratigraphic age	-0.3860525	0.1604257	-2.4064249	0.0165576	-0.7015273	-0.0705777
XA2	Intercept	0.0323457	0.0535260	0.6042983	0.5459845	-0.0729124	0.1376037
D	Insolation attitudes	13.1267037	2.8734278	4.5683082	0.0000065	7.4761522	18.7772552
E	Insolation exposure	-108.8001619	24.4046274	-4.4581776	0.0000107	-156.7914855	-60.8088382
F	Percentage rock cover	0.3917668	0.1072666	3.6522726	0.0002941	0.1808287	0.6027048
G	Soil depth	-0.0540852	0.0188558	-2.8683578	0.0043425	-0.0911649	-0.0170056
H	Physionomic	-4.4635661	1.6156273	-2.7627450	0.0059936	-7.6406723	-1.2864600
I	Soil forms	3.8177180	1.5304438	2.4945170	0.0130115	0.8081239	6.8273121
J	Average yearly precipitation	-0.0723717	0.0290833	-2.4884258	0.0132330	-0.1295636	-0.0151798
K	Altitude	-2.5171637	1.1175772	-2.2523399	0.0248369	-4.7148620	-0.3194654

Figure 28: DECORANA ordination plot showing the first cutlevel TWINSPAN division and the most significant environmental trends (Eigen values)



Symbol	Variable	Coefficients	Standard Err	t Statistic	P-value < Alpha @ 0.05	Lower 95.00%	Upper 95.00%
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B	Species per relevé	-2.6591162	0.8082865	-3.2898188	0.0010905	-4.248[illegible]992	-1.0696332
C	Chronostratigraphic age	-0.3860525	0.1604257	-2.4064249	0.0165576	-0.7015273	-0.0705777
XA2	Intercept	0.0323457	0.0535260	0.6042983	0.5459845	-0.0729124	0.1376037
D	Insolation attitudes	13.1267037	2.8734278	4.5683082	0.0000065	7.4761522	18.7772552
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Figure 28: DECORANA ordination plot showing the first cutlevel TWINSPAN division and the most significant environmental trends (Eigen values)

The multiple regression analysis revealed three statistically significant environmental trends on the AX1 ordination axis, of which soil water availability was the most significant. On the AX2 axis the insolation attitudes were the most significant. High soil water availability is associated with valley bottoms, while low values represent crests. The high species richness reflects woody communities associated with high water availability and lower values with grassland and lower soil water availability. Rock of the older Cryptozoic eon is associated with low values, while those of the younger Phanerozoic eon are indicated with high values. With the study area being drained from the western high-lying interior plateau of Phanerozoic rock towards the eastern low-lying coastal borderland of Cryptozoic rock, it is expected that most of the rivers and streams would be found within the areas of Cryptozoic rock.

The insolation attitudes reflect a broad trend from top to bottom, of mountainous areas with generally steep slopes to plains with low slopes. In the mountainous areas not all slopes receive insolation all year, while the opposite is true for the plains. In the mountainous area the percentage surface rock is higher, soils are shallower, more woody species are found, soil forms are younger and less well developed. Contrary to expectations, low average annual precipitation and altitudes are associated with the mountainous areas. This is because few really high altitude environments were sampled. These were generally inaccessible, and therefore a larger number of low lying areas within rain shadowed valleys were sampled. The Barberton Mountain, although classified as a mountain in terms of relief and slope configuration, is at a lower altitude than the mountains associated with the escarpment or the plains on top of the interior plateau.

3. Discussion

The original hypothesis concerning the vegetation and soil patterns was falsified by the numerical classification. Two additional hypotheses were tested concerning physiognomic types and landforms. Only the hypothesis concerning the landforms was verified. Three mappable broad landforms are involved: mountains, hills and plains, and these are separated into two ecosystems by a soil moisture gradient.

Terrain morphological units, footslope and valley bottom, are associated with aquatic ecosystems along riparian wetlands. The terrestrial ecosystem is associated with the crest, scarp and midslope terrain morphological units. The numerical classification and ordination thus verified the second original hypothesis concerning the terrain morphological units and vegetation distribution. The importance of the configuration of these terrain morphological units in terms of slope and aspect is confirmed by the statistical significance of the insolation attitudes which represent these two variables in combination. Insolation attitudes occur in all of these landforms but, depending on the landform, their dimensions differ in terms of slope and aspect. Steep slopes and distinct aspect differences are found within mountains, while low slopes and less distinct aspect differences occur on plains.

These results are not surprising because the influence of topography and the importance of water availability on vegetation distribution are well documented (Chapter III). Studies from the drier western area of the grassland biome showed that soil patterns are important (Bezuidenhout 1988; Kooij 1990), while studies from the eastern area showed that soil patterns are not that important but rather topography (Eckhardt 1993; Fuls 1993). They concluded that the effect of high rainfall overshadows the influence of the soil patterns. The results of the present study support and confirm their conclusion.

To attempt to separate the two ecosystems for mapping purposes would be impossible because of scale limitations and complexity; therefore they are combined and analysed as a single data set within each of the different landforms. When it comes to managing and conservation, this decision would make the forming of policies easier because, although they represent different ecosystems, depending on scale and level of research or development, these two ecosystems are inter-dependant (Chapter III, paragraph 2.5). For the same reasons and to emphasise their inter-dependance, the ordination was executed on the combined datasets instead of the individual ecosystems.

These results represent a significant simplification, compared to previous broad classifications such as Acocks' (1988) veld types and Low and Rebelo's (1996) vegetation units, and the two regions of O'Connor and Bredenkamp (1997) for the same area.

Although these former classifications are based on different sampling techniques and definitions of plant communities in terms of one another and the current study, they all emphasise the importance of landforms in plant community distribution. Furthermore both Acocks (1988) and Low and Rebelo (1996) recognise more than one physiognomic type or biome in this area. Acocks (1988) distinguishes between two woodland types and two grassland types, while Low and Rebelo (1996) distinguish vegetation types associated with the forest, savanna and grassland biomes. O'Connor and Bredenkamp only discussed the grassland biome. The presence of physiognomically different plant compositions across the major vegetation types was indicated to be statistically significant by the ordination.

The relevés associated with the ecosystems of the different vegetation types were grouped together because, while the two ecosystems are not mappable at a scale of between 1: 10 000 0000 and 1: 250 000, the broad landforms are. (Both a numerical, hierarchical, polythetic, divisive TWINSPAN classification and DECORANA ordination were executed and a phytosociological table compiled for each of the vegetation types. These results are discussed in chapters V, VI and VII.)

4. Conclusion

Three major vegetation types were identified within the southeastern Mpumalanga high altitude grasslands, each consisting of a terrestrial and aquatic or wetland ecosystem within three broad landforms. They are the:

Southeastern Mpumalanga Mountains Vegetation Type

Southeastern Mpumalanga Hills and Lowlands Vegetation Type and

Southeastern Mpumalanga Plains Vegetation Type (Figure 29)

The two most important environmental factors influencing the vegetation in the study area are soil water availability and topography.

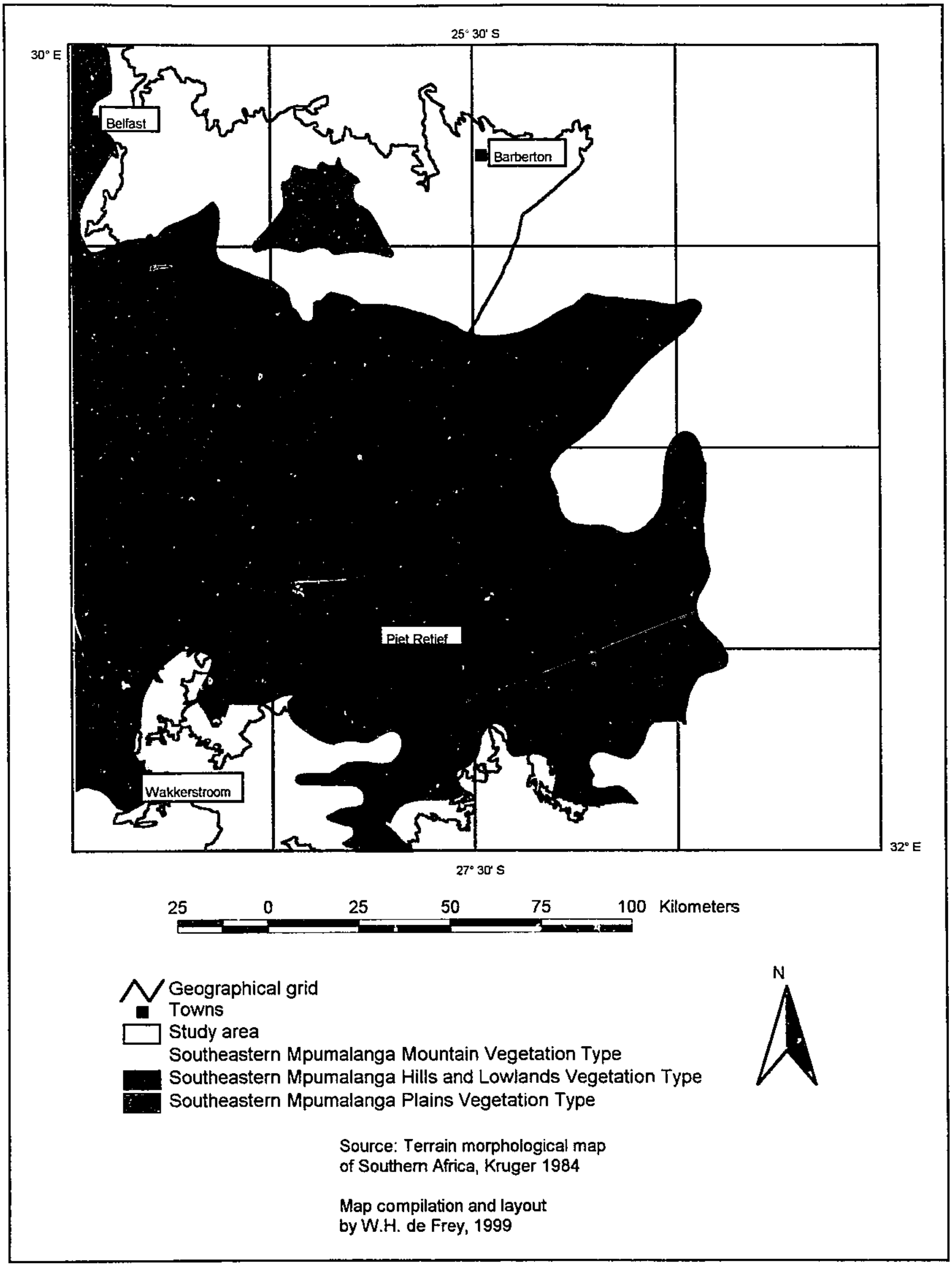


Figure 29: Vegetation map reflecting the three vegetation types

CHAPTER V - PHYTOSOCIOLOGY OF THE SOUTHEASTERN MPUMALANGA MOUNTAIN VEGETATION TYPE

1. Introduction

The mountain vegetation type occurs as two stands within the study area (Figure 30). Mountains are associated with this vegetation type (Chapter IV).

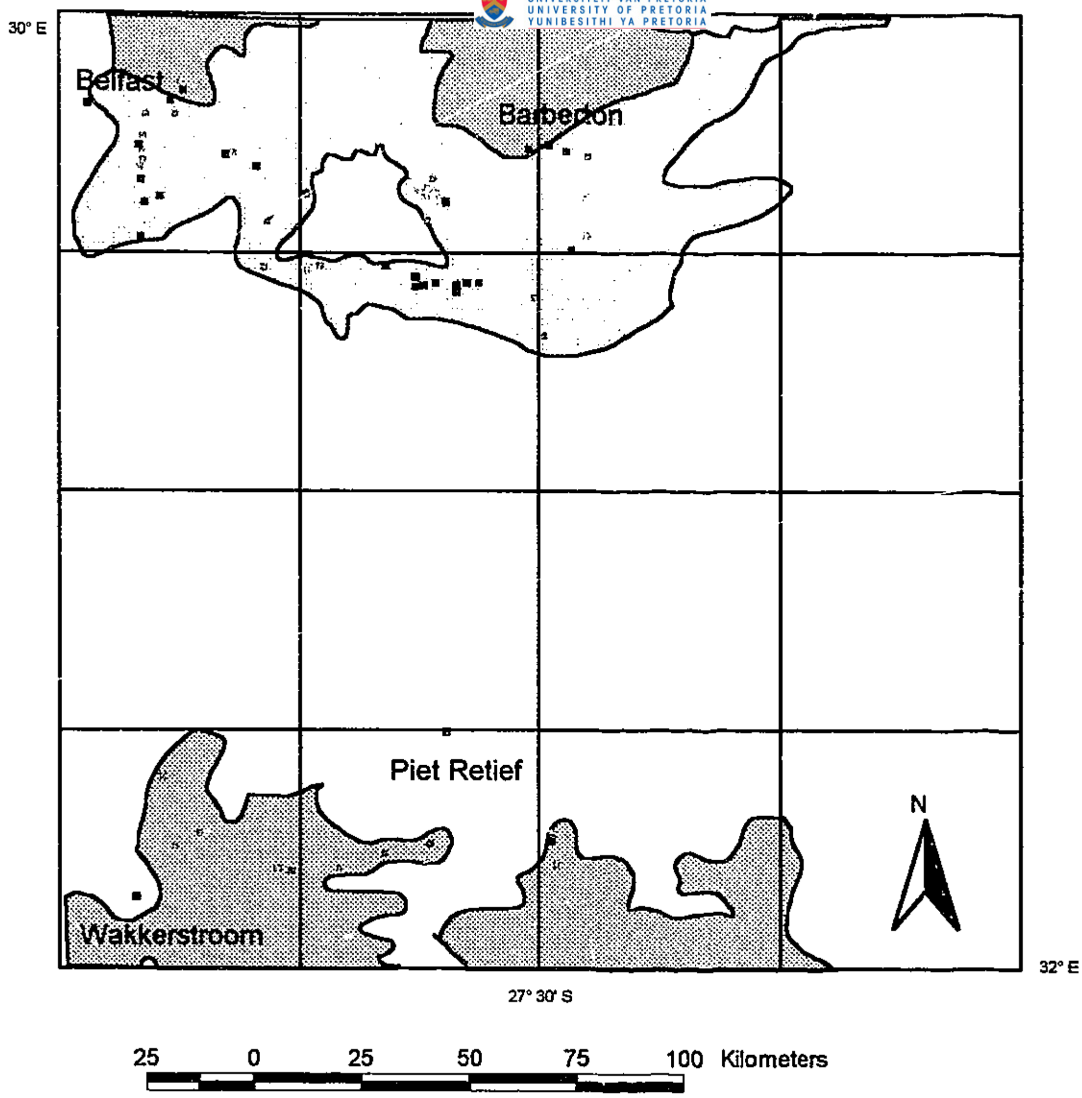
The abiotic components involved in the formation of mountains and their influence on the biotic components, are discussed in detail from both a global and local perspective in Chapter III. Based on relief, two mountain types are found within the study area: low and high mountains. The low mountains occur mainly to the south while the high mountains occur to the north of the study area. Rocks of the exposed shield are the origin of the high mountains, while rocks of both shields formed the low mountains.

The methods applied are described in Chapter II, paragraph 3.1. Plant communities were given a specific name consisting of two botanical names and a subjective physiognomic classification according to Edwards (1983). The first botanical name indicates the characteristic species with the highest fidelity and constancy and the second the constant species with the highest constancy and lowest fidelity. If more than one species was found which qualified either as characteristic or constant then the species with the highest estimated cover abundance was selected. Pure low or short grassland communities indicate communities in which woody species with shrub or tree-like life forms do not occur. In the floristic descriptions, woody species are printed in bold, grasses are underlined and forbs are in italic. Species richness was based on the average number of species per relevé in the plant community.

2. Results and discussion

2.1. Classification

Eighteen clusters of the TWINSPAN classification executed on the 145 plots associated with the mountain landform, qualified as being separable and of informational value (Figure 31). Results from the analysis of the environmental attributes confirmed their separability and informational value. Environmental attributes printed in bold are those attributes which differentiate at 80% frequency or more between one environmental division and another or between one cluster and another (Figure 31).

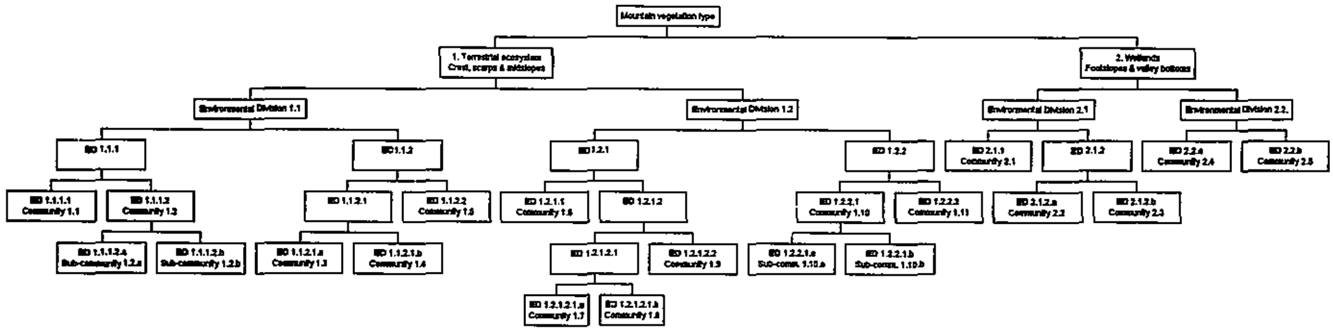


Geographical grid
Towns
Mountain wetland ecosystem
- 2.01. Eriosema salignum - Hyparrhenia hirta Short closed grassland community
- 2.02. Schizostylis coccinea - Eragrostis plana Low// short bushland community
- 2.03. Combretum erythrophyllum - Setaria sphacelata Low// short bushland community
- 2.04. Setaria nigrirostris - Themeda triandra Pure low closed grassland community
- 2.05. Helichrysum harveyana - Setaria sphacelata Pure low closed grassland community

Mountain terrestrial ecosystem
- 1.01. Loudetia flavida - Heteropogon contortus Pure short closed grassland community
- 1.02. Schistostephium crataegifolium - Themeda triandra Low// short sparse shrubland community
- 1.03. Cussonia paniculata - Themeda triandra Low// short thicket community
- 1.04. Crabbea acaulis - Themeda triandra Pure low closed grassland community
- 1.05. Anthospermum rigidum - Themeda triandra Pure low closed grassland community
- 1.06. Melinis repens - Hyparrhenia hirta Low// short sparse shrubland community
- 1.07. Zanthoxylum capense - Themeda triandra Low// short sparse woodland community
- 1.08. Acacia karroo - Heteropogon contortus Low// short thicket community
- 1.09. Rhus pentheri - Hyparrhenia hirta Low// short sparse woodland community
- 1.10. Hyperthelia dissoluta - Heteropogon contortus Woodland (Sensu lato) community
- 1.11. Englerophytum magalismontanum - Heteropogon contortus Low// short thicket community

Southeastern Mpumalanga Mountain Vegetation Type
- High mountains
- Low mountains

Figure 30: The Southeastern Mpumalanga Mountain Vegetation Type, indicating the approximate distribution of the terrestrial and aquatic ecosystems and their communities



1. Terrestrial ecosystem communities

1.1 *Loudetia flavida - Heteropogon contortus* Pure short closed grassland

1.2. *Schistostephium crataegifolium - Themeda triandra* Low// short sparse shrubland

1.2.a *Faurea speciosa - Schistostephium crataegifolium* Low// short sparse shrubland sub-community

1.2.b. *Helichrysum dasycephalum - Schistostephium crataegifolium* Low// short sparse shrubland sub-community

1.3. *Cussonia paniculata - Themeda triandra* Low// short thicket

1.4. *Crabbea acaulis - Themeda triandra* Pure low closed grassland

1.5. *Anthospermum rigidum - Themeda triandra* Pure low closed grassland

1.6. *Melinis repens - Hyparrhenia hirta* Low// short sparse shrubland

1.7. *Zanthoxylum capense - Themeda triandra* Low// short sparse woodland

1.8. *Acacia karroo - Heteropogon contortus* Low// short thicket

1.9. *Rhus pentheri - Hyparrhenia hirta* Low// short sparse woodland

1.10. *Hyperthelia dissoluta - Heteropogon contortus* Woodland (*Sensu lato*)

1.10.a. *Annona senegalensis - Hyperthelia dissoluta* Low// short thicket sub-community

1.10.b. *Sutera aurantiaca - Hyperthelia dissoluta* Low// short sparse shrubland sub-community

1.11. *Englerophytum magalismontanum - Heteropogon contortus* Low// short thicket

2. Wetland plant communities

2.1. *Eriosema salignum - Hyparrhenia hirta* Short closed grassland

2.2. *Schizostylis coccinea - Eragrostis plana* Low// short bushland

2.3. *Combretum erythrophyllum - Setaria sphacelata* Low// short bushland

2.4. *Setaria nigrirostris - Themeda triandra* Pure low closed grassland

2.5. *Helichrysum harveyana - Setaria sphacelata* Pure low closed grassland

Figure 31:TWISPAN classification dendrogram reflecting the floristic and environmental data

Table 24.a (Appendix H) reflects those species included in the phytosociological table at constancy levels of more than 33% per cluster. Diagnostic species groups indicate those species with very high fidelity (low percentage) and separability per cluster (Table 24.b). Estimated cover abundance and number of relevés per cluster are displayed in Table 24.c. Each cluster represents a specific abstract plant community with its own set of species and environmental attributes.

2.1.1. Southeastern Mpumalanga Mountain Vegetation Type

This mountain vegetation type (Figure 31) consists of two ecosystems: a terrestrial ecosystem with thirteen abstract plant communities and an aquatic ecosystem with five abstract wetland plant communities. In general, it is underlain by lithological units from the Archaean erathem of the Cryptozoic eon and Precambrian system. The topography is **closed hills and mountains with moderate and high relief, with the majority of slopes between 2 – 25°, receiving perpendicular insolation only in the summer**. Slopes with angles between **0 - 15 %** are under pressure from **crop growth.**

1. Terrestrial ecosystem (Figure 31)

Associated with the crest, scarps and midslopes, its general aspect is towards the **north,** receiving **insolation all year.** The dominant insolation attitude is **gentle, north facing**, receiving perpendicular insolation only during the summer. This abstract ecosystem consists of eleven communities and four sub-communities. These are as follows:

1.1 *Loudetia flavida - Heteropogon contortus* pure short closed grassland community
1.2. *Schistostephium crataegifolium - Themeda triandra* low// short sparse shrubland community
1.2.a. *Faurea speciosa - Schistostephium crataegifolium* low// short sparse shrubland sub - community
1.2.b. *Helichrysum dasycephalum - Schistostephium crataegifolium* low// short sparse shrubland sub-community
1.3. *Cussonia paniculata - Themeda triandra* low// short thicket community
1.4. *Crabbea acaulis - Themeda triandra* pure low closed grassland community
1.5. *Anthospermum rigidum - Themeda triandra* pure low closed grassland community
1.6. *Melinis repens - Hyparrhenia hirta* low// short sparse shrubland community
1.7. *Zanthoxylum capense - Themeda triandra* low// short sparse woodland community
1.8. *Acacia karroo - Heteropogon contortus* low// short thicket community
1.9. *Rhus pentheri - Hyparrhenia hirta* low// short sparse woodland community
1.10. *Hyperthelia dissoluta - Heteropogon contortus* woodland community
1.10.a. *Annona senegalensis - Hyperthelia dissoluta* low// short thicket sub-community
1.10.b. *Sutera aurantiaca - Hyperthelia dissoluta* low// short sparse shrubland sub-community
1.11. *Englerophytum magalismontanum - Heteropogon contortus* low// short thicket community

Communities 1.1 to 1.5 are associated with **high relief mountains, midslopes** and **Glenrosa** soil form (Environmental Division 1.1 - Figure 31).

1.1. *Loudetia flavida - Heteropogon contortus* pure short closed grassland community

GENERAL DESCRIPTION: This community covers the flat areas between rocky outcrops away from drainage lines. Although Hyperthelia dissoluta is strongly present, this community is characterised by the presence of Loudetia flavida. Shrub and tree-like woody species are absent. Its spatial distribution is limited to the inselberg-dotted landscapes approaching the high relief areas of the mountains.

GEOLOGICAL ENVIRONMENT: It is a community underlain by **gneiss**, a type of **metamorphic** rock from the **Swazian** erathem. Stratigraphically this geological unit is **unnamed.**

GEOMORPHOLOGICAL ENVIRONMENT: A community of the high relief mountains, it's associated nature of terrain type is **B4** (Chapter III, paragraph 3.3.A). Although subjectively sampled within midslopes (Chapter II, paragraph 2.3.1), it occurs within a slope range of 0 – 12% associated with **footslopes and valley bottoms** (Chapter III, parapgraph 3.3.B). Average values based on quantitative data for slope (°, %), aspect and altitude are 2.6°, 4.7%, and 331.7° from North and 1352.9 m.a.s.l.

CLIMATIC ENVIRONMENT: The community was sampled during **May 1994**, at an altitudinal interval of between **1 100 and 1 200 m.a.s.l.** The average annual precipitation is **894.1 mm** associated with **climate zone 118**, in the summer. It has a gentle, north facing insolation attitude (Chapter III, paragraph 3.2.3.B).

PEDOLOGICAL ENVIRONMENT: It is situated mainly within land type **Fa166** of the Fa soil pattern at altitudes not lower than **900 m.a.s.l.** The dominant soil form is Glenrosa and the soil texture of the **A horizon is coarse sand to sandy loam**, with soil depths of **300 - 400 mm. Surface rocks are limited** and when they do occur they do not cover more than 5% of the surface area in the form of stones.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group A (Fidelity very high (V): Table 24.b) containing Loudetia flavida with a very high constancy (5) (Table 24.a) and highest estimated cover abundance (Table 24.c.1). Other species included in this diagnostic species group are *Ipomoea bathycolpos, Indigofera hedyantha, Euryops transvaalensis* and *Waltheria indica.* Species group Y and AA represent constant species. Species group Y include those species associated with terrestrial ecosystems in general of which Heteropogon contortus has a low fidelity (II) and a very high (5) constancy. Included in this species group are Tristachya leucothrix, Panicum natalense, Eragrostis racemosa, *Senecio venosus* and Loudetia simplex. Species group AA is associated with herbaceous species while no woody species or species associated with overutilisation occur, in species groups AC and AD. Physiognomically it represents **pure short closed grassland,** with an average number of species per relevé of thirty-one. This unit is representative of plant communities found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland.**

WILDLIFE MANAGEMENT: This community is associated with **flat areas** according to the adapted pasture classes (Chapter II, paragraph 2.6.3). It is a community at little risk from erosion at slopes of less than 15% and therefore under pressure from agriculture, with a land use suitability of annual cropping, in areas with slopes of not more than 3%.

DISCUSSION: It is a dry community on gentle, north facing insolation attitudes on shallow sandy soils, exposed to insolation all year round and perpendicular insolation during summer, the warmest period of the year. Soil water availability is too low to sustain woody species or even grasses associated with moist conditions such as Hyparrhenia hirta, in spite of high average annual precipitation. The soil water deficiency is most probably caused by the warmer, drier conditions of north facing slopes and poor water retention of sandy soils. Found within the Fa soil pattern, which represent dys- to mesotrophic soils, its nutrient values are low, representing sour veld and are therefore most probably only utilised during summer. This has prevented it from being over-utilised, while the shallow soils and distance from water protects it from cultivation.

1.2. *Schistostephium crataegifolium - Themeda triandra* lo*w*// short sparse shrubland community

GENERAL DESCRIPTION: From a distance this community could easily be mistaken as a pure grassland community. The shrubs are not very tall and are widely spaced. They are normally associated with surface rock and ***Schistostephium crataegifolium*** is characteristic but not necessarily dominant. The dominant grass is Themeda triandra. The community occurs at higher altitudes than the previous one, on steep to very steep slopes.

GEOLOGICAL ENVIRONMENT: Rocks from the Archaean to the Swazian erathem underlie this community. It is petrologically associated with **igneous** rock, either ultramafic rock or lava. The lava stratigraphically occurs in the Onverwacht Group of the Barberton Sequence, while the ultramafic rock is unnamed.

GEOMORPHOLOGICAL ENVIRONMENT: Another community of the high relief mountains, it's associated nature of terrain type is **C4**. This nature of terrain type has fewer level areas than that of the previous community. The steeper environment is confirmed by its inclusion within the midslope and crests category, on slopes ranging from **12 – 100 %**, while subjectively sampled on midslopes. Average values based on quantitative data for slope (°, %), aspect and altitude range: 9.7 - 10.8°, 17.3 - 19.2%, 173.4 - 242.9° from North and 1250.5 - 1420.7 m.a.s.l.

CLIMATIC ENVIRONMENT: The community was sampled during **April 1994** at elevations of between 1200 to 1500 m.a.s.l. The average annual precipitation is **1403.4 mm** associated with **climate zone 1089**, in the summer. This community has an insolation attitude of gentle, north to south facing.

PEDOLOGICAL ENVIRONMENT: It is situated mainly within land type **Fa 337** of the Fa soil pattern at altitudes not lower than **1280 m.a.s.l.** The dominant soil form is Glenrosa, with soil textures of the **A horizon ranging from fine sandy clay loam to sandy clay**, with soil depths of **200 - 600 mm**. Surface rockiness ranges from 6 to 28% in extent and from stones to rocks in size.

FLORISTIC DATA: The characteristic species are represented by diagnostic species group B containing *Schistostephium crataegifolium* with average (3) constancy (Table 24.a) but very high (V) fidelity (Table 24.b). Other species included in this diagnostic species group are *Gnidia caffra* and Cymbopogon plurinodis. Species groups X, Y, AA and AD represent constant species. Species group X includes general constant species of which Themeda triandra has very high (5) constancy (Table

24.a) and low (II) fidelity (Table 24.b) Included in this species group is Setaria sphacelata. Species associated with terrestrial ecosystems in species group Y representative of this community are: *Vernonia natalensis*, Tristachya leucothrix, Panicum natalense, *Senecio venosus*, Diheteropogon amplectens, *Bulbostylis burchellii* and Loudetia simplex. Herbaceous species (Species group AA) occurring are Cymbopogon excavatus, Eulalia villosa, Trachypogon spicatus, *Gladiolus elliotii*, *Berkheya seminivea* and Schizachyrium sanguineum. Aristida junciformis in species group AD is associated with overutilisation (Van Oudtshoorn 1991). Physiognomically it represents **low// short sparse shrubland**, with an average number of species per relevé of thirty-nine. This unit is representative of a plant community found within Acocks' North-eastern Mountain Sourveld and Piet Retief Sourveld and Low and Rebelo's **Sour Lowveld Bushveld.**

WILDLIFE MANAGEMENT: Adapted pasture classes associate this community with steep to very steep slopes. Based on erosion limitation classes, this community should be utilised for **grazing.** Land use suggestions are **natural veld or afforestation.**

DISCUSSION: In spite of it's very high average annual orographic precipitation (1403 mm), this steep sloped community has low soil water availability due to low infiltration and high runoff. Woody species grow in areas of higher soil water availability associated with rockiness. Water accumulates behind the surface rock resulting in increased infiltration while the finely textured nature of the igneous rock increases the water retention capability of the soil. This lower soil water deficiency is not enough to allow shrubs to become prominent or to form a closed canopy. Although capable of supporting woody species in the form of shrubs, it is suggested that this community should rather be used for grazing than afforestation.

1.2.a. *Faurea speciosa - Schistostephium crataegifolium* low// short sparse shrubland sub - community

GENERAL DESCRIPTION: A sub-community characterised by widely spaced broad-leaved ***Faurea speciosa*** trees within the lower range of the main community's altitude range on the north facing slopes. These steep slopes are dotted with large rocks.

GEOLOGICAL ENVIRONMENT: This sub-community is underlain by the igneous unnamed **ultramafic** rocks of the **Archaean** erathem.

GEOMORPHOLOGICAL ENVIRONMENT: Average values based on quantitative data for slope (°, %), aspect and altitude are 10.8°, 19.2%, 242.9° from North and 1250.5 m.a.s.l.

CLIMATIC ENVIRONMENT: This was sampled at an altitude of between **1200 and 1 300 m.a.s.l.** This sub-community is found on gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: Surface **rocks (200 - 1000 mm) occur**, which cover on average up to 38% of the surface.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group C containing species with an average constancy (3) (Table 24.a) and very high (V) fidelity (Table 24.b) of which ***Faurea speciosa*** is a conspicuous woody species. Other species include in this diagnostic species group are *Raphionacme galpinii*, *Senecio oxyriifolius*, *Sutera caerulea* and *Clutia cordata*. Species groups X, Y, AA, AB and AC represent constant species. The following species from species groups Y and AA occur mainly in this sub-community: Heteropogon contortus, *Stachys natalensis* and

Lotononis foliosa. Associated with rockiness from species group AB is ***Aloe marlothii***. From species group AC the following two woody species occur: ***Euclea natalensis*** and ***Rhus dentata***. Physiognomically it represents low// short sparse shrubland, with an average number of thirty-nine species per relevé. This unit is representative of a plant community found within Acocks' **North-eastern Mountain Sourveld** and Low and Rebelo's Sour Lowveld Bushveld.

WILDLIFE MANAGEMENT: Based on adapted pasture classes, this sub-community occurs on **steep slopes of between 16 and 25%.**

DISCUSSION: The presence of trees within this sub-community indicates lower soil water deficiency than in general for the main community. Having a gentle north facing insolation attitude, it is essentially a dry, warm habitat, as indicated by the wide spacing of the broad-leaved trees and their deciduous nature.

1.2.b. *Helichrysum dasycephalum - Schistostephium crataegifolium* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: This sub-community has the same appearance as the main community, except that it occurs on very steep south facing slopes.

GEOLOGICAL ENVIRONMENT: This is a sub-community underlain by **lava**, igneous rock of the **Onverwacht Group** from the **Barberton Sequence** within the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: Average values based on quantitative data for slope (°, %), aspect and altitude are 9.7°, 17.3%, 173.4° from North and 1420.7 m.a.s.l.

CLIMATIC ENVIRONMENT: It occurs at an altitudinal interval of **between 1 400 and 1500 m.a.s.l.**, on mainly **southern aspects.** Insolation attitudes range from **gentle, southeast to south facing.**

PEDOLOGICAL ENVIRONMENT: Surface rock, when it does occur, does not cover more than 6% of the surface area in the form of **stones (50 - 200 mm).**

FLORISTIC DATA: The differentiating species are represented by diagnostic species group D containing species with constancy values ranging from 37% (2) to 93% (5) (Table 24.a) and very high (V) fidelity (Table 24.b) of which *Helichrysum dasycephalum* is characteristic. Other species included in this diagnostic species group are <u>Andropogon schirensis</u>, *Nidorella anomala*, *Tephrosia multijuga*, *Kalanchoe paniculata*, *Albuca* species and *Helichrysum nudifolium*. Species groups X, Y and AA represent constant species. The following species from species groups Y and AA occur mainly in this sub-community: *Acalypha angustata*, <u>Eragrostis racemosa</u>, *Berkheya setifera*, *Haplocarpha scaposa*, *Berkheya echinacea*, <u>Microchloa caffra</u>, <u>Monocymbium ceresiiforme</u>, *Indigofera hilaris*, <u>Digitaria diagonalis</u>, *Athrixia phylicoides*, *Chaetacanthus setiger* and *Alepidea longifolia*. Physiognomically it represents low// short sparse shrubland, with an average number of species per relevé of thirty-nine. This unit is representative of a plant community found within Acocks' Piet Retief Sourveld and Low and Rebelo's Sour Lowveld Bushveld.

WILDLIFE MANAGEMENT: This sub-community is associated with **very steep areas** of the *Schistostephium crataegifolium - Themeda triandra* low// short sparse shrubland community

DISCUSSION: Although found within a gentle, south facing insolation attitude with cool, moist conditions and high water availability, large shrubs and trees are absent from this community. The combination of very steep slopes with shallow soils and low stone coverage, result in very low infiltration rates and water retention, creating a soil water deficiency incapable of maintaining large woody species. This sub-community is currently under pressure from afforestation. The shallow soil and easily weathered lava is ripped deeply along the natural contours, thereby lowering the runoff and increasing the infiltration rate, artificially creating conditions conducive to tree growth.

Communities 1.3 to 1.5 are **less steep (< 12%)** with **limited surface rock** and predominately associated with Low & Rebelo's **North-eastern Mountain Grassland** with **flat areas** suitable for **annual cropping** (Environmental Division 1.1.2 - Figure 31).

1.3. *Cussonia paniculata - Themeda triandra* low// short thicket community

GENERAL DESCRIPTION: This is a woodland community of widely spaced closed canopy woody clusters on slopes underlain by sedimentary rock which surfaces as large rocks or boulders. The open areas between the clusters are grass-covered with *Themeda triandra* dominant. The individual woody clusters are recognised by the presence of ***Cussonia paniculata***.

GEOLOGICAL ENVIRONMENT: lithological units within the Swazian and Vaalian erathem underlie this community. These lithological units of sedimentary origin consist of arenite and shale, from stratigraphic units such as the Moodies Group of the **Barberton Sequence** and the Silverton Formation of the Pretoria Group of the Transvaal Sequence.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of terrain type of this high mountain community is **C4**. A community of subjectively sampled rocky outcrops or scarps, it occurs on slopes of less than 12% associated with the footslopes and valley bottoms. The average values based on quantitative data for slope (°, %), aspect and altitude are 5.2°, 9.1%, 173.2° from North and 1591 m.a.s.l.

CLIMATIC ENVIRONMENT: Sampling was done during January of 1995. This community occurs at elevations of between **1 400 to 1 500 m.a.s.l.** and 1600 to 1700 m.a.s.l. It occurs in a wide variety of climate zones, with average annual precipitation ranging from 720 mm to 1400 mm. This community occurs on gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community is found mainly within the Ac soil pattern, not below 1450 m.a.s.l. Mispah is the dominant soil form in association with rocks, of which the **A horizon** soil texture is of fine sandy clay loam to sand clay. Soil depth varies from 200 mm to 600 mm. Surface rocks (200 - 1000 mm), when it occurs, cover up to 33% of the area.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group E with very high (V) fidelity (Table 24.b) and average (3) constancy (Table 24.a), of which ***Cussonia paniculata*** is the most conspicuous. Other species include in this diagnostic species group are ***Tetradenia riparia***, *Scilla nervosa*, *Vernonia sutherlandii*, *Ledebouria ovatifolia*, *Senecio erubescens*, *Aristea woodii*, ***Leucosidea sericea***, *Cyanotis speciosa*, *Scabiosa columbaria*, *Aloe greatheadii*, *Helichrysum pallidum*, *Elionurus muticus* and ***Myrsine africana***. Species group G represents a transitional group with *Cyperus obtusiflorus* and *Alloteropsis semialata*. Species groups X, Y, AA and AB represent constant species. In species group X, *Themeda triandra* has the highest cover abundance, very high (5) constancy and low (II) fidelity. Other species included in this species group are *Setaria sphacelata* and *Hyparrhenia hirta*. Species group Y includes *Hypoxis rigidula*, which did not occur in the previous two communities. In species group AA the following species occur which also were not present in the previous two communities, *Helichrysum rugulosum*, *Eragrostis capensis*, *Commelina africana*, *Dicoma anomala*, *Leonotis microphylla* and *Cheilanthes quadripinnata*. Species group AB contains species associated with rockiness when it occurs, while species group AC contains the woody species associated with this community. The average number of species per relevé is fifty-one. This community occurs within Acocks' **North-eastern Mountain Sourveld** and North-eastern Sandy Highveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community occurs in the flat areas of the adapted pasture classes. Slopes of less than 15% are not erosion prone, making this community suitable for crop growth. Therefore the non-rocky, deep soil areas of this community are most probably under pressure from agriculture, especially the slopes of less than 3%, which are suitable for annual cropping.

DISCUSSION: The rocks and boulders associated with this community are block shaped and of arenite, a coarse sandstone. It is most probably relics of the pediplanation which occurred within the area and therefore of wide spatial occurrence within the landscape approaching areas of high relief underlain by sedimentary rock. Soil water availability in the vicinity of the outcrops is high due to the lowered runoff and increased infiltration on the sandy textured soil. Further away from the rocks the sandy texture is less developed, resulting in lower infiltration and higher runoff. This prevents the expansion of the thickets and maintains the grassland through warmer and drier soil conditions. It has a gentle, north facing insolation attitude.

1.4. *Crabbea acaulis - Themeda triandra* pure low closed grassland community

GENERAL DESCRIPTION: This is a community associated with the northern part of the study area, where the high relief mountains occur. *Themeda triandra* dominates this community of forbs and grasses, but it is characterised by *Crabbea acaulis*, a forb which is easy to recognise but not easily seen. Spatially distributed above the previous community, it has a higher soil water deficiency.

GEOLOGICAL ENVIRONMENT: The subsurface rock underlying this community is internationally within the Proterozoic erathem of the Precambrium system, but nationally within the Vaalian erathem. Silverton Formation shale is sedimentary rock, from the Pretoria Group of the Transvaal Sequence.

GEOMORPHOLOGICAL ENVIRONMENT: The terrain type of this high mountain community is **B4.** It is less steep environment compared to the previous two communities, as confirmed by its association with footslopes and valley bottoms, while it was subjectively sampled on crests. Average values based on quantitative data for slope (°, %), aspect and altitude are 5.3°, 9.9%, 131.4° from North and 1482.6 m.a.s.l.

CLIMATIC ENVIRONMENT: During January 1995, it was sampled at altitudes from 1500 to 1800 m.a.s.l. It is found mainly within climate zone 52, receiving an average annual precipitation of 794.6 mm. This community is associated with a **gentle, southeast facing** insolation attitude.

PEDOLOGICAL ENVIRONMENT: This community, in the same way as the previous community, is associated with the Ac soil pattern, at altitudes of not less than 1500 m.a.s.l. The dominant soil form is Hutton. **A horizon** soil textures range from fine sandy clay loam to sandy clay and B horizon from fine sandy clay to clay. Soil depth ranges from 200 to 600 mm. Surface rocks are limited but when it does occur, it does not cover more than 31% of the surface area in a wide range of sizes.

FLORISTIC DATA: diagnostic species group F with very high (V) fidelity (Table 24.b) represents the differentiating species of which *Crabbea acaulis* has an average (3) constancy (Table 24.a). Other species included in this diagnostic species group are *Asclepias affinis* and *Brachiaria serrata*. Species group G represents a transition group with *Cyperus obtusiflorus* and *Alloteropsis semialata*. Species groups X, Y, AA and AD represent constant species. In species group X, *Themeda triandra* has the highest cover abundance, very high (5) constancy and low (II) fidelity. *Setaria sphacelata* is included in this species group but *Hyparrhenia hirta* excluded. Species group Y includes the following species, which were absent in the previous two communities, *Tristachya leucothrix* and *Heteropogon contortus*. Some herbaceous species from species group AA which did not occur in the previous community are *Microchloa caffra*, *Pentanisia angustifolia*., *Chaetacanthus costatus*, *Indigofera comosa* and *Gnidia capitata*. *Melinis repens* occurs in species group AD in association with overutilisation or disturbance (Van Oudtshoorn 1991). The average number of species per relevé of this community is thirty-eight. This community occurs in Acocks' Lowveld Sour Bushveld, North-eastern Mountain Sourveld, North-eastern Sandy Highveld and Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: The area is flat. As in the case of the previous community, it is suitable for crop growth and not at risk from erosion. The majority of slopes have angles of less than 3% and are used for annual cropping. It would seem as if this community is used for grazing and might even be to some extend overgrazed.

DISCUSSION: Found within a gentle, south east facing insolation attitude, this community experiences insolation early in the morning during the summer and perpendicular insolation at elevations above the beneficial effect of orographic precipitation. These parameters, together with limited surface rock and shallow fine textured soils, result in a soil water deficiency only capable of maintaining short grassland. Within his Lowveld Sour Bushveld veld type, one of his inland tropical forest types, Acocks (1988) distinguishes between both bush and grass covered areas. According to him this is a transitional veld type between his Lowveld and North-eastern Mountain Sourveld veld types. The largest number of plots occurred between one of his pure grassland types, the North-eastern Sandy Highveld veld type and one of his false grassland types, the Piet Retief Sourveld veld type. Therefore this community has much more the appearance of grassland than of woodland.

1.5. *Anthospermum rigidum - Themeda triandra* pure low closed grassland community

GENERAL DESCRIPTION: This community represents the grassland area found inbetween the woody clusters of the *Cussonia paniculata - Themeda triandra* low// short thicket community, because it is found within the same insolation attitudes and at the same elevations.

GEOLOGICAL ENVIRONMENT: Igneous and sedimentary rocks from both the exposed and covered shields underlie this community. The Karoo dolerites are the youngest, followed by the Vryheid Formation arenite and Volksrust Formation shale of the Ecca Group, Karoo Sequence within the

Phanerozoic erathem, then Silverton Formation shales from the Vaalian erathem and finally the oldest, the unnamed granites of the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: A community of the low relief mountains, the nature of the terrrain type is B3. The relief in the areas associated with this community does not exceed 150 m. Although subjectively sampled on midslopes, it occurs on slopes associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 3.9°, 6.9%, 255.9° from North and 1532 m.a.s.l.

CLIMATIC ENVIRONMENT: This community was sampled in 1995, at altitudes of between 1600 to 1700 m.a.s.l. within a wide variety of climate zones and at low and high average annual precipitation figures of between 720 - 733 mm and 1073 - 1099 mm. Stands of this community are associated with gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community is absent from the Fa soil patterns, but occurs in a wide variety of Ac land types of the Ac soil pattern. It is generally not found below 1500 m.a.s.l. The dominant soil form is Hutton, while Glenrosa and Mispah soil forms are absent. In general **A horizon**, soil texture is medium to coarse sandy clay loam and the B horizon, fine to medium sandy clay loam to sandy clay or fine to medium sandy loam to sandy clay loam. Soil depth ranges from 450 mm or 600 mm to 1200 mm or more. Surface rockiness is low at 7% and when it does occur ranges from pebbles to rocks.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group H, with a very high (V) fidelity and *Anthospermum rigidum* with the highest constancy at 53% (3). Species included in this species group are *Helichrysum cephaloideum*, Eragrostis chloromelas, *Vernonia oligocephala* and *Crepis hypochoeridea*. Species groups X, Y, AA, AC and AD represents constant species. In species group X, Themeda triandra has a very high (5) constancy and low (II) fidelity. Other species included in this species group are Setaria sphacelata and Hyparrhenia hirta. Species group Y does not include *Acalypha angustata* and *Senecio venosus*, which occurred in the previous community. In species group AA the following species occur which did not occur in the previous community, Eulalia villosa, Trachypogon spicatus and *Helichrysum rugulosum*. Species group AC contains the woody species, ***Diospyros lycioides***, found within this community, while the four species in species group AD are well known for their association with overutilised or disturbed areas. The average number of species per relevé is thirty-three. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is also suitable for annual crops because of its slopes of less than 3%.

DISCUSSION: This community has a lower soil water deficiency than the previous community, but still not low enough to support woody vegetation under pristine conditions. The higher soil water availability is indicated by the presence of grasses such as Setaria sphacelata and Hyparrhenia hirta, two species associated with moist, well-drained conditions (Van Oudtshoorn 1991). In spite of its suitability for crop growth, it would seem as if this community is even more suitable for grazing than the previous two communities, as it has soil of a sandy clay loam texture and therefore represents sweet veld. This thought is strengthened by the presence of a species such as Eragrostis plana, which is well represented in the wetland ecosystem (species group Z), a system known for its over-utilisation. The woody species, ***Diospyros lycioides*** is most probably a pioneer species as a result of the over-grazing which limits the competition effect of the herbaceous species.

Communities 1.6 to 1.11 are found on stratigraphically **unnamed** rock of the **Swazian** erathem (Environmental Division 1.2 - Figure 31). Communities 1.6 to 1.9 are underlain by **igneous** rock, on slopes associated with footslopes and valley bottoms in general **at slopes less than 12%.** According to the adapted pasture classes, this area would be described as **a flat area** of slopes not more than 8% (Environmental Division 1.2.1 - Figure 31).

1.6. *Melinis repens - Hyparrhenia hirta* low// short sparse shrubland community

GENERAL DESCRIPTION: This community is distinguished from the previous Themeda triandra and Heteropogon contortus dominated communities, because Hyparrhenia hirta dominates in localities associated with the previous communities away from drainage lines on slopes with cultivation potential. Both Hyparrhenia hirta and the characteristic species Melinis repens are associated with disturbed areas (Van Oudtshoorn 1991).

GEOLOGICAL ENVIRONMENT: This community is underlain by stratigraphically **unnamed** igneous granite of the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain type of this high mountain community is **C4**. The community was subjectively sampled on midslopes and scarps, and it is associated with footslopes and valley bottoms on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 3.39°, 5.9%, 108.5° from North and 1285.7 m.a.s.l.

CLIMATIC ENVIRONMENT: This community was sampled mainly from January to March 1995 at altitudes ranging from **1 100 - 1 300 m.a.s.l.** It receives an average annual precipitation of above 973.5 mm but areas that receive on average less than 856.9 mm also occur. Stands of gentle, north facing insolation attitudes are associated with this community.

PEDOLOGICAL ENVIRONMENT: This community is found mainly on red-yellow, freely drained soil associated with Ab to Ae soil patterns, at elevations of not more than 1150 m.a.s.l. Prominent soil forms are Hutton and Glenrosa of which the **A horizon** texture is fine sandy clay loam and that of the B horizon sandy clay. Soil depth ranges from 150 to 350 mm and 900 to 1200 mm or more, depending on the dominant soil form. Occurrence of **surface rock is limited**, but when it does occur covers up to 25% of the area, in the form of stones (50 - 200 mm).

FLORISTIC DATA: No very high (V) fidelity, diagnostic species group (Table 24.b) exits for this community. It has representatives in all the constant species groups, except species group Z, which is associated with the wetland ecosystem. Melinis repens (species group AD), associated with overutilisation or disturbance, has a very high (5) constancy at 87% (Table 24.a) and an average (III) fidelity at 50% (Table 24.b) in this community. Hyparrhenia hirta in constant species group X, has a high (4) constancy at 73% and an average (III) fidelity at 50%. The average number of species per relevé is forty-five. Physiognomically it is associated with **low// short sparse shrubland.** This community represents vegetation units found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland.**

WILDLIFE MANAGEMENT: A community of flat areas, it is suitable for crop growth and very few precautions need to be taken concerning erosion control. Suitable for **annual cropping** at slopes of less than 3%, it most probably represents old fields in different stages of succession.

DISCUSSION: This hypothesis is motivated by the presence of a wide variety herbaceous and woody species (Table 24.a - cluster 7) at frequency of 33% and less. It can therefore either develop into a grass or tree dominated area depending on the soil water availability and fire regime (O'Connor and Bredenkamp 1997).

1.7. *Zanthoxylum capense* - *Themeda triandra* low// short sparse woodland community

GENERAL DESCRIPTION: A widely spaced, sparse canopy, broad-leave woody community found amongst the granite rock and boulders of castle kopjes.

GEOLOGICAL ENVIRONMENT: This community is underlain by unnamed igneous granite of the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: A community of the low relief mountains, it has the same terrain type as the previous community, namely C4. This community of rocky areas or scarps, occurs within the slopes range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.9°, 5%, 78.8° from North and 1101 m.a.s.l.

CLIMATIC ENVIRONMENT: This community was sampled during February 1995 at altitudes between 800 to 1000 m.a.s.l. It occurs within climate zone 112, with an average annual summer precipitation of 838.8 mm. Stands of this community are associated with flat to gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: Associated with the Fa366 land type, this community is not found on soils below **900 m.a.s.l.** No soil form is dominant due to the surface rockiness, which is high at 53% and ranges from stones to **rocks**. Where soil is present, the soil texture of the **A horizon** is medium to coarse sandy loam to sandy clay loam and ranges from soil depths of 200 to 700 mm

FLORISTIC DATA: The differentiating species are represented by diagnostic species group I, with a very high (V) fidelity and high (4) constancy with ***Zanthoxylum capense*** a conspicuous woody species. Species included in this species group are *Conyza podocephala*, *Sonchus wilmsii* and *Eriosema burkei*. Species groups X, Y, AA, AC and AD represent constant species. In species group X, *Themeda triandra* has a high (4) constancy and low (II) fidelity. *Hyparrhenia hirta* is also found in this species group. Species from species group Y excluded in the previous community are *Acalypha angustata* and *Hypoxis rigidula*. In species group AA the following species occur which did not occur in the previous community *Berkheya seminivea* and *Leonotis microphylla*. Species group AC contains the following woody species ***Rhoicissus tridentata***, ***Diospyros lycioides***, ***Acacia caffra***, ***Dombeya rotundifolia***, ***Athrixia elata***, ***Rhus dentata*** and ***Ziziphus mucronata***. Species group AD is associated with overutilised or disturbed areas. The average number of species per relevé is fifty. The high species richness reflects the combined effect of the herbaceous and woody layers. This community represents a vegetation unit found within Acocks' Northern Tall Grassveld and Low and Rebelo's North-eastern Mountain Grassland

WILDLIFE MANAGEMENT: Although associated with flat areas, the rocks or castle kopjes are the result of inselbergs forming during deep weathering and stripping, during alternating dry and wet periods of geological time. The area inbetween the castle kopjes is suitable for crops in general but is currently being used for grazing. If it were ploughed, it would have been utilised either for annual cropping or rotated between ley and crops or placed under permanent crops.

DISCUSSION: The geological structure and mineral composition of the granite castle kopjes, results in an environment with sufficient moisture to maintain trees. Coarse sandy soil textures and deep fissures, result in localised high infiltration, low runoff and a water table which could be utilised by trees with deep penetrating roots. It's gentle, north facing insolation attitude, in combination with the mineral-poor soil and low water retention, creates a warm, dry environment suitable for the dominant grass Themeda triandra.

1.8. *Acacia karroo - Heteropogon contortus* low// short thicket community

GENERAL DESCRIPTION: This is a closed canopy, bipinnate compound-leaved woody community of less steep slopes in valleys at altitudes below that of the *Rhus discolor - Schistostephium crataegifolium* low// short sparse shrubland sub-community.

GEOLOGICAL ENVIRONMENT: Igneous fine textured lava from the Onverwacht Group of the Barberton Sequence within the Swazian erathem underlay this community.

GEOMORPHOLOGICAL ENVIRONMENT: The terrain type of this high relief mountain community is C4. This community was subjectively sampled within three terrain units (midslope, scarp and valley bottom) which occured within the footslopes and valley bottoms slope range of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 6°, 10.7%, 305.6° from North and 982 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January 1995 at an elevation of between 800 to 900 m, within climate zone 120 at an average annual precipitation of 737.6 mm. Gentle, north facing insolation attitudes maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: This community occurs within the Fa soil pattern, specifically the Fa169 land type. This land type is generally not found below 650 m.a.s.l. The dominant soil form is Glenrosa, of which the B horizon soil texture ranges from fine sandy clay loam to sandy clay. Surface rockiness is 10% and occurs as rocks.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group J, with a very high (V) fidelity and ***Acacia karroo*** a very high (5) constancy. Species included in this species group are ***Bauhinia galpinii***, ***Maytenus heterophylla***, ***Cussonia spicata***, *Lantana rugosa*, *Sebaea grandis* and *Raphionacme burkei*. Species groups Y, AA, AB, AC and AD represent constant species. In species group Y, Heteropogon contortus has a high (4) constancy and low (II) fidelity. Species group AA includes the following herbaceous species Cymbopogon excavatus, Bewsia biflora, *Stachys natalensis* and *Cheilanthes quadripinnata*. In species group AB associated with surface rock, ***Diospyros whyteana*** occurred. Species group AC contains the following woody species, which did not occur in the previous community: ***Euclea crispa***, ***Peltophorum africanum*** and ***Combretum apiculatum***. Species group AD contains Aristida congesta subsp. barbicollis a grass known for its association with overutilisation and disturbance (Van Oudtshoorn 1991). The average number of species per relevé is thirty-eight. This community represents vegetation units found within Acocks' North-eastern Mountain Sourveld and Lowveld Sour Bushveld, two of his Inland Tropical Forest Types and Low and Rebelo's Sour Lowveld Bushveld.

WILDLIFE MANAGEMENT: A community of flat areas, it is suitable for crop growth, more specifically for ley or special tillage.

DISCUSSION: This is a community found on the lower slopes of areas with high relief, within a gentle north facing insolation attitude on fine textured soils. It has a soil water deficiency low enough to support trees in spite of receiving relatively low annual average precipitation due to the accumulation of water within the soil profile from the high lying areas. Fine textured soils retain more water than coarse textured soils, which extends water availability into the dry season. In spite of the presence of woody species, this is a dry environment as indicated by the deciduous nature of most of the trees and the presence of Heteropogon contortus. These fine textured soils are high in nutrients, thus representing sweet veld, and are over-utilised.

1.9. *Rhus pentheri - Hyparrhenia hirta* low// short sparse woodland community

GENERAL DESCRIPTION: This open-spaced, park-like woodland community, although characterised by the presence of ***Rhus pentheri***, is made obvious by the presence of large ***Acacia sieberiana*** trees. The dominant grass is Hyparrhenia hirta. Within the study area it occurs at low elevations, mainly within the vicinity of Barberton, with a few stands occurring from north to south on the eastern boundary.

GEOLOGICAL ENVIRONMENT: Igneous granite of the Kaap Valley Granite Suite from the Archaean erathem underlies this community.

GEOMORPHOLOGICAL ENVIRONMENT: This low relief mountain community has nature of terrain type is B3, and the area comprises more level areas with lower relief. This community consists of samples from three subjective terrain units (crests, footslopes and midslopes) within slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 1.3°, 2.4%, 43.3° from North and 789.1 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January 1995 at elevation between 700 to 800 m, within climate zone 1095, at an average annual precipitation of 716.9 mm. Stands of this community are associated with gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community is associated with the Ae105 land type at altitudes of less than 630 m.a.s.l. The dominant soil form is Hutton of which the B horizon soil texture is medium to coarse sandy loam to sandy clay. Soil depth ranges from 300 to 600 mm. Surface rockiness is average at 17%, occuring mainly as widely spaced rocks.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group K, with a very high (V) fidelity and ***Rhus pentheri*** with a very high (5) constancy. Species included in this species group are ***Acacia sieberiana*** and *Hermannia depressa*. Species groups X, Y, AA, AC and AD represent constant species. In species group X, Hyparrhenia hirta has a high (4) constancy and average (III) fidelity as well as the highest cover abundance. Another species included in this species group is Setaria sphacelata. Species group Y associated with terrestrial ecosystem contains Heteropogon contortus. *Helichrysum rugulosum* (species group AA) is a herbaceous species which did not occur, in the previous community. The woody species ***Lippia javanica*** , which was absent from the previous communities, occurs in species group AC. Species of species group AD are well known for their association with over-utilised or disturbed areas. Species group AD contains the following species not found in the previous community: Sporobolus africanus, *Oenothera tetraptera*, *Richardia brasiliensis* and *Sida alba*. These species are associated with disturbed areas (Bromilow 1995; Van Wyk & Malan 1988). The average number of species per relevé was thirty-six. This community represents vegetation units found within Acocks' Lowveld and Low and Rebelo's **Sour Lowveld Bushveld.**

WILDLIFE MANAGEMENT: A community of flat areas, it could be used for crop growth, especially for annual cropping on slopes of less than 3%.

DISCUSSION: Found mainly within the Ae soil pattern, the community occurs on eutrophic soils. The coarse textured, poorly leached, nutrient rich soils have developed *in situ* on the granite because of the low annual average precipitation and slope. Low soil water deficiency is maintained by the coarse soil texture, which provides maximum infiltration, and the low slopes, which prevent runoff. Its park-like appearance is the result of a mosaic of shallow and deep soils, with trees occurring on the deep soils and grasses on the shallow soils. The fine textured minerals or clays in the soil profile improve soil water retention, enabling a tall grass such as Hyparrhenia hirta to dominate this community which occurs on a gentle, north facing insolation attitude. Furthermore it should be noted, that this community and its widely dispersed stands often occur in close approximation to areas with high runoff such as mountains which form part of the escarpment or large bornhardts. If the distribution of ***Acacia sieberiana*** is taken into consideration, it appears that it prefers the nutrient rich areas of igneous rock and drainage lines (Table 24.a). It would seem from species composition that this community is grazed intensively because of its high nutrient availability.

Communities 1.10 and 1.11 are associated with **rocks of 200 mm to 1 000 mm and more in diameter**. The dominant physiognomic category is **low// short sparse shrubland.** These communities occur mainly within Low and Rebelo's **North-eastern Mountain Grassland** (Environmental Division 1.2.2 - Figure 31).

1.10. *Hyperthelia dissoluta - Heteropogon contortus* woodland community

DESCRIPTION: This is the mixed broadleaf-dominated woody community of the inselbergs, found within the *Loudetia flavida - Heteropogon contortus* pure short closed grassland community to the north of the study area.

GEOLOGICAL ENVIRONMENT: The stratigraphically unnamed metamorphic gneiss of the Swazian erathem underlies this community.

GEOMORPHOLOGICAL ENVIRONMENT: This high relief mountain community is associated with two nature of terrain types: B4 and C4. It was sampled with all the subjective terrain units except valley bottoms, on slopes associated with either footslopes and valley-bottoms with or midslopes-and-crests. Average values based on quantitative data for slope (°, %), aspect and altitude range: 4.3 - 10.8°, 7.6 - 19.3%, 107 - 260° from North and 1010 - 1153 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during March and May of 1994, at elevations ranging from 1000 to 1200 m.a.s.l., within climate zones 116 and 118. Average annual precipitation ranges between 800 and 900 m. Stands of this community have gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community occurs only within the Fa soil patterns, at altitudes not lower than 900 m.a.s.l. Prominent soil forms are Glenrosa and Hutton, of which the **A horizon** soil texture is coarse sand to sandy loam. Soil depth does not exceed 400 mm. Surface rockiness is very high at 65 - 82%, mainly comprising large rocks and boulders.

FLORISTIC DATA: The characteristic species are represented by diagnostic species group L, with a very high (V) fidelity and *Hyperthelia dissoluta* with a very high (5) constancy. Species included in this species group are *Aristida congesta* subsp. congesta, ***Pavetta edentula***, *Geigeria burkei*, *Cucumis zeyheri*, ***Ozoroa sphaerocarpa***, *Aristida diffusa*, and *Plectranthus madagascariensis*. Species groups Y, AA, AB, AC and AD represent constant species. In species group Y, *Heteropogon contortus* has a very high (5) constancy and low (II) fidelity. Other species in species group Y associated with terrestrial ecosystem are *Acalypha angustata*, *Senecio venosus*, *Diheteropogon amplectens* and *Loudetia simplex*. In species group AA, the following species occur: *Trachypogon spicatus*, *Gladiolus elliotii*, *Stachys natalensis* and *Chaetacanthus costatus*. All the species in species group AB associated with surface rock occur in this community: *Pellaea calomelanos*, ***Diospyros whyteana*** and *Aloe marlothii*. In species group AC the following woody species are representative of this community ***Rhoicissus tridentata*** and ***Dombeya rotundifolia***. In species group AD the grass *Melinis repens* occurs. The average number of species per relevé ranges from twenty-six to fourty-one. Physiognomically it appears either as low// short sparse shrubland or low// short thicket. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: A community within a wide range of slope categories, it is under pressure from the following agricultural practices: crops (0-15% slope), cattle (15-30% slope) and afforestation (30%+ slope).

DISCUSSION: Found on steeper slopes than the *Loudetia flavida - Heteropogon contortus* pure short closed grassland community, trees are only able to grow as a result of the higher soil water availability associated with rockiness. Species richness, composition and canopy vary according to the size of the inselberg (area covered and height), extent of fissuring and the level of weathering.

1.10.a. *Annona senegalensis - Hyperthelia dissoluta* low// short thicket sub-community

GENERAL DESCRIPTION: This sub-community covers castle kopjes or the lower slopes of large bornhardts. Its distribution is mainly on the Badplaas side of the Barberton Mountains.

GEOLOGICAL ENVIRONMENT: The stratigraphically unnamed metamorphic gneiss of the Swazian erathem found in the area underlies this community.

GEOMORPHOLOGICAL ENVIRONMENT: This sub-community is found in areas where the nature of terrain type is B4. Slopes within the footslopes and valley bottom range are associated with this sub-community. Average values based on quantitative data for slope (°, %), aspect and altitude are 4.3°, 7.6%, 260.4° from North and 1010.9 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during March 1994 at altitudes of between 1000 and 1100 m.a.s.l. This sub-community occurs within climate zone 118, with an average annual precipitation of 894.1 mm, and is a sub-community of gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community occurs within the Fa166 land type at altitudes **not lower than 900 m.a.s.l.** Glenrosa is the dominant soil forms of which the **A horizon** is coarse sand to sandy loam. Its soil depth range from 300 to 400 mm. Surface rockiness is the highest of all the abstract plant communities within this major vegetation type at 83%, and comprises large rocks, boulders and rock sheets.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group M, with very high (V) fidelity and average (3) to very high (5) constancy. ***Annona senegalensis*** has the highest cover abundance in this diagnostic species group. Other species included in this species group are *Barleria quenzii*, *Haplocarpha lyrata*, ***Ficus glumosa***, *Eriosema cordatum*, *Helichrysum dasymallum*, *Thunbergia neglecta*, *Felicia muricata*, *Acalypha peduncularis*, ***Pavetta gardeniifolia***, ***Mundulea sericea***, *Oldenlandia herbacea*, <u>*Aristida scabrivalvis*</u>, *Leonotis dysophylla*, ***Acacia nilotica***, ***Euclea divinorum***, *Pachycarpus* species, *Clematis brachiata*, ***Dovyalis zeyheri***, *Amaranthus hybridus*, *Cyphostemma lanigerum*, *Sphedamnocarpus pruriens*, ***Maytenus undata***, *Helichrysum setosum*, ***Tarchonanthus camphoratus***, *Xysmalobium undulatum*, ***Lannea discolor***, ***Faurea speciosa***, *Sansevieria hyacinthoides*, ***Lippia rehmannii***, ***Rhus pondoensis***, *Lotononis eriantha*, *Vernonia poskeana*, *Dicerocaryum eriocarpum*, *Dianthus mooiensis*, <u>*Melinis nerviglumis*</u>, *Cheilanthes eckloniana*, <u>*Eragrostis aspera*</u> and ***Acacia ataxacantha***. Species unique to this sub-community found amongst the constant species groups of the community are *Vernonia natalensis*, <u>*Panicum natalense*</u>, *Bulbostylis burchellii*, *Hypoxis rigidula*, *Berkheya seminivea*, <u>*Monocymbium ceresiiforme*</u>, *Indigofera hilaris*, *Athrixia phylicoides*, *Cyperus rupestris*, *Alepidea longifolia*, *Polygala hottentotta*, *Gnidia capitata*, *Berkheya speciosa*, *Lotononis foliosa*, *Asparagus laricinus*, ***Acacia caffra***, ***Athrixia elata***, ***Euclea crispa***, ***Peltophorum africanum***, ***Combretum apiculatum***, ***Pappea capensis***, ***Senecio barbertonicus***, <u>*Aristida junciformis*</u> and *Solanum elaeagnifolium*. The average number of species per relevé was forty-six. Physiognomically this sub-community represents woodland, which could either have a low// short shrubland or low// thicket appearance. This sub-community represents a vegetation unit found within Acocks' Piet Retief Sourveld or Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found within a flat area suitable for crop growth. Two land uses which could affect this community are ley or special tillage and rotation of ley and crops. However, the rockiness limits cultivation and it is therefore most probably utilised for grazing.

DISCUSSION: The Barberton mountains originated from a very large batholith, which was modified by tectonic activity and exposed through denudation as a gneiss bornhardt. Castle kopjes and bornhardts have large areas of shallow soils and exposed rock covering large areas, resulting in very high runoff of received precipitation. The runoff flows down fissures and cracks, accumulating between the rocks, where the deep reaching roots of the trees can extract the water. Due to the relatively high annual average precipitation, these areas receive, excess water that seeps from the inselbergs, providing water over extended periods, and thus enabling a tall grass species such as Hyperthelia dissoluta to dominate. Gneisses are generally rich in quartz but poor in clay-forming minerals, and are therefore nutrient poor. Thus is further enhanced by high rainfall and leaching. This community therefore represents sourveld on dys- to mesotrophic soils.

1.10.b. *Sutera aurantiaca - Hyperthelia dissoluta* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: A broadleaf dominated woody sub-community occurring on elevations above the previous sub-community. The woody components are more widely spaced and shrub-like.

GEOLOGICAL ENVIRONMENT: The stratigraphically unnamed metamorphic gneiss of the Swazian erathem found in the area underlies this community.

GEOMORPHOLOGICAL ENVIRONMENT: This sub-community occurs within steeper environments of the community in the high relief mountains as indicated by its nature of terrain type **C4**. The steeper environment is confirmed by its occurence within slopes of the midslope and crest range. Average values based on quantitative data for slope (°, %), aspect and altitude are 10.8°, 19.3%, 107.6° from North and 1153.5 m.a.s.l.

CLIMATIC ENVIRONMENT: This sub-community was sampled during May 1994 at elevations of between 1100 and 1200 m.a.s.l.. It lies within climate zone 116, and receives an average precipitation of 856.9 mm per annum. Stands of this sub-community occur in insolation, and attitudes ranging from gentle, north to south facing.

PEDOLOGICAL ENVIRONMENT: This sub-community occurs also within the Fa soil pattern at altitudes not much higher than 1200 m.a.s.l. Dominant soil forms are Glenrosa and Hutton, of which the dominant **A horizon** soil texture is fine sandy clay loam. Soil depth ranges between 100 or 200 mm up to 450 mm. Surface rockiness is average at 66%, mainly occuring as large rocks and boulders.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group N, with very high (V) fidelity and low (2) to average (3) constancy. *Sutera aurantiaca* are one of the species with the highest constancy in this diagnostic species group. Other species included in this species group are *Euclea undulata*, Trichoneura grandiglumis, ***Rhus rehmanniana***, Pogonarthria squarrosa, *Xerophyta retinervis*, ***Dichrostachys cinerea***, *Pearsonia sessifolia* and *Rhynchosia nitens*. Species unique to this sub-community which are found amongst the constant species groups of the community are Themeda triandra, Tristachya leucothrix, Bewsia biflora, *Dicoma zeyheri*, *Chaetacanthus setiger*, *Dicoma anomala*, ***Diospyros lycioides***, ***Euclea natalensis***, and ***Lippia javanica***. The average number of species per relevé was forty-one. Physiognomically this sub-community represents a low// short shrubland. It correlates with a vegetation unit found within Acocks' Piet Retief Sourveld or Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Although found over a wide range of slope categories, this sub-community tends towards the steep and very steep environments. Therefore the suggested land use from an erosion point of view for slopes of 15 to 30% is grazing and for more than 30% wildlife and afforestation.

DISCUSSION: This sub-community has less soil water available than the previous community, because it occurs on steeper slopes or on newly exposed bornhardts, preventing a closed canopy community from forming. Deep soils and too little exposed rock surround a newly exposed bornhardt for increased runoff. Water which accumulates in fissures is released deep into the soil profile at lower elevations, providing the moisture which maintains the tall grasses of the *Loudetia flavida* - *Heteropogon contortus* pure short closed grassland. Where this sub-community occurs above the *Annona senegalensis* - *Hyperthelia dissoluta* low// short thicket sub-community, slopes are steep, therefore naturally lowering the grazing pressure if compared to its neighbour (Species Group AD - Table 24.b).

1.11. *Englerophytum magalismontanum* - *Heteropogon contortus* low// short thicket community

GENERAL DESCRIPTION: A broadleaf woody community of a very large bornhardt on the road between Badplaas and Oshoek. Although characterised by the presence of the shrub ***Englerophytum magalismontanum***, it is most easily recognised from a distance by the Tree euphorbia (***Euphorbia ingens***).

GEOLOGICAL ENVIRONMENT: This community is underlain by igneous syenite of the Bosmankop Syenite Suite within the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of terrain type of this high relief mountain community is **C4**. This community was sampled within all the subjecitve terrain units except valley bottoms. It is found within slopes of 12 to 100% associated with crests and midslopes. Average values based on quantitative data for slope (°, %), aspect and altitude are 15.4°, 28.5%, 235.8° from North and 1284.5 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during March 1994 at altitudes of between 1200 and 1300 m.a.s.l. It is found within climate zone 116, with an average of 856.9 mm precipitation annually. Stands of this community occur within gentle to steep, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community occurs within land type Fa168, at altitudes not below 1200 m. The dominant soil form is Glenrosa, with a coarse to medium sandy clay texture **A horizon**. Soil depth ranges from 100 to 350 mm. Surface rockiness is high at 73%, and consists of rocks.

FLORISTIC DATA: The differentiating species are represented by species group O, with a very high (V) fidelity and high (4) to very high (5) constancy. ***Englerophytum magalismontanum*** has the highest constancy and estimated cover abundance. Species included in this species group are *Zantedeschia aethiopica*, ***Rhus chirindensis***, ***Euphorbia ingens***, Hyparrhenia dregeana, Sporobolus pectinatus, *Rhus discolor*, *Aloe arborescens*, *Chamaecrista biensis*, *Chaetacanthus burchellii*, ***Buddleja salviifolia*** and *Cheilanthes eckloniana*. Species groups X, Y, AA, AB, AC and AD represent constant species. In species group Y, Heteropogon contortus has a high (4) constancy and low (II) fidelity, although Setaria sphacelata in constant species group X has a higher estimated cover abundance than Heteropogon contortus. Heteropogon contortus was, however, chosen as the general species because it is the only species in the genus, compared to the number of variations found for Setaria sphacelata. Another species found in species group Y, is *Senecio venosus*. Species found in this community but not the previous one are Cymbopogon excavatus, *Berkheya echinacea*, *Commelina africana*, Schizachyrium sanguineum, Digitaria diagonalis, Panicum maximum and *Xanthium strumarium*. The average number of species per relevé was thirty. This community represents a vegetation unit found within Acocks' Lowveld Sour Bushveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community occurs within the very steep slope range of the adapted pasture classification. It should be used for wildlife and afforestation, because such slopes of 31% or more are prone to erosion.

DISCUSSION: This community is found within the same inselberg-dotted landscape of the previous communities, but is separated from them by size and lithology. It covers a larger area than castle kopjes but is not as high as the Barberton Mountains. The tree line associated with the Barberton Mountains is absent and grasses form part of the herbaceous layer underneath a closed canopy tree layer. Acocks (1988) described this Lowveld Sour Bushveld veld type as transitional between his Lowveld and North-eastern Mountain Sourveld veld types. The difficult but beautiful terrain associated with this community makes it a potential national heritage site. Eco-tourism is the only land use this community would facilitate with its steep slopes, shallow soils and rugged terrain.

2. Wetlands (Figure 31)

Wetland sample plots from the mountain vegetation type in the **valley bottoms** are mainly underlain by geological formations of the **Swazian erathem**. Slopes are flat (8%) ranging from **0 to 12%**, associated with footslopes and valley bottoms. The dominant soil form is **Katspruit. Rocks are limited**. It occurs within Acocks' **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland** (Figure 31). This abstract association consists of five plant communities representing five communities. They are:

2.1 *Eriosema salignum* - *Hyparrhenia hirta* short closed grassland community

2.2. *Schizostylis coccinea* - *Eragrostis plana* low// short bushland community

2.3. *Combretum erythrophyllum* - *Setaria sphacelata* low// short bushland community

2.4. *Setaria nigrirostris* - *Themeda triandra* pure low closed grassland community

2.5. *Helichrysum harveyana* - *Setaria sphacelata* pure low closed grassland community

Communities 2.1 to 2.3 are found on **igneous** rock and physiognomically represent **low// short bushland** (Environmental Division 2.1 - Figure 31). Communities 2.2 and 2.3 are underlain by lava, and are not found below 900 m.a.s.l. The B horizon soil texture ranges from fine sandy clay loam to sandy clay. These communities are found within Acocks' Northern Tall Grassland (Environmental Division 2.1.2 - Figure 31).

2.1 *Eriosema salignum* - *Hyparrhenia hirta* short closed grassland community

GENERAL DESCRIPTION: This community is found along drainage lines right through the mountain vegetation type. The herbaceous layer is dominated by Hyparrhenia hirta.

GEOLOGICAL ENVIRONMENT: This community is underlain by igneous and **sedimentary** rock. **Unnamed** igneous **granite** from the Swazian erathem and sedimentary **arenite** of the Vryheid Formation of the Ecca Group within the Karoo Sequence from the Phanerozoic erathem.

GEOMORPHOLOGICAL ENVIRONMENT: It is a community of the **low relief mountains.** The associated nature of terrain type of its stands is **B3.** It was subjectively sampled within the valley bottoms, terrain unit on slopes associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 3.4°, 5.8%, 137.9° from North and 1385.9 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during 1995 at elevations of between **1400 to 1500 m.a.s.l.** It is found within climate zone 111, and receives 821.9 mm precipitation on average annual. **Gentle, south-east facing** insolation attitudes maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: This community is found within land type Ba45, at altitudes not below 1300 m.a.s.l. The dominant soil form is Katspruit with a sandy clay to clay texture B horizon. This is a typical area next to drainage lines, which becomes periodically inundated. The soil depth ranges from **300 to 1200 mm.** Surface rockiness is limited at 1% and is not larger than stones.

FLORISTIC DATA: Diagnostic species group P represents the differentiating species, with a very high (V) fidelity and average (3) constancy. *Eriosema salignum* has the highest constancy at 60%, while Hyparrhenia cymbaria occurs also within this species group. *Kyllinga alba* and *Wahlenbergia undulata* are found in diagnostic species group R, which is a transitional species group. Another transitional species group is diagnostic species group U, consisting of *Coleochloa setifera* and *Mariscus congestus*. Constant species are found within species groups X, Z, AA, AC and AD. Hyparrhenia hirta in constant species group X has the highest estimated cover abundance with an average (III) fidelity and very high (5) constancy. Other species in this species group are Themeda triandra and Setaria sphacelata. Species group Z contains species associated with wetland ecosystems, i.e. Eragrostis plana, *Cyperus esculentus*, *Verbena brasiliensis* and Arundinella nepalensis. Herbaceous species from species group AA are *Haplocarpha scaposa*, Cymbopogon excavatus, Eulalia villosa, Bewsia biflora, *Helichrysum rugulosum*, *Commelina africana*, *Hypoxis iridifolia*, *Chaetacanthus costatus*, *Cyperus rupestris* and *Berkheya speciosa*. ***Lippia javanica*** is a woody species from species group AC. Two species associated with overutilisation from species group AD are Aristida junciformis and Eragrostis curvula. Physiognomically it is associated with a short closed grassland. The average number of species per relevé was thirty. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found within a flat area. It is suitable for crop growth, more specifically for **ley or special tillage crops and rotation of ley and crops.**

DISCUSSION: This community represents the transitional zone between the terrestrial ecosystem and the frequently or permanently inundated communities of the wetland ecosystem. Its width varies according to local relief and climate. It only becomes flooded during floods, following high rainfall in the summer catchment areas. It is possible in the case of this community that Eulalia villosa might have been mistakenly identified and should rather be Ischaemum fasciculatum. According to Van Oudtshoorn (1991), the former seldom occurs in moist areas.

2.2. *Schizostylis coccinea - Eragrostis plana* low// short bushland community

GENERAL DESCRIPTION: This community is associated with perennial streams. These streams have low levees and narrow streambeds. This is typical of narrow drainage lines where the amount of water, the currents and the sediment loads change frequently.

GEOLOGICAL ENVIRONMENT: On rocks of Swazian age, igneous unnamed granite and lava from the Onverwacht Group of the Barberton Sequence underlies the community. In areas underlain by rocks of the Phanerozoic erathem, the rocks are sedimentary arenite from the Vryheid Formation and shale of the Pietermaritzburg Formation of the Ecca Group within the Karoo Sequence.

GEOMORPHOLOGICAL ENVIRONMENT: It is a community which occurs within low relief mountains. Stands of this community are not associated with a specific nature of terrain type. More than 50% of the area consists of slopes less than 8%, with relief ranging from 30 – 150 m. It was subjectively sampled within valley bottoms on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.4°, 4.2%, 182.4° from North and 1199.3 m.a.s.l.

CLIMATIC ENVIRONMENT: Sampling took place during January **1995** at elevations between 1100 and 1500 m.a.s.l. over a wide variety of climate zones, with an average annual precipitation ranging from 775 to 1099.2 mm. Stands of this community occur within **flat** to gentle, **north facing** insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community was sampled within the Ac, Ad, Ae and Fa soil patterns, at altitudes not below **900 m.a.s.l.** The dominant soil form is Katspruit, of which the dominant soil texture of both the A and B horizons is sandy clay loam. The soil depth ranges from 300 to 600 mm and more. Surface rockiness is low at 15%, and consists of stones and rocks.

FLORISTIC DATA: diagnostic species group Q, with very high (V) fidelity and low (2) constancy represents the differentiating species. *Schizostylis coccinea* has the highest estimated cover abundance. Other species in this species group are *Chamaecrista comosa*, *Bidens pilosa*, *Senecio affinis* and *Oxalis purpurea*. Species of both the transitional species groups, diagnostic species groups R and U, occur within this community. Additional species from another transitional species group, represented by diagnostic species group T are Phragmites australis and Miscanthus junceus. Species constantly present in this community are found in species groups X, Z and AD. Eragrostis plana in species group Z has a high fidelity, very high constancy and high estimated cover abundance. Other species in this community, which did not occur in the previous one, are Paspalum dilatatum, *Schkuhria pinnata*, Imperata cylindrica, *Persicaria lapathifolia*, *Hypochoeris radicata* and *Oenothera tetraptera*. Physiognomically it is associated with low// short bushland. The average number of species per relevé was twenty-nine. This community represents a vegetation unit found within Acocks' Northern Tall Grassland and Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found within the adapted pasture classification's flat area. It is suitable for crop growth, more specifically annual crops and ley or special tillage.

DISCUSSION: This is a community of the upper course of drainage lines, where its physiognomic appearance changes according to local topographic conditions. Grassland occurs within wide valleys, while shrubland to bushland occur within narrow valleys. The characteristic species *Schizostylis coccinea*, is a forb is usually associated with the grassland variation under pristine conditions. Woody species occur at frequencies less than 33 % (Table 24.a - cluster 15), ***Leucosidea sericea, Acacia karroo, Rhoicissus tridentata, Diospyros lycioides, Euclea natalensis*** and ***Acacia caffra***, are associated with the shrub- or bushland variation, depending on the degree of over-utilisation.

2.3. *Combretum erythrophyllum - Setaria sphacelata* low// short bushland community

GENERAL DESCRIPTION: This broadleaf woody community is found on the banks of perennial rivers within the lower course of drainage lines. This is typical of large drainage lines or rivers, with wide streambeds, prominent levees and variable water levels.

GEOLOGICAL ENVIRONMENT: This community is underlain by igneous lava of the **Onverwacht Group** of the **Barberton Sequence** within the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain type of this **high relief mountain** community is A3 and represents largely level areas. This community was subjectively sampled within valley bottoms. The slope ranges from 0 to 12%, and is associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 1°, 1.9%, 149.3° from North and 950.3 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during **February 1995** at elevations between 800 and 900 m.a.s.l. This low// short bushland community is found within climate zone 121, with an average annual precipitation of 656.4 mm. This community's stands are associated with **flat, no aspect** insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community was sampled within land type Ae54 at altitudes not lower than 750 m.a.s.l. Soil forms include Hutton, Shortlands, Katspruit, Bonheim and Oakleaf. The soil texture varies from medium to coarse sand to fine sandy clay loam to sandy clay. The soil depth ranges from **200 to 1200 mm and more**. No surface rockiness occurs.

FLORISTIC DATA: The differentiating species associated with diagnostic species group S, has a very high fidelity (V) and high (4) constancy, with ***Combretum erythrophyllum*** a conspicuous woody species. Other species in this diagnostic species group are Bothriochloa insculpta, *Conyza scabrida* and Cynodon dactylon. The species from the two transitional diagnostic species groups T and U also occurr in this community. Constant species for this community are found in species groups X, Z, AA, AC and AD. Setaria sphacelata in constant species group X has a high (4) constancy and low (II) fidelity, but a higher estimated cover abundance than Hyparrhenia hirta, which is also found in this species group. Species from species groups AA, AC and AD absent from the previous community but found in this community are Panicum maximum, *Xanthium strumarium*, ***Diospyros lycioides, Dombeya rotundifolia***, Melinis repens, *Solanum elaeagnifolium*, Sporobolus africanus, *Phymaspermum athanasioides*, *Richardia brasiliensis* and *Sida alba*. The last six species from species group AD are associated with overutilisation. Physiognomically it is associated with low// short bushland. The average number of species per relevé was thirty-seven. This community represents a

vegetation unit found within Acocks' **Lowveld Sour Bushveld**, Northern Tall Grassland and Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.
WILDLIFE MANAGEMENT: This community associated with flat areas is also suitable for crop growth, especially **annual cropping**.
DISCUSSION: The topography along the lower course is less steep, well within the category suitable for cultivation. Soils are deep and rocks limited. For these reasons this community is often reduced to a narrow strip, most of it being replaced by annual crops. This community is seldom in a pristine state, as indicated by the number of species associated with over-utilisation which occur.

Communities 2.4 and 2.5 are found within the **high relief mountains**, in areas where the slopes range from **0 to 2°**, and never receives perpendicular insolation. It is habitat suitable for **annual cropping** because the slopes range from 0 to 3% (Environmental Division 2.2 - Figure 31).

2.4. *Setaria nigrirostris* - *Themeda triandra* pure low closed grassland community
GENERAL DESCRIPTION: This grassland community occurrs along the non-perennial tributaries of streams and rivers.
GEOLOGICAL ENVIRONMENT: **Sedimentary** shale of the Silverton Formation of the Pretoria Group within the Transvaal Sequence of the Vaalian erathem underlays this community.
GEOMORPHOLOGICAL ENVIRONMENT: Stands of this high relief mountain occur in areas where the nature of terrain type is A3. Samples from this community were subjectively sampled in valley bottoms on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 1.6°, 2.8%, 110° from North and 1569.3 m.a.s.l.
CLIMATIC ENVIRONMENT: It was sampled during **January 1995** at elevations higher than 1400 m.a.s.l. It occurs within two climate zones, climate zone 52 and 1105. Annual average precipitation ranges from 758 to 794 mm. Representative stands of this community occur within **flat, no aspect** insolation attitudes.
PEDOLOGICAL ENVIRONMENT: It is found within land type Ac72, at altitudes not lower than 1460 m.a.s.l. The dominant soil form is Katspruit followed by Griffin. In general the soil texture ranges from fine sand clay to clay. The soil depth ranges from 400 to 900 mm and deeper. Surface rockiness is low at 17% and ranges from pebbles to stones.
FLORISTIC DATA: The differentiating species are found within diagnostic species group V, with a very high (V) fidelity and average (3) constancy. Of the two species, Setaria nigrirostris and *Datura stramonium* found in this species group, Setaria nigrirostris has the highest estimated cover abundance. Constant species for this community are found in species groups Y, Z, AA and AD. Themeda triandra (species group X) has a very high (5) constancy, low (II) fidelity and highest estimated cover abundance. The other two species found in this species group, are Setaria sphacelata and Hyparrhenia hirta. Species associated with wetlands (species group Z), which did not occur in the previous community, are *Cyperus esculentus*, *Verbena brasiliensis* and Imperata cylindrica. Eragrostis capensis is the only representative of species group AA in this community. In species group AD associated with overutilisation the following species are found: Eragrostis curvula, *Oenothera tetraptera*

and *Hibiscus trionum*. Physiognomically it is associated with pure low closed grassland, and the average number of species per relevé was twenty-six. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found within flat areas, and is used for crop growth because it is less sensitive to erosion. The suggested land use is annual cropping.

DISCUSSION: This community is found in the same position as the *Eriosema salignum* - *Hyparrhenia hirta* short closed grassland community, except that the drainage line is less well defined. In most cases these drainage lines are no more than erosion gullies or shallow depressions, making it difficult to distinguish this community from grassland communities of the terrestrial ecosystems. This community is seldom inundated as indicated by the presence of the Griffin soil form.

2.5. *Helichrysum harveyana* - *Setaria sphacelata* pure low closed grassland community

GENERAL DESCRIPTION: Found within poorly developed tributaries (drainage lines), erosion gullies or shallow depressions, this community is only temporarily inundated after heavy rains during the summer.

GEOLOGICAL ENVIRONMENT: This community is underlain by **unnamed** metamorphic gneiss of the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain type associated with this high relief mountain community terrain type is B4. It was subjectively sampled within valley bottoms, occurring on slopes of between 0 to 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 0.9°, 1.7%, 105° from North and 1346.6 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during May 1994 at altitudes of between 1000 and 1200 m.a.s.l. It occurs within climate zone 118, with an average annual precipitation of 894.1 mm. Stands of this community occur on **flat, north** and south facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community occurs within land type Fa166, at altitudes not lower than 900 m.a.s.l. The dominant soil form is Katspruit of which the **A horizons soil texture is fine sandy clay loam to sandy clay**. The soil depth ranges from 300 to 700 mm. No surface rock occurs.

FLORISTIC DATA: Diagnostic species group W represents the differentiating species, with a very high (V) fidelity and average (3) constancy. Within this species group, *Helichrysum harveyana* has the highest constancy at 60%. Other species in diagnostic species group W are <u>Leersia</u> <u>hexandra</u>, <u>Andropogon</u> <u>eucomus</u>, <u>Agrostis</u> <u>eriantha</u>, *Mentha aquatica* and *Gunnera perpensa*. Constant species for this community are found within species groups X, Z and AD. <u>Setaria</u> <u>sphacelata</u> (species group X) has a low (II) fidelity and high (4) constancy. Species of species group Z, absent in the previous community but present in this community are <u>Arundinella</u> <u>nepalensis</u> and *Persicaria lapathifolia*. *Phymaspermum athanasioides* (species group AD) is absent from this community. Physiognomically it is associated with pure low closed grassland, and the average number of species per relevé was fifteen. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community of flat areas could be used for crop growth. Within this community slopes of between 0 to 3% are under pressure from agriculture because it is suitable for annual crops.

DISCUSSION: The presence of water within this community is too unpredictable and variable to support wetland species associated with well developed streams and rivers. Where water seeps from stratum springs or perched water tables, the forb *Gunnera perpensa* is able to grow, while the presence of *Leersia hexandra* and *Persicaria lapathifolia* indicate that standing water occurs occasionally.

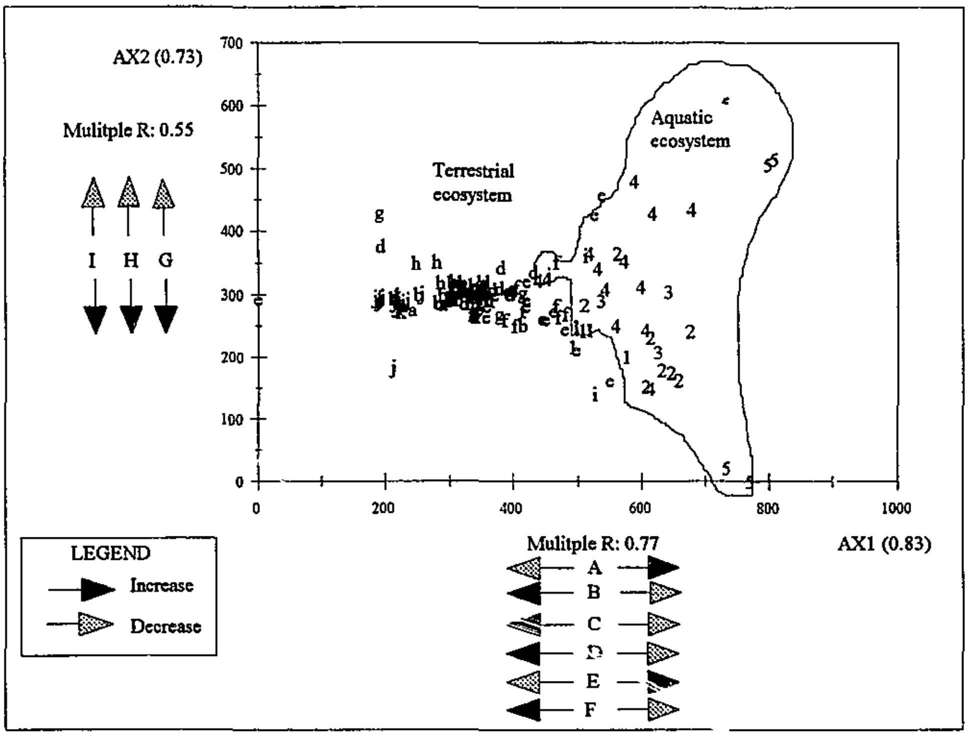
Communities 2.1 to 2.3 qualify for inclusion in two of the five main riparian wetland categories of South Africa. Community 2.2 belongs to the floodplain vlei category, community 2.3 to the riparian fringe category, while community 2.1 belongs to the floodplains associated with both of these categories (Cowan 1995).

Those species at the bottom of the species list of the phytosociological table, occurred in between one and ten percent of the 405 plots surveyed, but not in this vegetation type of 145 plots. They are *Eragrostis gummiflua*, *Syncolostemon concinnus*, *Moraea pubiflora*, *Convolvulus sagittatus* var. *hirtellus*, *Tephrosia macropoda*, *Trifolium africanum* and *Setaria lindenbergiana*. Their inclusion is based on the hypothesis that their absence should indicate some or other environmental factor not found within the mountain vegetation type. *Eragrostis gummiflua* is abundant in areas of high precipitation on rocky and sandy soils and *Setaria lindenbergiana* prefers rocky slopes and ravines, where it grows in cracks and in the shade of trees (Van Oudtshoorn 1991). Little or no information is available on the forbs, making it impossible to find any factor of significance.

2.2. Ordination

Environmental trends were identified by means of DECORANA and multiple regression (Figure 32). The communities of the terrestrial ecosystem were assigned letters in chronological sequence and that of the aquatic or wetland ecosystem numbers. The ordination plot reflects only those variables of the different environments of which the trends were statistically significant (P-value $< \alpha$ at $\alpha = 0.5$). The table associated with the figure reflects those statistical parameters supplied by multiple regression analysis. Of these parameters only the coefficients and P-value fields were of value. Only environmental variables with low P-value were included while the coefficients indicated whether a positive or negative correlation existed between the environmental variable gradient and the floristic data.

Most significantly on the AX1 axis is soil water availability, which is based on the subjectively sampled terrain units. The positive gradient reflects the increase in soil water availability from crest to the valley bottoms, where crests were assigned a value of one and valley bottoms a value of five. Soil texture has



Symbol	Variables	Coefficients	Standard Error	t Statistic	P-value < Alpha@0.05	Lower 95.00%	Upper 95.00%
AX1	Intercept	1981.796503	1031.012459	1.922185	0.056557	-60.631235	4024.224242
A	Soil water availability	38.798568	8.723540	4.447572	0.000017	21.517303	56.079834
B	Terrain type	-73.515236	19.993175	-3.677017	0.000332	-113.1216[illegible]	-33.908910
C	Chronostratigraphic age	-2.028662	0.957219	-2.119329	0.035778	-3.924906	-0.132418
D	Average annual precipitation	-0.153525	0.073691	-2.083362	0.038986	-0.299505	-0.007544
E	Climate zone	2.856442	1.371346	2.082947	0.039024	0.139816	5.573069
F	Terrain type nature	-18.925683	9.518605	-1.988283	0.048676	-37.781966	-0.069400
AX2	Intercept	955.818796	672.372802	1.421561	0.157316	-376.146544	2287.784137
G	Soil texture	-2.834551	0.928691	-3.052201	0.002706	-4.674281	-0.994822
H	Climate zone	-2.065618	0.894321	-2.309705	0.022326	-3.837260	-0.293975
I	Soil depth (mm)	-0.089245	0.044874	-1.988794	0.048619	-0.178139	-0.000350

Figure 32: DECORANA ordination scatter diagram showing the two ecosystems, their communities and the most significant environmental trends (Eigen values)

a very important function because it is significant on both axes. This correlates well with soil water availability because soil texture influences the water retaining capabilities of soils. The soil texture was assigned a texture index based on the average percentage sand, silt and clay. The lower the index the higher the sand content, the higher the index the higher the silt and clay content. Therefore poor soil water availability is associated with a low soil texture index on the AX1 axis, correlating with the terrestrial ecosystem. The AX2 axis reflects a broad trend from top to bottom of a dry, warm environment to a cool, moist environment. Sandy textures, northerly high relief mountains, warm wide valleys, low lying rain-shadowed, low rainfall, shallow soils on igneous and metamorphic rock of Archaean and Swazian age occur at the top. Clay textures, southerly low relief mountains, cool, narrow valleys, high lying rain-receiving, high rainfall and deep soils on igneous and sedimentary rock of Vaalian and Phanerozoic age occur at the bottom.

2.3. General

It is clear from the results that the eighteen clusters from the TWINSPAN classification, which conform to the conditions set, are separable and of informational value. Thirteen of these clusters represent abstract vegetation communities found within the terrestrial ecosystem of the Southeastern Mpumalanga Mountain Vegetation Type. The other five represent abstract vegetation communities from the aquatic or wetland ecosystem.

Within the terrestrial ecosystem it would seem that woody communities of large shrubs and trees are associated with large rocks and boulders of igneous and metamorphic origin. Broad leafed dominant woodland communities occur on coarse textured soils (Community 1.2, 1.7, 1.10. 1.11), while bipinnately compound leafed dominant woodland communities occur on fine textured soils (Community 1.8). Pure grassland communities of low or short grass within the terrestrial ecosystem are found in areas where surface rockiness and water percolation is limited. When the average lengths of the grass species indicated in Van Oudtshoorn (1991), are used, the physiognomic classification of the grassland communities should be changed from short (0.5 - 1 m) to tall (1 - 2 m) and from low (0 - 0.5 m) to short (0.5 - 1 m). Tall grass occurs in areas of higher soil water availability [higher precipitation, less steep slopes, closer to sources of water (e.g. surface rocks and adjacent to areas of low infiltration and high runoff), fine textured soils, less leached soils, deep soils and drainage lines] than short grass.

In the aquatic ecosystem, *Hyparrhenia hirta* is associated with areas adjacent to well developed drainage lines such as streams (Community 2.2) and rivers (Community 2.3). Trees are found on the levees of rivers and streams in narrow valleys (gorges). Communities 2.4 and 2.5 represent areas of temporary water accumulation such as depression or gullies. In community 2.5 the water tends to remain the longest and might even flow at times. The concept of woody species reflecting the soil texture is also present in the aquatic ecosystem, where broadleaf trees grow on the coarse textured levees of rivers and bipinnately compound leave trees on the fine textured soils of streams. These differences in species composition of woodland communities due to soil texture differences are well documented for the savanna biome (Scholes 1997, Winterbach 1998).

In general, tall grasses are dominant throughout the southeastern Mpumalanga Mountain Vegetation Type, and it therefore may be seen as the South African equivalent of prairie. It is interesting that most of the widely spaced woody communities occur on rocks of Precambrium age (Archaean, Swazian and Vaalian erathems). These rocks are associated with exposed shield, consisting of igneous and metamorphic rock on the eastern side of the study area.

CHAPTER VI - THE PHYTOSOCIOLOGY OF THE SOUTHEASTERN MPUMALANGA HILLS & LOWLANDS VEGETATION TYPE

1. Introduction

The undulating hills and lowland vegetation type occur to the east of the study area, with a section extending to the northwest in the north (Figure 33). Undulating hills and lowlands are associated with this vegetation type (Chapter IV).

The abiotic components involved in the formation of undulating hills and lowlands and their influence on the biotic components, are discussed in detail from both a global and local perspective in Chapter III. The undulating hills and lowlands formed mainly on the igneous rocks of the exposed shield.

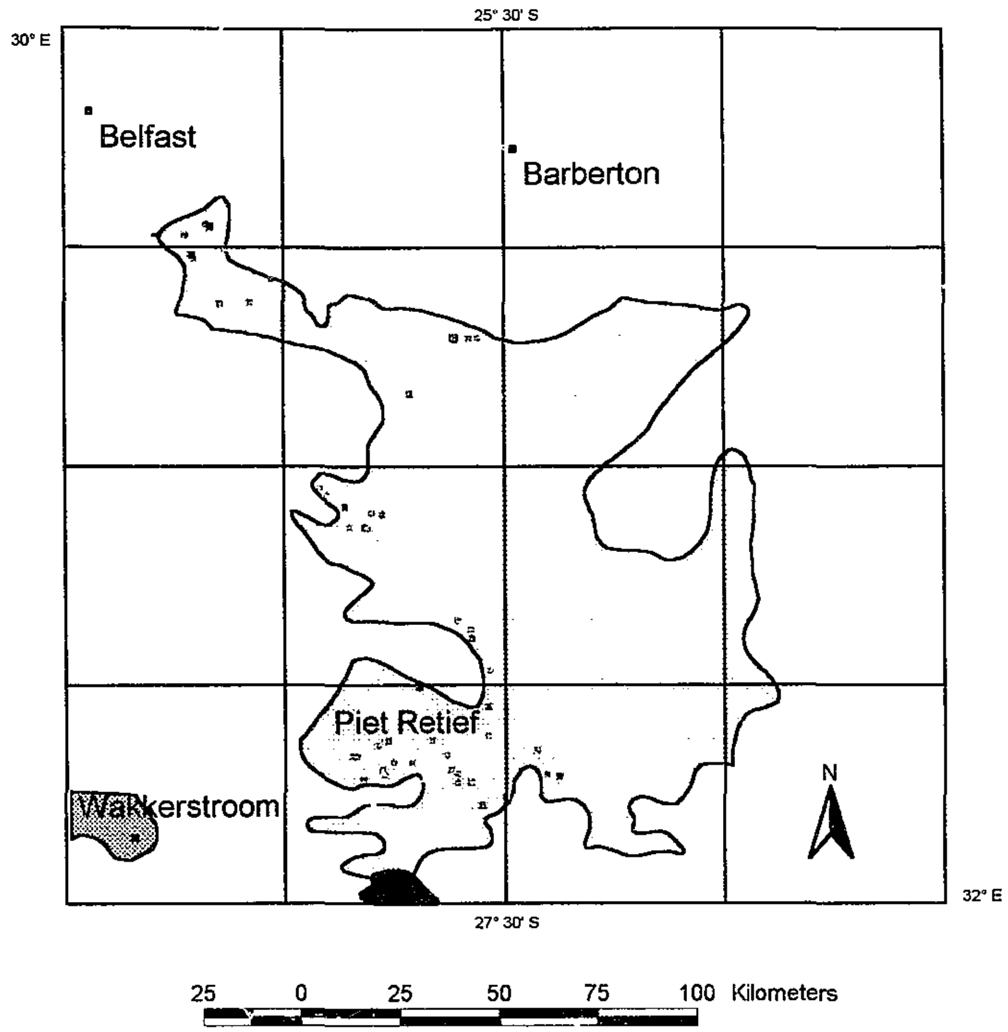
The methods applied are described in Chapter II, paragraph 3.1. Plant communities were given a specific name consisting of two botanical names and a subjective physiognomic classification according to Edwards (1983). The first botanical name indicates the characteristic species with the highest fidelity and constancy and the second the constant species with the highest constancy and lowest fidelity. If more than one species was found which qualify either as characteristic or constant then the species with the highest estimated cover abundance was selected. Pure low or short grassland communities indicate communities in which woody species with shrub or tree-like life forms do not occur. In the floristic descriptions, woody species are printed in bold, grasses are underlined and forbs are in italic. Species richness was based on the average number of species per relevé in the plant community.

2. Results and discussion

2.1. Classification

Thirteen clusters of the TWINSPAN classification executed on the 109 plots associated with the hills and lowlands landform, qualified as being separable and of informational value (Figure 34). Results from the analysis of the environmental attributes confirmed their separability and informational value. Environmental attributes printed in bold are those attributes which differentiate at 80% frequency or more, either one environmental division or one cluster from another (Figure 34).

Table 25.a (Appendix I) reflects those species, included in the phytosociological table at constancy levels of more than 33% per cluster. Diagnostic species groups indicate those species with very high fidelity (low percentage) and separability per cluster (Table 25.b). Estimated cover abundance and

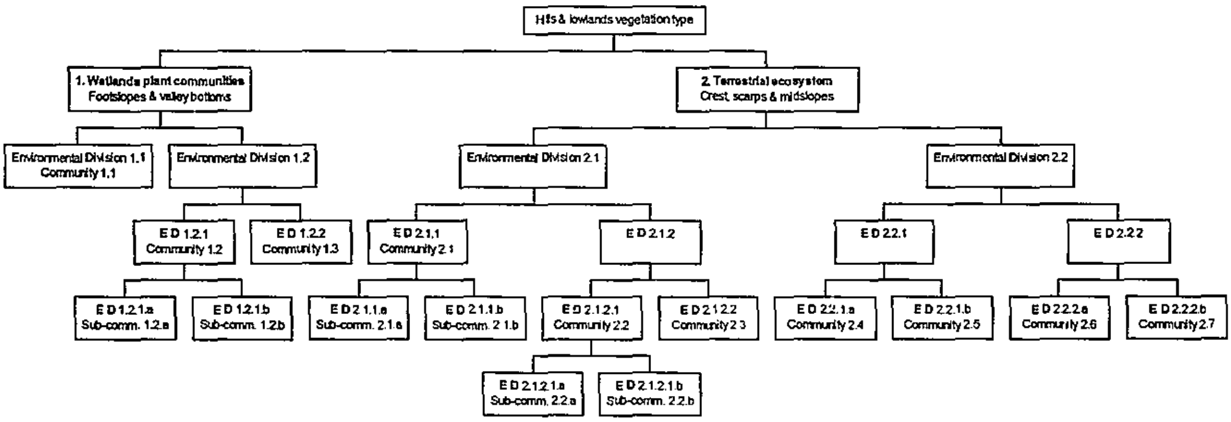


Geographical grid
Towns
Hills and Lowlands wetlands ecosystem
- 1.01. Cliffortia nitidula - Setaria sphacelata Pure low closed grassland community
- 1.02. Miscanthus junceus - Cyperus esculentus Pure low closed grassland community
- 1.03. Oenothera tetraptera - Paspalum dilatatum Pure low closed grassland community

Hills and Lowlands terrestrial ecosystem
- 2.01. Helichrysum nudifolium - Hyparrhenia hirta Pure low closed grassland community
- 2.02. Pentanisia angustifolia - Themeda triandra Pure low closed grassland community
- 2.03. Oxalis purpurea - Helichrysum rugulosum Pure low closed grassland community
- 2.04. Aloe marlothii - Hyparrhenia hirta Low// short thicket community
- 2.05. Diheteropogon amplectens - Themeda triandra Low// short thicket community
- 2.06. Tetraselago wilmsii - Commelina africana Low// short sparse shrubland community
- 2.07. Sporobolus pectinatus - Tristachya leucothrix Low// short sparse shrubland community

Southeastern Mpumalanga Hills and Lowlands Vegetation Type
- Irregular undulating lowlands with hills
- Strongly undulating irregular land
- Undulating hills and lowlands

Figure 33: The Southeastern Mpumalanga Hills and Lowlands Vegetation Type, indicating the approximate distribution of the terrestrial and aquatic ecosystems with their communities



1. Wetland plant communities
1.1 *Cliffortia nitidula - Setaria sphacelata* Pure low closed grassland
1.2. *Miscanthus junceus - Cyperus esculentus* Pure low closed grassland
1.2.a. *Arundinella nepalensis - Miscanthus junceus* Pure low closed grassland sub-community
1.2.b. *Sporobolus africanus - Miscanthus junceus* Pure low closed grassland sub-community
1.3. *Oenothera tetraptera - Paspalum dilatatum* Pure low closed grassland
2.Terrestrial ecosystem communities
2.1. *Helichrysum nudifolium - Hyparrhenia hirta* Pure low closed grassland
2.1.a. *Paspalum scrobiculatum - Helichrysum nudifolium* Low// short sparse shrubland sub-community
2.1.b. *Indigofera comosa - Helichrysum nudifolium* Pure short closed grassland
2.2. *Pentanisia angustifolia – Themeda triandra* Pure low closed grassland
2.2.a. *Helichrysum cephaloideum - Pentanisia angustifolia* Pure low closed grassland sub-community
2.2.b. *Clutia monticola - Pentanisia angustifolia* Low// short sparse shrubland sub-community
2.3. *Oxalis purpurea - Helichrysum rugulosum* Pure low closed grassland
2.4. *Aloe marlothii - Hyparrhenia hirta* Low// short thicket
2.5. *Diheteropogon amplectens – Themeda triandra* Low// short thicket
2.6 . *Tetraselago wilmsii - Commelina africana* Low// short sparse shrubland
2.7. *Sporobolus pectinatus - Tristachya leucothrix* Low// short sparse shrubland

Figure 34: TWINSPAN classification dendrogram of the hills and lowlands vegetation type

number of relevés per cluster are displayed in Table 25.c. Each cluster represents a specific abstract plant community with its own set of species and environmental attributes.

2.1.1. Southeastern Mpumalanga Hills and Lowlands Vegetation Type

Southeastern Mpumalanga hills and lowlands vegetation type (Figure 34) consists of two ecosystems: a terrestrial ecosystem with nine abstract plant communities and an aquatic ecosystem with four abstract wetland plant communities.

Lithological units from the Cryptozoic eon and Precambrian system of igneous origin underlie the hills and lowlands vegetation type. The representative terrain is **open hills, lowlands and mountains with moderate to high relief** of which the prominent terrain type is **undulating, hills and lowlands.** Dominant terrain morphological units are **footslopes and valley bottoms** at slopes of between **0 and 12 %**. Only slopes with angles between **2 and 25°**, receive **perpendicular insolation** during the **summer**. The majority of the vegetation type occurs within Low and Rebelo's (1996) **North-eastern Mountain Grassland.** Large areas are considered to be **flat** at slopes of **0 to 8%,** while **slopes up to 15%** are used for **crop growth**.

1. Wetlands (Figure 34)

These wetlands have a low occurrence of surface rocks and therefore are suitable for crop growth.

Three communities and two sub-communities of wetland plant communities were identified along and in the vicinity of drainage lines. They are:
1.1. *Cliffortia nitidula - Setaria sphacelata* pure low closed grassland community
1.2. *Miscanthus junceus - Cyperus esculentus* pure low closed grassland community
1.2.a. *Arundinella nepalensis - Miscanthus junceus* pure low closed grassland sub-community
1.2.b. *Sporobolus africanus - Miscanthus junceus* pure low closed grassland sub-community
1.3. *Oenothera tetraptera - Paspalum dilatatum* pure low closed grassland community

1.1. *Cliffortia nitidula - Setaria sphacelata* pure low closed grassland community
GENERAL DESCRIPTION: This community is represented by grass-covered slopes further away and steeper than those directly along the drainage lines. These slopes are seldom inundated but the soil moisture content is high, as indicated by the presence of *Setaria sphacelata*.
GEOLOGICAL ENVIRONMENT: This is a community found on a wide variety of lithological units: igneous **Hekpoort formation andesite** and **Mpluze Granite quarts monozite** and sedimentary **Timeball Hill formation shale.** The Hekpoort and Timeball Hill formations are from the **Pretoria Group** within the Transvaal Sequence of **Vaalian age,** while the Mpluze Granite is of Randian age. The granite is an older rock than the other two, which is of the **Proterozoic Erathem.**

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain type of this community is **B3** (Chapter III, paragraph 3.3.A). These plots were subjectively sampled close to **valley bottoms** (Chapter II, paragraph 2.3.1), within the slope range associated with footslope and valley bottom (Chapter III, paragraph 3.3.B). Average values based on quantitative data for slope (°, %), aspect and altitude are 6.3°, 9.3%, 184.3° from North and 1656.8 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during **January 1995**, at an altitudinal interval of between **1 600 and 1 800 m.a.s.l.** The average annual precipitation is not more than **872 mm,** occuring mainly in the summer and associated with a wide variety of local climate zones. Stands of this community occur on **gentle, east, south and west facing** insolation attitudes (Chapter III, paragraph 3.2.3.B).

PEDOLOGICAL ENVIRONMENT: This community was sampled within land types of the **Ac soil pattern,** at an altitude not lower than 1550 m.a.s.l. Soil forms associated with this community are Hutton and **Katspruit**. The soil texture of the **A horizon is a fine to medium sandy clay loam to a sandy clay**, with soil depths of **300 - 600 mm**. **Surface rocks and stones** do not cover more than 37% of the surface area.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group A (Fidelity very high (V): Table 25.b) containing *Cliffortia nitidula* with a high constancy (4) (Table 25.a) and highest estimated cover abundance (Table 25.c.1). Another species in this diagnostic species group is Watsonia *densiflora*. Species groups S, T, V and X represent constant species for this community. Species group S includes Themeda triandra and Setaria sphacelata, of which only the latter has qualified for inclusion in the cluster. Setaria sphacelata has the highest constancy (5) and lowest fidelity (V) of all the species in this cluster. Species group T includes species associated with wetland ecosystems: Paspalum dilatatum, *Phymaspermum athanasioides* and Imperata cylindrica. This community's affinity with the drier grassland communities, is indicated by species found in species group V: *Helichrysum rugulosum*, Eragrostis capensis and *Monopsis decipiens*. The presence of species such as Eragostis plana and *Hypochoeris radicata* from species group X, and associated with overutilisation, indicates areas normally associated with overutilization. Physiognomically representing **pure low closed grassland**, it has an average number of species per relevé of twenty-two. This unit is representative of plant communities found within Acocks' **North-eastern Sandy Highveld** and Piet Retief Sourveld.

WILDLIFE MANAGEMENT: From a pasture perspective, the slopes are flat to medium inclined (Chapter II, paragraph 2.6.3). In terms of erosion control it is suitable for crop growth on slopes between 0 and 15%. Its land use classes range from **ley or special tillage, rotation of ley and crops to permanent cover crops**, excluding the less steep slopes which are suitable for annual cropping (0-3%).

DISCUSSION: This community is found along the upper courses of drainage lines, higher up on the slopes of hills or along the lower courses of drainage lines, on slopes towards the lowlands. It represents sponge areas. The location and composition of the soils, on which it is found, are ideally suited for this purpose. Soil depth is deeper than on the midslopes and crests of the hills and surrounding mountains, but shallower than those expected within the valley bottoms (Strahler & Strahler 1987). It's soil texture of sand and clay, create conditions for improved water infiltration and storage. All these factors result in a high water table and high soil moisture (White 1987) which, depending on precipitation, can become oversaturated, resulting in temporary marshes. As these areas provide the water which maintains streams and rivers by means of lateral flow, their effective management and protection cannot be overstressed (Cowan 1995).

Community 1.2 and 1.3 were mainly sampled within Acocks **Piet Retief Sourveld**, in areas suitable to **annual cropping on slopes of between 0 and 3%** (Figure 34 - Division 1.2)

1.2. *Miscanthus junceus - Cyperus esculentus* pure low closed grassland community

GENERAL DESCRIPTION: This community consists of two sub-communities physically associated with streambeds. These streambeds occur within flat slopes of valley bottoms and are temporarily or permanently inundated. The streambeds are narrow and the levees low with slow currents. *Miscanthus junceus* is the characteristic grass while *Cyperus esculentus* is a commonly found sedge.

GEOLOGICAL ENVIRONMENT: The community was sampled mainly on igneous **unnamed** granite of **Randian** age of the **Archaean** Erathem. It also occurs on other lithological units.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain types associated with this community and its sub-communities are B3 and A2. Subjectively sampled within valley bottoms along streambeds, it occured on slopes ranging from 0 –12% associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude range from: 2 - 2.5°, 3-4%, 134 to 135° from North and 1173 - 1333 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during the first three months of **1995**, at an altitude not higher than 1600 m.a.s.l. It occurs within several local climate zones, with an annual average precipitation ranging from 803 to 1073 mm. Flat to gentle, east and south facing insolation attitudes are associated with this community and its sub-communities.

PEDOLOGICAL ENVIRONMENT: The community was sampled mainly within Ab to Ad soil patterns, at altitudes below 1550 m.a.s.l. The presence of streambeds distinguishes this community from the other Katspruit soil form dominated wetlands. Soil texture range from sandy clay loam to sandy clay, with soil depths from 300 to 800 mm. **Surface rocks are limited** to 10% or less of the surface area.

FLORISTIC DATA: Diagnostic species group B contains the characteristic species of this community (Fidelity very high (V): Table 25.b), including *Miscanthus junceus* and *Persicaria lapathifolia* with constancy levels of average (3) and above. *Miscanthus junceus* has the highest overall estimated cover abundance (Table 25.c.1). Other diagnostic species found in this community, are the species from the two sub-communities in diagnostic species groups C and D. *Cyperus esculentus*, the constant or companion species of the community, is found within species group T. It has a high (IV) fidelity and high to very high constancy compared to the next species, *Eragrostis plana* (species group X). *Hyparrhenia hirta* and *Themeda triandra* two species from constant species group S, were absent in the previous community. *Verbena brasiliensis* (Species group T), associated with wetland ecosystems, was absent in the previous community but is present in this community. In the same category, but from a different species group and environmental trend, is *Conyza podocephala* (Species group X: Species associated with overutilisation). Physiognomically, this community represents **pure low/ short closed**

grassland, with an average number of species per relevé of thirty. It is representative of plant communities found within Acocks' Piet Retief Sourveld and Northern Tall Grassveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is associated with **flat areas** according to the adapted pasture classes. The risk for erosion is limited in this community and it is therefore under pressure from agriculture. Depending on the slope, potential land use is annual cropping, ley or special tillage and rotation of ley and crops.

DISCUSSION: This community is found on the fringes of streams with limited water supply, of either permanent or seasonal flow. Depending on the variability of the flow, the streambed is either well defined or covered by vegetation, making the identification of this community and its sub-communities very easy. Occasionally woody species such as ***Diospyros lycioides*** (species group W) occur on the fringes of these drainage lines, usually in association with surface rocks, resulting in the community and its sub-communities having a low// short bushland physiognomy.

1.2.a. *Arundinella nepalensis - Miscanthus junceus* pure low closed grassland sub-community

GENERAL DESCRIPTION: A plant community of non-perennial drainage lines, that becomes temporarily (seasonally) inundated. The streambed is covered by vegetation due to the low, slow flowing current. *Arundinella nepalensis* dominates this community.

GEOLOGICAL ENVIRONMENT: Sampled mainly on igneous **unnamed** granite of **Randian** age of the **Archaean** Erathem, it also occurs on other lithological units.

GEOMORPHOLOGICAL ENVIRONMENT: This community's nature of terrain type of B3 differentiates it from the other sub-community of community 1.2. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.4°, 4%, 135° from North and 1333 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January and February 1995, at altitudes **below 1600 m.a.s.l.** The average annual precipitation tends to be below 872 mm. Stands of this sub-community occur within **flat** to gentle, **north facing** insolation attitudes.

PEDOLOGICAL ENVIRONMENT: The soil patterns in which this community was sampled did not occur above 1550 m.a.s.l. High soil moisture content and inundation is indicated by the presence of the G horizon of the Katspruit and Rensburg soil forms. The soil texture of the **A horizon** is sandy clay loam, with a tendency towards sandy clay or clay. Soil depths is 300 - 750 mm. Surface rocks are limited and when it occurs do not cover more than 10% of the surface area in the form of rocks and stones.

FLORISTIC DATA: The differentiating species are represented by diagnostic species group C (Fidelity very high (V): Table 25.b) which contain *Arundinella nepalensis* with a very high constancy (5) (Table 25.a) and high estimated cover abundance (Table 25.c.1). *Senecio affinis* is also present in diagnostic species group C. *Themeda triandra* from constant species group S, qualified for inclusion in this cluster. *Wahlenbergia undulata* and the sedge *Kyllinga alba* (species group T) are two species associated with wetland ecosystems, which occur in this community. *Setaria nigrirostris* (species group V) associated with grassland communities prefers moist environments (Van Oudtshoorn 1991).

Verbena venosa (species group X) is associated with overutilisation. Physiognomically this community represents pure short closed grassland, with an av~rage number of species per relevé of thirty.

WILDLIFE MANAGEMENT: This community is associated with **flat areas** according to the adapted pasture classes. It is suitable for crop growth because the risk of erosion is limited. Depending on the slope, potential land use is annual cropping, ley or special tillage and rotation of ley and crops.

DISCUSSION: Depending on size this community is often ploughed as part of the surrounding area, because of its lack of permanent water and well-defined boundaries. It becomes seasonally inundated because the perpendicular insolation, which the slopes receive, lowers the water storage capacity of the surrounding areas (community 1.1), resulting in less water to maintain the stream.

1.2.b. *Sporobolus africanus* - *Miscanthus junceus* pure low closed grassland sub-community

GENERAL DESCRIPTION: A community of perennial streams with seasonally fast-flowing currents. The streambed is well defined and covered with water. Three zones are easily identified within this community: an open water zone, next to it a zone of saturated or temporarily inundated soils and furthest from the water a zone of soils at field capacity, which only becomes inundated during excessive floods.

GEOLOGICAL ENVIRONMENT: Sampled mainly on igneous **unnamed** granite of **Randian** age of the **Archaean** Erathem, it also occurs on other lithological units.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of the terrain type of this community is A2. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 3%, 134° from North and 1173 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during February 1995, at an altitude below 1300 m.a.s.l. The average annual precipitation is below 835 mm. This community's stands never receive perpendicular insolation, as they occur within flat insolation attitudes facing different aspects.

PEDOLOGICAL ENVIRONMENT: This community was sampled on soil patterns below 1170 m.a.s.l. A poorly developed levee is present along the streambed, due to sporadic flooding. The zone of oversaturation is indicated by the Katspruit soil form, while Hutton and Shortland soil forms occur in the zone of field capacity or excessive flooding. The **A horizon**'s soil texture is predominately sandy clay. Soil depth range from 300 to 600 mm.

FLORISTIC DATA: Differentiating species are represented by diagnostic species group D (Fidelity very high (V): Table 25.b) containing Sporobolus africanus with a very high constancy (5) (Table 25.a). Agrostis eriantha is the only other grass in this diagnostic species group, while the other species are the sedges *Schoenoplectus corymbosus*, *Mariscus congestus* and the forb *Cirsium vulgare*. Two of the three species found in constant species group S occurs in this community: Hyparrhenia hirta and Setaria sphacelata. Only the sedge *Coleochloa setifera* from species group T did not occur in sub-community 1.2.a. The two grasses of species group V associated with grassland communities are Hyparrhenia dregeana and Panicum natalense, of which the latter prefers well drained soils (Van Oudtshoorn 1991). All the species of species group X, which occurred in the previous sub-community, are present in this sub-community, except Verbena venosa. Physiognomically representing pure low closed grassland, this community has an average number of species per relevé of thirty.

WILDLIFE MANAGEMENT: This community is less steep than the previous sub-community, occurring on slopes suitable to annual cropping (0-3%). Therefore its outer zone is often destroyed by cultivation.
DISCUSSION: Found at lower altitudes or within the lower courses of drainage lines than the previous sub-community, it receives water from a larger area (Community 1.1). Together with the flat environment and lack of perpendicular insolation, enough soil water is stored to maintain flow throughout the year. The continuous flow of water removes sediment from the streambed and surrounding area, resulting in shallower soils compared to the previous community. Water is available all year round. This community is often overgrazed and its levees trampled.

1.3. *Oenothera tetraptera - Paspalum dilatatum* pure low closed grassland community
GENERAL DESCRIPTION: A disturbance community found in the vicinity of proper wetland communities associated with depressions, erosion gullies and other areas of water accumulation due to anthropological disturbances. This community is not associated with drainage lines, but could represent the start of future drainage lines.
GEOLOGICAL ENVIRONMENT: As would be expected from a disturbance community of this nature, it occurs on and over a wide variety petrological, lithological and chronostratigraphical units. This includes igneous granite, dolerite and sedimentary shale and quartzite from both the Cryptozoic and Phanerozoic eons. The Karoo dolerites and Pietermaritzburg shale are from the Mesozoic and Palaeozoic erathems respectively, while the unnamed granite and Mozaan quartzite are from the Precambrian system.
GEOMORPHOLOGICAL ENVIRONMENT: This community's nature of terrain type is **A3**. Samples were taken subjectively within footslopes on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.8°, 5%, 65° from North and 1280 m.a.s.l.
CLIMATIC ENVIRONMENT: This community was sampled during the first three months of 1995, at an altitudinal interval of between **1 300 and 1 400 m.a.s.l.** The average annual precipitation is above 872 mm during the summer within different local climate zones. Stands of this community occur on gentle insolation attitudes facing different aspects.
PEDOLOGICAL ENVIRONMENT: These samples were taken mostly from the Ac soil pattern, at an altitude not exceeding 1350 m.a.s.l. The presence of soil forms such as Griffin and Hutton additional to the Katspruit soil form associated with water logged areas, indicates this community's affinity with the drier grassland environments. Soil texture of the A and B horizons range from sandy clay loam to sandy clay. Soil depth range from 600 to 1200 mm or more. No surface rock occurs.
FLORISTIC DATA: Diagnostic species group E reflects the species characteristic for this community, of which *Oenothera tetraptera* has a very high fidelity (V) (Table 25.b) and high constancy (4). Other species included in this diagnostic species group is ***Lippia javanica***. Both the low and short grassland species of constant species group S, <u>Themeda triandra</u> and <u>Hyparrhenia hirta</u>, occur in this community. <u>Paspalum dilatatum</u> (species group T), associated with wetland ecosystems, has the highest constancy (5) and average estimated cover abundance. Only two species from species group T do not occur in this community, *Phymaspermum athanasioides* and <u>Imperata cylindrica</u>. This community has the largest number of species associated with overutilisation or disturbances of the wetland plant

communities, excluding *Conyza podocephala*, *Verbena venosa* and Melinis repens. The dominant physiognomy is a pure low closed grassland although this community also occurs within other grassland physiognomic units. In terms of species richness, it has an average number of species per relevé of twenty-two. This unit is representative of plant communities found within Acocks' Northern Tall Grassland and Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.
WILDLIFE MANAGEMENT: This community occurs within flat areas. In general, this community is at very little risk from erosion. Potential land uses of this community by agriculture are annual cropping, ley or special tillage and rotation of ley and crops.
DISCUSSION: The disturbances which create this community are animals and people moving to and from available water. Depressions are associated with the beginning (head) of erosion gullies. As the slope configuration of the broader area is such that it is not prone to erosion, the occurrence of this community indicates excessive overutilisation of the pathways by animals and people. The influence of accumulating water (water logging, oversaturation) on vegetation distribution is indicated by the absence of species from species group V, species associated with grassland communities, although this community occurs within the drier grassland communities. This is confirmed by the two species from constant species group S, Themeda triandra and Hyparrhenia hirta, and the absence of the other constant species, Setaria nigrirostris, a species associated with moist conditions.

2. Terrestrial ecosystem (Figure 34)

The plant communities of the terrestrial ecosystem occur mainly on **unnamed** granite of the **Archaean** Erathem. This abstract association consists of seven plant communities and four sub-communities. They are:
2.1. *Helichrysum nudifolium* - *Hyparrhenia hirta* pure short closed grassland community
2.1.a. *Paspalum scrobiculatum* - *Helichrysum nudifolium* low// short sparse shrubland sub-community
2.1.b. *Indigofera comosa* - *Helichrysum nudifolium* pure short closed grassland sub-community
2.2. *Pentanisia angustifolia* - *Themeda triandra* pure low closed grassland community
2.2.a. *Helichrysum cephaloideum* - *Pentanisia angustifolia* pure low closed grassland sub-community
2.2.b. *Clutia monticola* - *Pentanisia angustifolia* low// short sparse shrubland sub-community
2.3. *Oxalis purpurea* - *Helichrysum rugulosum* pure low closed grassland
2.4. *Aloe marlothii* - *Hyparrhenia hirta* low// short thicket
2.5. *Diheteropogon amplectens* - *Themeda triandra* low// short thicket
2.6. *Tetraselago wilmsii* - *Commelina africana* low// short sparse shrubland
2.7. *Sporobolus pectinatus* - *Tristachya leucothrix* low// short sparse shrubland

Communities 2.1 to 2.3 occur mainly on **southerly slopes,** which seldom receive perpendicular insolation, with limited rockiness (Environmental division 2.1 - Figure 34). They represent the pure grassland communities of the hills and lowlands vegetation type. Community 2.1 (Environmental division 2.1.1) is associated with melanic **A horizons** at altitudes below 1400 m.a.s.l. while communities 2.2 and 2.3 are associated with orthic **A horizons** at altitudes above 1400 m.a.s.l. (Environmental division 2.1.2).

2.1. *Helichrysum nudifolium* - *Hyparrhenia hirta* pure short closed grassland community

GENERAL DESCRIPTION: This community covers the lowland slopes within the undulating hills and lowlands terrain type, at altitudes below 1500 m.a.s.l. on soils in which melanic **A horizons** dominate.

GEOLOGICAL ENVIRONMENT: The majority of rock underlying this community is igneous **unnamed granite** from the Cryptozoic Eon but it is also found on a variety of other petrologic, lithologic and chronostratigraphic units, mainly from the Karoo Sequence.

GEOMORPHOLOGICAL ENVIRONMENT: A wide range of nature of the terrain types is associated with this community. More than 50% of the area has slopes of less than 8% and local relief ranging from 30 - 300 m. Subjectively sampled on crests and midslopes, it still falls within the footslope and valley bottom category of the surface model at slopes of between 0 - 12%. Average values based on quantitative data for slope (°, %), aspect and altitude range from 2.6 - 2.8°, 4.5 - 4.9%, 119 - 138° from North and 1093 - 1234 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during **February** and March 1995 at elevations of between 1000 to 1500 m.a.s.l. The community is influenced by a number of local climate zones, and therefore the average annual precipitation ranges from 803.4 mm to 1073.9 mm. Stands of this community are associated with warmer habitats of gentle insolation attitudes facing all aspects except southeast.

PEDOLOGICAL ENVIRONMENT: Characteristically this community occurs within the Ea soil pattern, but is also found within the Ab, Ac and Fa soil patterns. These soil patterns occur below 1350 m.a.s.l. Soil forms associated with the Ea soil pattern are Bonheim, Mayo and Milkwood. The soil texture of the **A horizon** tends towards coarse sand, while that of the B horizon towards sandy clay. This is confirmed by the presence of a soil form such as Shortlands, which has a red structured B horizon. The soil depth varies from 200 to 1200+ mm. Surface rockiness ranges from 12 - 23%, ranging in size from gravel to rocks.

FLORISTIC DATA: The species of diagnostic species group F are characteristic of this community. Of the two species found in this group *Helichrysum nudifolium* has an average constancy (3) and very high fidelity (V), and higher average estimated cover abundance, than *Anthospermum rigidum*. Hyparrhenia hirta (constant species group S) has low fidelity (II) and very high (5) constancy. Other species occurring within this community are diagnostic species group G, Themeda trianda and Setaria sphacelata (constant species group S) and species from species groups U, V and X, respectively associated with terrestrial ecosystems, grassland communities and overutilisation. Physiognomically it is associated with pure short closed grassland. Depending on soil texture, rockiness and management this community could contain ***Diospyros lycioides*** (Species group W), and would therefore being classified as low// short sparse shrubland. The average number of species per relevé ranges from thirty-six to forty-nine. This community represents vegetation units found within Acocks' Piet Retief Sourveld and Northern Tall Grassveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is under threat from agriculture because it occurs on flat slopes suitable to annual cropping. It tends toward a medium sloped environment, with slopes suitable for ley or special tillage and rotation of ley and crops.

DISCUSSION: Melanic **A horizons** with higher clay content reflect a nutrient rich environment. The clays most probably accumulate in this environment due to its location in the overall landscape. This community represents sweetveld favoured by animals and confirmed by the presence of species group X associated with overutilisation. *Hyparrhenia hirta* dominates this community physiognomically due to the extended available moisture from the higher clay content and selective grazing by domestic animals.

2.1.a. *Paspalum scrobiculatum - Helichrysum nudifolium* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: This woody sub-community occurs within the sandier areas associated with a higher percentage surface rock.

GEOLOGICAL ENVIRONMENT: Only igneous unnamed granite and Mpluze granite quartz monzonite underlie this sub-community. Both the lithological units are from the Precambrian system, with the unnamed granite from the Swazian erathem and the quartz monzonite from the Randian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: This sub-community occurs within the nature of terrain type B3. Although subjectively sampled within crests, scarps and midslopes, it occurs on slopes of less than 12% associated foothills and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.6°, 4.5%, 119° from North and 1093 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during February 1995 at elevations between 1000 to 1300 m.a.s.l. The annual average precipitation is below 835 mm and tends towards the lower end of the community's range. Stands of this community are associated with cool to warm habitats of flat to gentle, south- to northeast- facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This sub-community is also found in the Ab soil pattern, at altitudes below 940 m.a.s.l. The Ab soil pattern represents the boundaries of landscapes in which dystrophic and/or mesotrophic Huttons (orthic A, red apedal B horizons) are dominant, supporting the concept of higher sand content in the B horizons and sufficient soil moisture. The soil depth range from 200 to 900+ mm. Surface rocks (200 - 1000 mm) cover close to 25% of the area.

FLORISTIC DATA: This sub-community is differentiated from other sub-communities by the additional species found in diagnostic species group G. The species in diagnostic species group G have a very high fidelity (V), but *Paspalum scrobiculatum* has the highest constancy (4). Other species occurring in this diagnostic species group are: *Vernonia oligocephala*, *Moraea pubiflora*, *Trachyandra* species, *Solanum elaeagnifolium*, *Ruellia patula*, *Thunbergia atriplicifolia*, *Corchorus confusus*. *Sonchus wilmsii*, *Aster harveyanus*, *Diospyros galpinii*, *Striga bilabiata*, *Alepidea setifera* and ***Rhus discolor***. *Tristachya leucothrix* (Species group U) and the characteristic species *Paspalum scrobiculatum* prefer sandy soils (Van Oudtshoorn 1991). Other species from species group U, not found in the other sub-community, are *Acalypha angustata*, *Trachypogon spicatus*, *Scabiosa columbaria*, *Phyllanthus parvulus*, *Eriosema cordatum*, *Eulalia villosa*, *Schistostephium crataegifolium* and *Clutia pulchella*. The only species from species group V, associated with grassland communities, which does not occur in the other sub-community, is Eragrostis chloromelas. Physiognomically this sub-community is classified as low// short sparse shrubland. The average number of species per relevé was forty-nine. This sub-community represents a vegetation unit found within Acocks' Northern Tall Grassland and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community occurs on slopes suitable for growing crops within flat areas. These slopes are used for annual cropping and ley or special tillage.

DISCUSSION: The high percentage of sand and rock present, result in high infiltration rates, giving rise to a high soil moisture content, capable of sustaining the growth of woody species such as ***Rhus discolor*** and ***Diospyros lycioides***. *In situ* weathering of the granite and quartz monzonite is the source of quartz crystals, resulting in the high percentage of sand. The scarps indicate plots in which rocks were visible from a distance. These large rocks or large concentrations of rocks result in a rugged terrain, which decreases runoff and increases infiltration.

2.1.b. *Indigofera comosa* - *Helichrysum nudifolium* pure short closed grassland sub-community

GENERAL DESCRIPTION: This grassland sub-community occurs within clayey areas with a low percentage surface rock.

GEOLOGICAL ENVIRONMENT: In addition to being underlain by igneous rock from the Cryptozoic Eon, it also covers sedimentary arenite, quartzite, tillite and shale. These sedimentary rocks are from the Pongola and Karoo Sequences. The majority of these lithological units are fine textured (shale, tillite, dolerite, tuff and basalt), while the others (arenite, quartzite, gabbro and granite) are coarse textured.

GEOMORPHOLOGICAL ENVIRONMENT: The wide range of lithological units involved, resulted in a wide range of nature of terrain types being associated with this community. More than 20% of the area has slopes of less than 8% and local relief ranging from 30 - 300 m. A community on slopes of less than 12%, it was sampled subjectively on crests and midslopes. Average values based on quantitative data for slope (°, %), aspect and altitude are 2.8°, 4.9%, 138° from North and 1234 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during February and March 1995, at altitudes below 1500 m.a.s.l. At an annual precipitation of above 835.4 mm, this sub-community is found within the higher rainfall range of the community. In terms of insolation attitude, this sub-community does not differ, much from the previous sub-community except for a tendency towards a more inclined environment. The dominant insolation attitude is gentle towards all aspects.

PEDOLOGICAL ENVIRONMENT: This sub-community is also found within the Ac and Fa soil patterns, at altitudes below 1350 m.a.s.l. Ac soil pattern is associated with landscapes in which dystrophic and/or mesotrophic Huttons and Clovelly (orthic A, yellow-brown apedal B horizons) soil forms are dominant. Fa soil pattern is associated with young landscapes in which no regular lime occur in any of the horizons. Dominant soil forms of pedological young landscapes are Mispah and Glenrosa. The Shortlands soil form indicates the presence of a higher percentage clay in the B horizon compared to the previous sub-community. The soil depth ranges from 400 to 900 + mm. Surface rockiness is limited at 12% and ranges from pebbles to rocks.

FLORISTIC DATA: This community is characterised by the presence of species *Indigofera comosa* from transitional diagnostic species group J and the absence of species from diagnostic species group G. *Indigofera comosa* has an average (3) constancy and very high fidelity (V) compared to other species found in this sub-community. The presence of drier soil moisture conditions compared to the previous sub-community is confirmed by the higher percentage constancy of *Themeda triandra* and lower percentage *Setaria sphacelata* and it's overall improved accessibility by the higher percentage constancy of *Hyparrhenia hirta* (Table 25.a - Constant species group S). These trends are also reflected by the subjective cover abundance estimates of these species (Table 25.c - Constant species group S). Species found in this community which did not occur in the previous sub-community are *Hypoxis rigidula* (Species group U), *Eragrostis racemosa* and *Vernonia natalensis* (both from species group V) and *Eragrostis plana*, *Hypochoeris radicata* and *Verbena venosa* from species group X. These three species groups are associated respectively with terrestrial ecosystems, grassland communities and areas of overutilisation. Physiognomically it is associated with pure short closed grassland. The average number of species per relevé was thirty-six. This sub-community represents vegetation units found within Acocks' Piet Retief Sourveld and Northern Tall Grassland veld types and Low and Rebelo's North-eastern Mountain Grassland vegetation unit.

WILDLIFE MANAGEMENT: The medium sloped areas tend to be still suitable for crop growth. Depending on slope, current land uses range from annual cropping, ley or special tillage and rotation of ley and crops.

DISCUSSION: This grass dominated sub-community has a larger soil moisture deficiency than the previous shrub dominated sub-community due to lower infiltration rates. This is due to the higher clay content, less surface rock and shallower soils. The higher clay content in the B horizon prevents deep infiltration of rain during thunderstorms, therefore increasing loss through evapotranspiration. In the absence of surface rock, fewer puddles form that would allow slow infiltration, while in areas of shallow soils, the soils easily reach oversaturation as well as wilting point. Sufficient soil moisture to maintain short to tall (0.5 - 1 m +) grass species (*Hyparrhenia hirta* and *Cymbopogon plurinoides*) are provided by continuous showers and lateral flow along the slopes within the soil.

2.2. *Pentanisia angustifolia* - *Themeda triandra* pure low closed grassland community

GENERAL DESCRIPTION: This community represents pure low *Themeda triandra* dominated closed grassland at altitudes of above 1400 m.a.s.l. The soils have orthic A horizons and sandy textures. Lower percentage clay results in lower nutrient availability and therefore sourveld.

GEOLOGICAL ENVIRONMENT: Lithological units from mainly the **Randian Erathem** within the Precambrian System underlay this community. The dominant petrological unit amongst these rocks is igneous: Mpluze Granite quartz monzonite, unnamed granite and Amsterdam formation tuff, followed by sedimentary Dwyka Formation tillite (Karoo Sequence) and Timeball Hill Formation shale (Pretoria Group - Transvaal Sequence) as well as metamorphic unnamed gneiss. The Dwyka Formation tillite is the youngest and dates from the Phanerozoic Erathem or Permian System.

GEOMORPHOLOGICAL ENVIRONMENT: Based on slope and local relief, this community covers two nature of terrain types, B3 and C4. Sampled subjectively within crests and midslope, it occured within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude range from 2 - 4°, 4 - 7%, 74 - 195° from North and 1383 - 1387 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January and February of 1995, at elevations of between 1400 and 1700 m.a.s.l., and occurs in a variety of local climate zones. Annual average precipitation ranges from 795 to 894 mm. Stands occur within flat, no aspect insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community is found mainly within the Ac land type but also within the Ab and Fa land types, at altitudes of not more than 1450 m.a.s.l. Depending on the local terrain type nature, the dominant soil form is either Hutton or Glenrosa, with Griffin and Mispah also occurring. Soil texture of the A horizon tends toward medium or coarse sandy loam, while that of the B horizon tends towards fine to coarse sandy clay. The soil depth range from 100 to 1200 mm or more. Surface rockiness ranges from 31 - 38 %, either as stones (50 - 200 mm) or rocks (200 - 1000 mm).

FLORISTIC DATA: Diagnostic species group H, with a very high (V) fidelity and average (3) to high (4) constancy represents the characteristic species. *Pentanisia angustifolia* was selected as the characteristic species, on the grounds that it is an easily distinguishable forb and has a marginally higher estimated cover abundance than the sedge *Cyperus obtusiflorus* (Table 25.c). The other two species, in diagnostic species group H representing the characteristic species, are *Dicoma zeyheri* and *Ledebouria ovatifolia*. Themeda triandra (constant species group S) has the overall highest constancy at very high (5) and low fidelity (II) as well as a higher estimated cover abundance than the other two species in the species group. Other species from species group U which occur in this community but not in the previous one are *Senecio venosus*, *Hypoxis iridifolia*, Loudetia simplex and *Gladiolus elliotii*. These species are all associated with terrestrial ecosystems. Panicum natalense and Heteropogon contortus occur in this community but not in the previous community. They are from species group V, species associated with grassland communities. Physiognomically it represents pure low closed grassland. The average number of species per relevé ranges from forty-four to forty-eight, depending on the physiognomy of the sub-community. This community represents vegetation units found within Acocks' North-eastern Sandy Highveld, Bankenveld to Sour Sandveld Transition, Piet Retief Sourveld and Northern Tall Grassveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Mainly associated with flat areas, it is suitable for crop growth. Possible land uses range from annual cropping, ley or special tillage and rotation of ley to crops.

DISCUSSION: The sour nature of this grassland community is supported by the absence of species from species group X, species associated with overutilisation and the strong presence of Themeda triandra, generally a decreaser (Van Oudtshoorn 1991). Sourveld is associated with areas of sandy texture, high leaching and low soil moisture content. Animals avoid these areas during the winter months while focusing on the vegetation with the higher nutrient content in the sweetveld, resulting in lower grazing pressure and less overutilisation in these areas. The movement of nutrients and clays downward within the soil profile is further supported by the higher clay content of the B horizons compared to that of the A horizons.

2.2.a. *Helichrysum cephaloideum - Pentanisia angustifolia* pure low closed grassland sub-community

GENERAL DESCRIPTION: This sub-community occurs within relatively flat areas, at local reliefs of 90 - 150 m of the community

GEOLOGICAL ENVIRONMENT: The three lithological units unnamed granite, unnamed gneiss and Mpluze Granite quartz monzonite are potential sources of sand, while the two sedimentary lithological units Dwyka tillite and Timeoall Hill shale are potential sources of clay.

GEOMORPHOLOGICAL ENVIRONMENT: The dominant nature of terrain type of this sub-community is **B3**. Subjectively sampled on crests and midslopes, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 4%, 74° from North and 1387 m.a.s.l.

CLIMATIC ENVIRONMENT: The dominant insolation attitude is flat, towards all aspects, except southeast, and therefore this sub-community never receives perpendicular insolation.

PEDOLOGICAL ENVIRONMENT: Occurring mainly within the Ac soil patterns, the modal soil form is Hutton, with the A horizon having a medium to coarse sandy loam to sand clay loam texture and the B horizon a coarse sandy clay to clay texture. Soil depth ranges from 100 to 600 mm. Surface rockiness is 31% and includes both stones and rocks.

FLORISTIC DATA: The differentiating species of this sub-community occur within diagnostic species group I, of which *Helichrysum cephaloideum* has the highest constancy (5) and very high fidelity (V) compared to the other species in the diagnostic species group. The other species in this diagnostic species group are *Adenanthellum osmitoides*, *Gerbera piloselloides* and Brachiaria serrata. Also occurring in this sub-community, are the two species from transitional diagnostic species group J, namely *Indigofera comosa* and *Zornia milneana*. Species from species group U and associated with terrestrial ecosystems are *Commelina africana*, *Scabiosa columbaria*, Microchloa caffra and *Bulbostylis burchellii*. Eragrostis capensis is the only species from species group V, which occurs only in this sub-community. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was forty-four. This community represents vegetation units found within Acocks' North-eastern Sandy Highveld, Piet Retief Sourveld and Northern Tall Grassland.

WILDLIFE MANAGEMENT: Due to the relative flatness of this area, it could be utilised for annual cropping (0-3% slopes) and ley or special tillage (4-7% slopes).

DISCUSSION: The soil moisture deficiency of this sub-community is a result of deep percolation in moderately deep sandy soils or dehydration of shallow sandy soils. The first hypothesis is supported by the only species from species group X, Eragrostis curvula ,associated with overutilisation. According to Van Oudtshoorn (1991), it is a species commonly found on well drained soils and cultivated lands. The second hypothesis is supported by the presence of Microchloa caffra, a species of shallow, sandy or rocky soils and outcrops (Van Oudtshoorn 1991). Relative rockiness and distance from water have most probably protected this sub-community from being excessively cultivated, while its low nutrient content protected it from overutilisation.

2.2.b. *Clutia monticola* - *Pentanisia angustifolia* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: This sub-community occurs on the moderately steep slopes of areas with local relief of 150 - 300 m.

GEOLOGICAL ENVIRONMENT: Igneous rock, mainly from the Randian erathem, of various textures, underlie this sub-community. The unnamed granite and Mpluze Granite quartz monzonite have a coarse texture, while the Amsterdam Formation tuff has a very fine texture.

GEOMORPHOLOGICAL ENVIRONMENT: Associated nature of terrain type of this sub-community is C4. Subjectively sampled on crests, it occured within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 4°, 7%, 194° from North and 1383 m.a.s.l.

CLIMATIC ENVIRONMENT: Predominately found on slopes of 2 - 25°, which receive perpendicular insolation, stands of this sub-community are associated with gentle insolation attitudes facing south, south west and north.

PEDOLOGICAL ENVIRONMENT: A sub-community of the Fa soil patterns, it is associated with a pedologically young landscape. The dominant soil form is Glenrosa, with a sandy loam A and fine sandy clay B horizon. Soil depth ranges from 300 to 450 mm. Surface rockiness is 38%, occuring in the form of stones.

FLORISTIC DATA: Diagnostic species group K is the differentiating species group for this sub-community, of which *Clutia monticola* has the highest constancy (4) and a very high fidelity (V). *Hibiscus aethiopicus*, *Aloe greatheadii*, *Cyanotis lapidosa* and *Lopholaena segmentata* are the other species occurring within this species group. The following species from species group U, associated with terrestrial ecosystems, occur in this sub-community but not in the previous sub-community: *Trachypogon spicatus*, *Phyllanthus parvulus*, *Berkheya echinacea*, *Sebaea grandis*, ***Rhus dentata*** and *Asparagus laricinus*. *Haplocarpha scaposa* and *Vernonia natalensis* (species group V) are two species from species group V, species associated with grassland communities, which occur in this sub-community but not in the previous sub-community. Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé was forty-eight. This community represents vegetation units found within Acocks' North-eastern Sandy Highveld, Bankenveld to Sour Sandveld Transition and Piet Retief Sourveld.

WILDLIFE MANAGEMENT: This sub-community occurs in two of the adapted pasture classes: flat and medium. Slopes of 0 - 15% are suitable for crop growth making use of the following land uses: annual cropping, ley or special tillage and rotation of ley and crops (8 - 12% slopes).

DISCUSSION: From a distance this sub-community would not easily be distinguished from the previous sub-community, as the shrubs, ***Rhus dentata*** and *Asparagus laricinus*, occur widely spaced in association with rockiness. This limited potential to maintain woody species is most probably due to the higher water retention capabilities of the clay containing tongues of lithocutanic B horizons within pedologically young landscapes. The rocks increase infiltration, while the presence of the clay prevents deep percolation, keeping moisture within reach of the woody species roots.

2.3. *Oxalis purpurea* - *Helichrysum rugulosum* pure low closed grassland community

GENERAL DESCRIPTION: This pure low closed grassland community, from which the grass *Hyparrhenia hirta* is basically absent, occurs at higher altitudes than the previous two communities.

GEOLOGICAL ENVIRONMENT: This community is predominately underlain by lithological units from the Pretoria Group of the Vaalian Erathem. Both the igneous Hekpoort Formation andesite and sedimentary Timeball Hill shales are sources of clay.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of terrain type associated with this commmunityon is **B3**. Subjectively sampled within crests, scarps and midslopes, it occurs on slope ranges associated with footslopes-and-valley bottoms and midslopes-and-crests of less than 100%. Average values based on quantitative data for slope (°, %), aspect and altitude are 4°, 8%, 156° from North and 1721 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during January 1995 at elevations above 1600 m.a.s.l. Annual average precipitation is 872 mm. **Gentle, south** and south east **facing** insolation attitudes maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: This community is found within the Ac soil pattern at altitudes not less than 1550 m.a.s.l. The dominant soil form is Hutton. The soil texture of the A horizon is fine to medium sandy loam to sandy clay loam, while that of the B horizon is fine to medium sandy clay loam to sandy clay. The soil depth range from 100 to 300 mm. Surface rockiness is 19%, predominately the size of stones (50 - 200 mm).

FLORISTIC DATA: Diagnostic species group L contains the characteristic species of this community. Within this species group *Oxalis purpurea* has a high constancy (4) and very high fidelity (V), compared to the average (3) constancy of *Hermannia transvaalensis* and *Walafrida tenuifolia*. Although at first glance it would seems as if _Themeda triandra_ should be the constant species, *Helichrysum rugulosum* has the best combination of constancy, fidelity and estimated cover abundance, respectively very high (5), average (III) and generally to conspicuously present. Other species occurring in this community are _Setaria sphacelata_ (constant species group S), _Tristachya leucothrix_, *Hypoxis rigidula*, *Commelina africana*, _Trachypogon spicatus_, _Microchloa caffra_ from species group U, _Eragrostis racemosa_, *Haplocarpha scaposa*, _Eragrostis capensis_, _Heteropogon contortus_, *Vernonia natalensis*, _Setaria nigrirostris_, _Eragrostis chloromelas_ from species group V and _Eragrostis curvula_ and *Hypochoeris radicata* from species group X. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was thirty-one. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community occurs within flat areas, tending towards medium, sloped areas. This hypothesis is supported by relevés being classified within slope categories more suitable to grazing (15 - 30%) and land use categories such as ley or special tillage (4 - 7%) and permanent cover crops (13 - 20%).

DISCUSSION: Based on the underlying lithological units, a predominately clayey soil texture was expected, but the modal soil texture frequencies of the A and B horizon indicated the contrary, as does the presence of species associated with sandy soil textures: _Tristachya leucothrix_, _Trachypogon spicatus_ and _Microchloa caffra_. A probable source of this predominately sandy texture is a layer of medium to fine grained quartzite, which occurs in between the Timeball Hill Formation shale (Walraven 1989a). Further support that this is a community of sandy soils and most probably sourveld, is its occurrence within the Ac soil pattern associated with dystrophic and/or mesotrophic soils and the lack of species associated with overutilisation, compared to community 2.1.

Communities 2.4 to 2.7 are woodland communities of the hills and lowlands vegetation type on slopes suitable to **annual cropping (0-3%)** (Environmental Division 2.2). Communities 2.4 and 2.5 occur at altitudes below 1500 m.a.s.l., in association with **rocks** (200 - 1000 mm) and boulders (1000 mm +) (Environmental Division 2.2.1), while communities 2.6 and 2.7 occur at altitudes above 1500 m.a.s.l. on slopes suitable to **annual cropping (0-3%)** but consisting of rock sheets (Environmental Division 2.2.2).

2.4. *Aloe marlothii - Hyparrhenia hirta* low// short thicket

GENERAL DESCRIPTION: This community is easily recognised from a distance, with *Aloe marlothii* being conspicuously present on outcrops of dykes and sills.

GEOLOGICAL ENVIRONMENT: Lithological units from the Phanerozoic erathem underlie this low// short thicket. These lithological units are igneous Karoo dolerites and sedimentary Pietermaritzburg Formation shale.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of terrain type within which this community occurs, is **A** across a wide range of local relief. Subjectively sampled on scarps, areas of high surface rock, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 4°, 8%, 153° from North and 1345 m.a.s.l.

CLIMATIC ENVIRONMENT: Sampling was done during March 1995 at elevations of between **1300 to 1400 m.a.s.l.** It is found within climate zone **253s**, receiving **1073.9 mm** precipitation on average annual. **Gentle, southwest facing** insolation attitudes are associated with this community.

PEDOLOGICAL ENVIRONMENT: This community is found within the Ac soil pattern, land type **Ac106,** at altitudes of 1350 m.a.s.l. The dominant soil form is Mispah in association with rocks. Soil texture is fine to medium sandy clay. Contrary to what would be expected regarding the soil form and rockiness, the soil depth ranges from 900 to 1200 mm +, while rocks of 200 - 1000 mm + cover at least 50% of the surface.

FLORISTIC DATA: Diagnostic species group M contains the characteristic species of this community. All these species have a high constancy (4) and very high fidelity (V). *Aloe marlothii* has the highest estimated cover abundance and unique growth form, compared to the other species, ***Myrsine africana***, ***Tetradenia riparia***, *Aristida congesta* subsp. *congesta*, *Rhus rigida*, *Rhus chirindensis*, ***Cussonia spicata***, *Justicia anagalloides* and ***Acokanthera rotundata***. Also found within this community, is diagnostic species group O, a transitional species group including ***Zanthoxylum capense***, *Eucomis autumnalis* and ***Maytenus heterophylla***. The fern, *Pellaea calomelanos* and woody species, ***Rhoicissus tridentata*** from transitional diagnostic species group Q, are associated with rockiness. In this community *Hyparrhenia hirta* (Constant species group S) has the highest constancy (5) compared to all the other communities or their sub-communities and low fidelity (II) also *Themeda triandra* is present in this species group. Species from species group U, which is associated with terrestrial ecosystems, are *Tristachya leucothrix*, *Acalypha angustata* and *Senecio venosus*. The following species associated with woodland communities (Species group W) are present: ***Diospyros lycioides*, *Diospyros whyteana*** and ***Vangueria infausta*.** In association with overutilization (Species group X), the following species are found: *Eragrostis plana*, *Eragrostis curvula*, *Conyza podocephala* and *Melinis repens*. Physiognomically it is associated with low// short thicket. The average number of species per relevé was fifty-one. This community represents a vegetation unit found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Classified within the adapted pasture classes, flat category, it would have been suitable for crop growth (0 - 15% slopes), if it were not for the presence of rocks. It tends towards the steeper slopes as indicated by its land use classes: **rotation of ley and crop** and permanent cover crops.

DISCUSSION: Forming part of the vegetation mosaic of the hills and lowland vegetation type, this woodland community occurs adjacent to the sweetveld *Helichrysum nudifolium* - *Hyparrhenia hirta* pure short closed grassland community (community 2.1). This hypothesis is supported by its altitudinal range (below 1500 m.a.s.l.), by the strong presence of *Hyparrhenia hirta*, and by overutilization. This association also explains the unusually deep soil depth range indicated by the modal soil depth interval, as the soil of sub-community 2.1.b occurs within this range. The improved infiltration of precipitation due to rockiness and the storage capabilities of the higher clay content, provide enough soil moisture to maintain woody species. Joints and cracks within the underlying lithological units act as drains for deep-water percolation, increasing the general water storage capabilities of the lowlands.

2.5. *Diheteropogon amplectens* - *Themeda triandra* low// short thicket

GENERAL DESCRIPTION: A community amongst the boulders of disappearing castle kopjes or newly appearing bornhardts, this community's most easily recognised life form is the woody species, ***Cussonia paniculata***.

GEOLOGICAL ENVIRONMENT: This community is mainly underlain by igneous unnamed granite from the Precambrian System of Swazian to Vaalian erathem age.

GEOMORPHOLOGICAL ENVIRONMENT: The nature of terrain type of this community has larger local relief differences than the previous community. Local relief ranges from 90 - 300 m, with the majority between 90 - 150 m, and 50 - 80% of the area has slopes of less than 8%. Subjectively sampled on scarps, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 5%, 110° from north and 1230 m.a.s.l.

CLIMATIC ENVIRONMENT: This community was sampled during February 1995 at elevations lower than the previous community, below 1200 m.a.s.l. The annual average precipitation range is between 835 and 850 mm, within a variety of local climate zones. Stands of this community occur within flat or gentle, south facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: A community with red to yellow-brown apedal B horizon, dys- to mesotrophic soil patterns, it is found mainly within the Ab soil pattern, and not above 1200 m.a.s.l. Within the Ab soil pattern, soils consisting of dystrophic and/or mesotrophic Huttons (orthic A, red apedal B horizons) are dominant. This is confirmed by the presence of Hutton soil forms among this community's soil attributes, although it occurs mainly in areas covered by rock or Mispah soil form. The

A horizon has a coarse sandy loam to sand clay loam texture. Where applicable the B horizon tends towards a sandy clay texture. Soil depth ranges from 100 to 400 mm. Although initially described as rocks, the exposed lithological units represent boulders and cover more than 48% of the surface.

FLORISTIC DATA: Diagnostic species group N contains the characteristic species of this community, including Diheteropogon amplectens, **Cephalanthus natalensis**, **Athrixia elata**, **Euclea natalensis**, *Dicoma anomala*, Panicum maximum, *Berkheya zeyheri*, *Pteridium aquilinum*, *Stachys natalensis*, **Rubus rigidus**, **Cussonia paniculata** and *Berkheya seminivea*. Of these, Diheteropogon amplectens has a very high constancy (5) and very high fidelity (V) compared to the average to high constancy of the other species. Also present in this community are the species from the transitional species groups of the previous community. All three species from the constant species group S have a very high constancy (5), but Themeda triandra has the highest estimated cover abundance and lowest fidelity (II) compared to other species in the community (Table 25.b). Species from species group U, associated with terrestrial ecosystem, which did not occur in the previous community are Cymbopogon plurinodis, *Hypoxis rigidula*, *Commelina africana*, Trachypogon spicatus, *Scabiosa columbaria*, Loudetia simplex, *Phyllanthus parvulus*, *Eriosema cordatum*, Eulalia villosa, *Berkheya echinacea*, **Schistostephium crataegifolium**, *Clutia pulchella*, *Sebaea grandis*, **Rhus dentata** and Asparagus laricinus. *Cheilanthes viridis* from species group W, associated with woodland communities, also occurs in this community, as well as *Senecio isatideus* from species group X. Both are associated with overutilization, but did not occur in the previous community. Physiognomically it is associated with low// short thicket. The average number of species per relevé was seventy-two. This community represents a vegetation unit found within Acocks' Northern Tall Grassveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: A community of flat areas with slopes suitable for crop growth. Typical land uses in the areas away from the boulders would be annual cropping, ley or special tillage and, on slopes of 13 - 20%, permanent cover crops.

DISCUSSION: This is another woodland community representing mixed sweetveld adjacent to the sweetveld grassland community 2.1. Support for this hypothesis is its altitudinal range, sandier soil texture and fewer species from species group X, species associated with overutilization. The higher sand content is the result of *in situ* weathering of granite, causing better infiltration, increased leaching and lowered nutrient availability in the vicinity of the boulders during the dry season. This results in lowered grazing pressure and a stronger presence of palatable decreaser grass species: Diheteropogon amplectens, Panicum maximum, Themeda triandra and increaser I species such as, Tristachya leucothrix, Cymbopogon plurinodis, Trachypogon spicatus, Loudetia simplex and Eulalia villosa compared to the Increaser IIc species Eragrostis plana, E. curvula and Melinis repens (Van Oudtshoorn 1991). Infiltration of precipitation along the joints and cracks within the granite increases the soil water availability within reach of the woody species, roots.

2.6. *Tetraselago wilmsii* - *Commelina africana* low// short sparse shrubland

GENERAL DESCRIPTION: This woodland community could easily be overlooked, as its woody species component is poorly developed. Although its existence could also be attributed to the presence of rocks, these lithological units range in size from pebbles to stones and are therefore difficult to see from a distance.

GEOLOGICAL ENVIRONMENT: The lithological unit, which underlies this community is igneous Mpluze Granite quartz monzonite from the Randian Erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The community's distribution is associated with the nature of terrain type **B3**. It was subjectively sampled on scarps and crests within the footslopes and valley bottom slope range. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 4%, 205° from North and 1598 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January 1995 at elevations of between 1500 and 1600 m.a.s.l. It is found within climate zone 54s, and does not receive more than an average annual precipitation of 872 mm. Stands of this community occur within **gentle, south facing insolation attitudes.**

PEDOLOGICAL ENVIRONMENT: This community is found within the Ac soil pattern at altitudes above 1270 m.a.s.l. The dominant soil form present is Mispah (medium to coarse sandy loam orthic A horizon, hard rock) in conjunction with surface rocks. Soil depth ranges from 100 to 600 mm or more. Pebbles (10 - 50 mm) and stones (50 - 200 mm) cover up to 9% of the surface area.

FLORISTIC DATA: This community is characterised by the species from diagnostic species group P: *Tetraselago wilmsii*, *Pelargonium luridum*, *Helichrysum aureonitens*, ***Pavetta edentula***, *Helichrysum coriaceum*, *Vernonia sutherlandii* and *Cyanotis speciosa*. Of these species *Tetraselago wilmsii* has the highest constancy (5) and very high (V) fidelity. The two transitional species from the two communities, *Pellaea calomelanos* and ***Rhoicissus tridentata***, also occur but to a lesser extent (Species group Q). Of all the species in constant species group S to species group X, *Commelina africana* has the highest constancy (5), with average fidelity (III). From constant species group S only Hyparrhenia hirta has a high abundance cover. The following species from species group U occur in this community but were absent from the previous community: *Acalypha angustata*, *Hypoxis iridifolia*, Microchloa caffra and *Bulbostylis burchellii*. *Senecio oxyriifolius* and ***Vangueria infausta*** (species group W), associated with woodland communities, are present in this community but were absent in the previous community. Only two species from species group X are present in this community, Melinis repens and *Hypochoeris radicata*. It is most likely that in this case, these two species do not reflect overutilization, but rather the presence of the rocks and anthropological disturbances (Van Oudtshoorn 1991; Van Wyk & Malan 1988). Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé was forty-seven. This community represents a vegetation unit found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: It might be thought possible that this community, which occurs within flat areas and is suitable to crop growth, could be subjected to land use practices such as annual cropping and ley or special tillage. The presence of the surface rocks, however, does not make this a viable option.

DISCUSSION: Reasons for the strong presence of Hyparrhenia hirta in a generally Themeda triandra dominant environment at altitudes above 1400 m.a.s.l (Grassland community 2.2 and 2.3) can only be speculated on. It could be attributed to selective grazing or fire or a combination of these factors.

Selective grazing might remove the more palatable species Themeda triandra, while regular burning makes the less palatable Hyparrhenia hirta accessible to livestock. Enough soil moisture to maintain trees and tall grasses is provided by the irregular surface and its south facing aspect, but fire prevents the formation of thick stands of trees and displaces the moisture-loving species, Setaria sphacelata (Constant species group S). It should be noted that this scenario does not necessarily reflect on bad management but on incorrect management, as species associated with neglect or overutilization from species group X are absent.

2.7. *Sporobolus pectinatus - Tristachya leucothrix* low// short sparse shrubland

GENERAL DESCRIPTION: A very poorly developed woodland community of medium slopes and rock sheets at higher altitudes than the previous community.

GEOLOGICAL ENVIRONMENT: Unnamed igneous granite from the Swazian Erathem underlies this community.

GEOMORPHOLOGICAL ENVIRONMENT: This community has a very similar nature of terrain type to that of the previous community. Local relief range from 90 - 150 m. Subjectively sampled on crests, it occurs on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 4%, 106° from North and 1662 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January 1995 at elevations of between 1600 to 1700 m.a.s.l. The average annual precipitation is above 872 mm, associated with different local climates. Flat, no aspect insolation attitudes maintain stands of this communty.

PEDOLOGICAL ENVIRONMENT: As with the previous community, this is a community of the Ac soil pattern at elevations of above 1550 m.a.s.l. With rock sheets of more than 1 m² in size, it is no surprise that the dominant soil form is Mispah in association with rocks. The A horizon's soil texture is predominantly medium to coarse sandy loam to sandy clay loam. The soil depth of the surrounding area ranges from 100 to 600 mm. Rock sheets cover up to sixty-four percent or more of the area.

FLORISTIC DATA: Diagnostic species group R contains the characteristic species of this community, of which Sporobolus pectinatus has a high constancy (4) compared to the average (3) constancy of the other species. This species together with Cymbopogon excavatus, *Zantedeschia albomaculata, Waltheria indica*, Elionurus muticus, Digitaria monodactyla, *Helichrysum pilosellum, Agapanthus nutans* and Alloteropsis semialata, has a very high (V) fidelity. Tristachya leucothrix (Species group U), a general species, has the highest constancy (4) and estimated cover abundance and lowest (II) fidelity of all the species outside the diagnostic species group. Other species in species group U not present in the previous community, which occur in this community, are *Senecio venosus*, Eulalia villosa and *Gladiolus elliotii*. The only significant woody species in this community is ***Diospyros whyteana*** (Species group W). Two other species from the same species group are *Cheilanthes viridis* and *Senecio oxyriifolius*, of which the latter clearly prefers this kind of habitat. Of significance is the absence of species associated with grazing (Hyparrhenia hirta and Themeda triandra - Constant species group S) and overutilization (Species group X). Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé was forty. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Similar to that of the previous community, except for the additional land use category: rotation of ley and crops on slopes of 8 - 12 %, indicating that this community occurs on steeper slopes than the previous one.

DISCUSSION: In terms of pedological environment, this community does not differ from the previous community, except that its surface has exposed rock sheets instead of pebbles and stones. This community is not suitable for any agricultural practices, as the rock sheets prevent cultivation while the slopes, the slippery rocks and the low vegetation cover discourage grazing. Associated with environments supporting sourveld and low utilization (Community 2.3), this community is extremely underutilised. Support for this hypothesis is based on the absence of decreasers such as *Diheteropogon amplectens*, *Panicum maximum*, *Themeda triandra* and the presence of increasers I, *Alloteropsis semialata*, *Tristachya leucothrix*, *Cymbopogon excavatus* and *Eulalia villosa*. The absence of *Hyparrhenia hirta* ,an increaser I, could be explained by low clay content and drier soil moisture conditions, which would also account for the absence of *Setaria sphacelata* (Constant species group S). Further support of the hypothesis of underutilization is the occurrence of only two increaser II species. *Elionurus muticus*, an increaser IIb, an indicator of moderate overutilization, which prefers poor, rocky soils just like the other increaser II species, and *Microchloa caffra* (increaser IIc), as well as the absence of all the other increaser IIc species found in species group X (Van Oudtshoorn 1991). ***Diospyros whyteana***, a medium sized shrub, occurs on the fringe of the rock sheets, where the soils are deep enough and water accumulates along the joints and cracks.

The species at the bottom of the phytosociological table's species list, occurred within 1% and 10% of the 405 plots surveyed, but not in this vegetation type of 109 plots. These are *Pogonarthria squarrosa*, *Kalanchoe paniculata*, *Aristida sciurus*, *Indigofera hilaris*, ***Acacia karroo***, *Perotis patens*, ***Acacia caffra***, *Dicerocaryum eriocarpum*, *Trichoneura grandiglumis*, ***Combretum apiculatum***, ***Acacia nilotica***, *Aristida diffusa*, *Nidorella anomala* and *Gnidia caffra*. If the assumption is correct that all the variation within the hills and lowlands vegetation type was sampled, the absence of the grasses listed could indicate the absence of sand-dominated soils in general from the hills and lowlands vegetation type (Van Oudtshoorn 1991). This is further supported by the absence of the woody species ***Combretum apiculatum***, a species well known for its association with sandy soils. Furthermore the absence of the thorn trees, ***Acacia caffra***, ***A. karroo*** and ***A. nilotica*** indicate the lack of vertic A horizon soils (Palgrave 1983, Van Wyk 1984, Scholes 1997). Both the hills and lowlands vegetation type communities confirm these concepts and their environmental attributes identified during this classification.

2.2. Ordination

Environmental trends were identified by means of DECORANA and multiple regression analysis (Figure 35). The communities of the terrestrial ecosystem were assigned letters in chronological sequence, and that of the aquatic or wetland ecosystem were given numbers. The indirect ordination plot reflects only those variables of the different environments of which the trends were statistically significant (P-value < $\propto$ at $\propto$ = 0.5). The table associated with the figure reflects the statistical parameters supplied by multiple regression. Of these parameters only the coefficients and P-value fields were of value. Only environmental variables with low P-values were included while the coefficients indicated whether a positive or negative correlation existed between the environmental variable gradient and the floristic data.

In the hills and lowlands vegetation type, two plots of the ordination results proved relevant. In the first plot (Figure 35.a) of AX1 against AX2, only two environmental attributes were significant, in spite of eigen values of 0.89 and 0.63 for the two axes, respectively. Both these attributes reflected environmental gradients which exist between the wetland communities and the terrestrial communities. These are soil water availability and terrain type nature, which indicated a decrease in soil moisture from the wetland communities to the communities of the terrestrial ecosystems (AX1) and an increase in slope and local relief along the same gradient on AX2.

The second plot (Figure 35.b) of AX1 against AX3 (eigen value: 0.52), has five significant environmental attributes. The only one associated with AX1, soil water availability, has already been discussed, while the remaining four on AX3 with a multiple regression coefficient of 0.83 reflect the environmental gradients between the different physionomical units within the hills and lowlands vegetation type. These are species per relevé, average annual precipitation, terrain unit classes (%) and Acocks' veld types.

The first three are concerned with the difference between the grass- and woodland communities, while the last is concerned with physionomical differences between the grassland communities. Grasslands are associated with the top and woodlands with the bottom of the AX3. Species per relevé increases from the grassland communities to the woodland communities, while woodlands are associated with an increase in annual average precipitation. Grasslands occur on the steeper terrain unit classes than woodland because of large soil water deficiency due to an increased runoff and perpendicular insolation. The Acocks' veld types reflect on the physiognomic difference between the grasses of the high and low lying areas. In this case the high lying areas are associated with the bottom of the AX3 axis. Acocks' North-eastern Sandy Highveld (Veld type 57) represents the *Themeda triandra*/*Tristachya leucothrix* dominated short grassland of high lying areas, while the Northern Tall Grassveld (Veld type 64) represent the *Hyparrhenia hirta* dominated tall grassland of low lying areas and drainage lines.

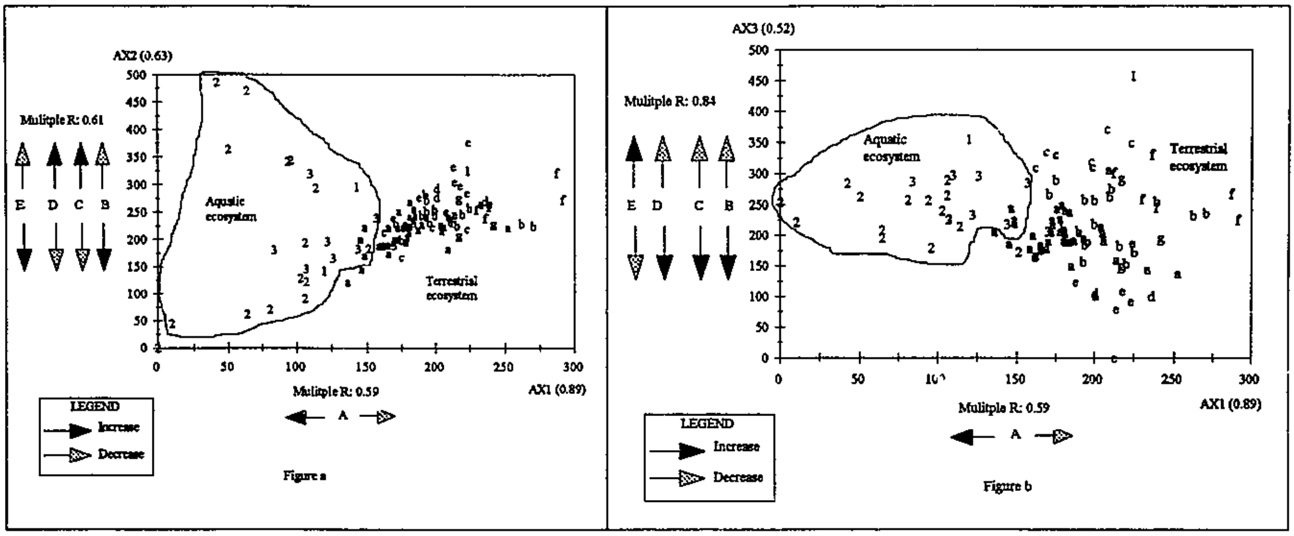


Figure 35.a: Plot of AX1 against AX2

Symbols	Variables	Coefficients	Standard Error	t Statistic	P-value < Alpha@0.05	Lower 95.00%	Upper 95.00%
AX1	Intercept	0.624842	0.344622	1.813124	0.072590	-0.061247	1.310931
A	Soil water availability	-27.477713	9.108068	-3.016854	0.003185	-45.610484	-9.344942
AX2	Intercept	-0.140791	0.227567	-0.618681	0.537429	-0.593841	0.312259
B	Terrain type nature	-17.729853	7.404798	-2.394374	0.018372	-32.471673	-2.988034
C	Percentage rock cover	0.563980	0.257966	2.186258	0.030955	0.050409	1.077550
D	Terrain unit classes (%)	125.231039	58.689190	2.133801	0.035122	8.389838	242.072241
E	Soil forms	-8.646792	4.080969	-2.118808	0.036399	-16.771377	-0.522206

Figure 35.b: Plot of AX1 against AX3

Symbols	Variables	Coefficients	Standard Error	t Statistic	P-value < Alpha@0.05	Lower 95.00%	Upper 95.00%
AX1	Intercept	0.624842	0.344622	1.813124	0.072590	-0.061247	1.310931
A	Soil water availability	-27.477713	9.108068	-3.016854	0.003185	-45.610484	-9.344942
AX3	Intercept	-0.168759	0.158700	-1.063380	0.289981	-0.484707	0.147189
B	Species per releve	-1.598735	0.497497	-3.213558	0.001729	-2.589174	-0.608295
C	Average annual precipitation	-0.299636	0.115799	-2.587541	0.010995	-0.530175	-0.069097
D	Physionomic classes	-8.197403	3.253862	-2.519284	0.013224	-14.675345	-1.719461
E	Terrain unit classes (%)	87.961360	40.928697	2.149137	0.033857	6.478584	169.444136

Figure 35: DECORANA ordination scatter diagram showing the two ecosystems, their communities and most significant environmental trends (Eigen values)

2.3. General

It is clear from the results that the thirteen clusters selected from the TWINSPAN classification and which conform to the conditions set are separable and of informational value. Nine of these clusters represent abstract vegetation communities found within the terrestrial ecosystem of the Southeastern Mpumalanga Hills and lowlands Vegetation Type. The other four represent abstract vegetation communities from the wetland areas of the aquatic ecosystem.

Pure grassland communities of low or short grass within the terrestrial ecosystem are found in areas where surface rockiness and water percolation is limited. When the average lengths of the grass species indicated in Van Oudtshoorn (1991) are used, the physiognomic classification of the grassland communities should be changed from short (0.5 - 1 m) to tall (1 - 2 m) and from low (0 - 0.5 m) to short (0.5 - 1 m). Tall grass occurs in areas of higher soil water availability [higher precipitation, less steep slopes, closer to sources of water (e.g. surface rocks and adjacent to areas of low infiltration and large runoff), fine textured soils, less leached soils, deep soils and drainage lines] than short grass.

Differences in soil texture and water availability result in different nutritional qualities of species growing on it. Species growing on fine textured soils tend to be more nutritious than those on coarse textured soils, resulting in the overutilisation of communities of fine textured soils (communities 1.1 to 2.1 and 2.4) compared to communities of coarse textured soils (communities 2.2, 2.3 and 2.5 to 2.7). Other factors influencing grazing pressure are rockiness, slope and management (communities 2.6 and 2.7)

In general, it could be stated the Southeastern Mpumalanga Hills and Lowlands Vegetation type occurs on lithological units of the exposed shield from the Precambrian System. It is a moist, low lying, tall to dry, high lying, short, grass dominated area with poorly developed woodlands restricted to widely spaced igneous outcrops of different size and origin.

CHAPTER VII- PHYTOSOCIOLOGY OF THE SOUTHEASTERN MPUMALANGA PLAINS VEGETATION TYPE

1. Introduction

The slightly to strongly undulating plains occuring to the west of the study area (Figure 36) are associated with this vegetation type (Chapter IV).

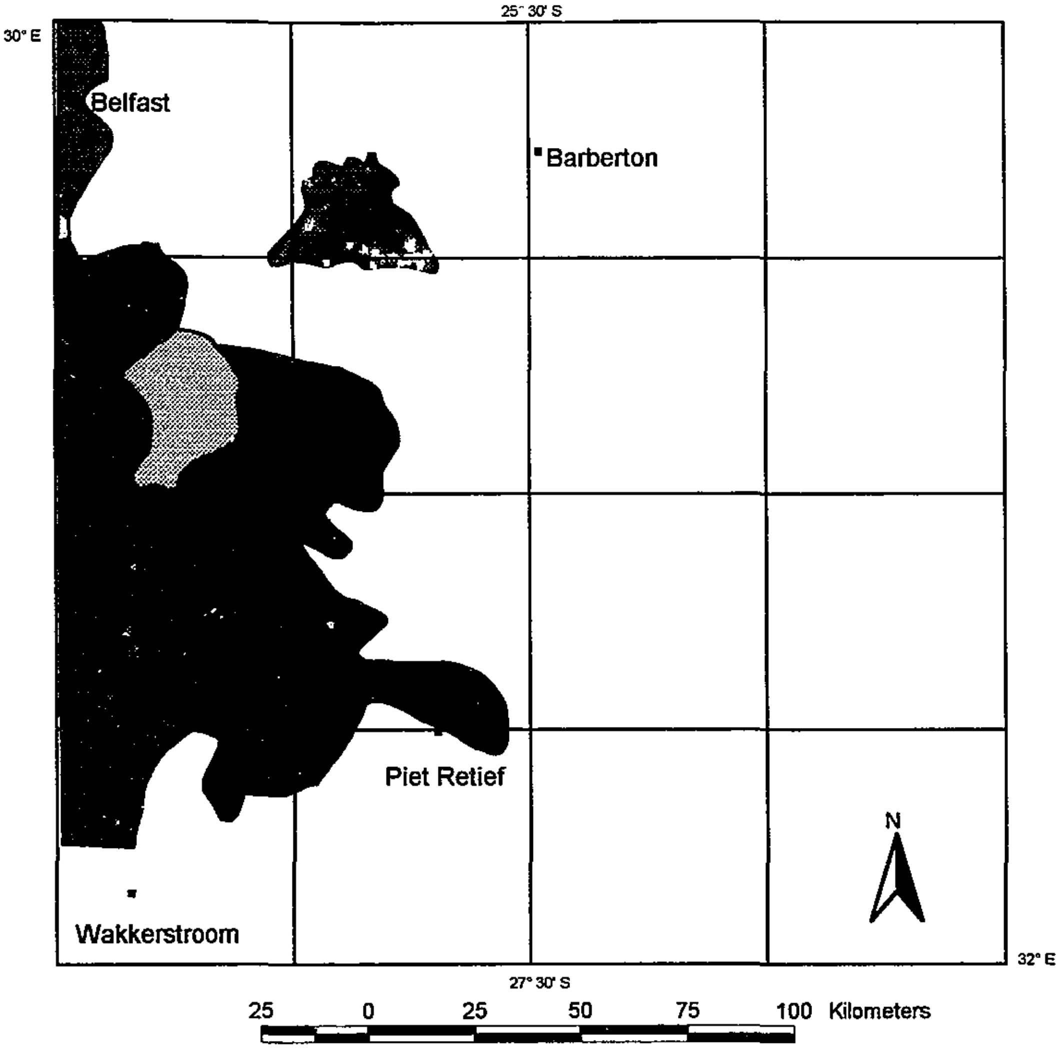
The abiotic components involved in the formation of the plains, and their influence on the biotic components, are discussed in detail from both a global and local perspective in Chapter III. Plains occur within both shields. Both plains and inselbergs are the result of either pediplanation or deep weathering and stripping, or a combination of both, during dry and wet periods (Buckle 1978). The plains represent sequential landforms, formed on easily weathered metamorphic and sedimentary rocks. The topography is simple, the microclimatology conforming, and deep, moderately to poorly drained, mesotrophic to eutrophic soils occur. Plains with low to moderate relief are associated with surface configurations of which 80% or more of the area has slopes of less than 5° (8%).

The methods applied are described in Chapter II, paragraph 3.1. Plant communities were given a specific name consisting of two botanical names and a subjective physiognomic classification according to Edwards (1983). The first botanical name indicates the characteristic species with the highest fidelity and constancy and the second the constant species with the highest constancy and lowest fidelity. If more than one species was found which qualifies either as characteristic or constant then the species with the highest estimated cover abundance was selected. Pure low or short grassland communities indicate communities in which woody species with shrub or tree-like life forms do not occur. In the floristic descriptions, woody species are printed in bold, grasses are underlined and forbs are in italic. Species richness was based on the average number of species per relevé in the plant community.

2. Results and discussion

2.1. Classification

Eighteen clusters of the TWINSPAN classification executed on the 151 plots associated with the plains landform, qualified as being separable and of informational value (Figure 37). Results from the analysis of the environmental attributes confirmed their separability and informational value. Environmental attributes printed in bold are those attributes which differentiate one environmental division from another or one cluster from another at 80% or more (Figure 37).



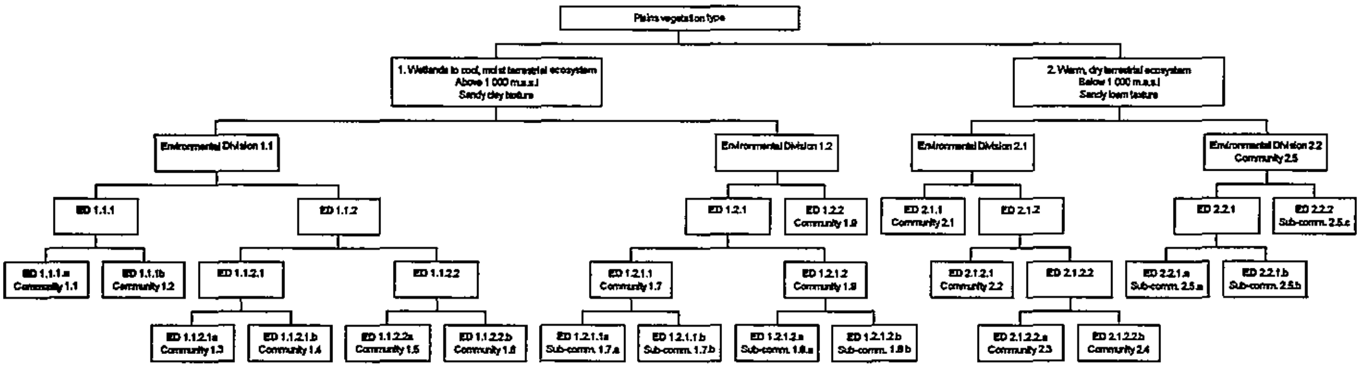
Geographical grid
▪ Towns

Aquatic to cool, moist terrestrial ecosystem
- 1.01. Senecio affinis - Imperata cylindrica Pure low closed grassland community
- 1.02. Wahlenbergia undulata - Eragrostis plana Pure low closed grassland community
- 1.03. Helichrysum pilosellum - Eragrostis plana Pure low closed grassland community
- 1.04. Conyza canadensis - Eragrostis plana Pure low closed grassland community
- 1.05. Salix babylonica - Setaria sphacelata Low// short bushland community
- 1.06. Pennisetum sphacelatum - Paspalum dilatatum Pure low closed grassland community
- 1.07. Vernonia natalensis - Themeda triandra Pure low closed grassland community
- 1.08. Cucumis zeyheri - Hyparrhenia hirta Low// short sparse shrubland community
- 1.09. Cymbopogon validus - Panicum natalense Low// short sparse woodland community

Warm, dry terrestrial ecosystem
- 2.01. Indigofera cryptantha - Heteropogon contortus Low// short sparse woodland community
- 2.02. Phragmites australis - Hyperthelia dissoluta Pure short closed grassland community
- 2.03. Perotis patens - Hyperthelia dissoluta Pure short closed grassland community
- 2.04. Crabbea angustifolia - Loudetia flavida Pure low closed grassland community
- 2.05. Pavetta edentula - Pellaea calomelanos Low// short thicket community

Southeastern Mpumalanga Plains Vegetation Type
- Moderately undulating plains
- Moderately undulating plains and pans
- Slightly undulating plains
- Slightly undulating plains and pans
- Strongly undulating plains

Figure 36: The Southeastern Mpumalanga Plains Vegetation Type, indicating the approximate distribution of the two ecosystems and their communities



1. Wetlands to cool, moist terrestrial ecosystem communities
1.1. *Senecio affinis - Imperata cylindrica* Pure low closed grassland
1.2. *Wahlenbergia undulata – Eragrostis plana* Pure low closed grassland
1.3. *Helichrysum pilosellum – Eragrostis plana* Pure low closed grassland
1.4. *Conyza canadensis – Eragrostis plana* Pure low closed grassland
1.5. *Salix babylonica - Setaria sphacelata* Low// short bushland
1.6. *Pennisetum sphacelatum - Paspalum dilatatum* Pure low closed grassland
1.7. *Vernonia natalensis – Themeda triandra* Pure low closed grassland
1.7.a. *Crabbea acaulis - Vernonia natalensis* Low// short sparse shrubland
1.7.b. *Microchloa caffra - Vernonia natalensis* Pure low closed grassland
1.8. *Cucumis zeyheri - Hyparrhenia hirta* Low// short sparse shrubland
1.8.a. *Helichrysum cephaloideum - Cucumis zeyheri* Low// short thicket
1.8.b. *Cephalanthus natalensis - Cucumis zeyheri* Low// short sparse shrubland
1.9. *Cymbopogon validus - Panicum natalense* Low// short sparse woodland

2. Warm, dry terrestrial ecosystem communities
2.1. *Indigofera cryptantha - Heteropogon contortus* Low// short sparse woodland
2.2. *Phragmites australis - Hyperthelia dissoluta* Pure short closed grassland
2.3. *Perotis patens - Hyperthelia dissoluta* Pure short closed grassland
2.4. *Crabbea angustifolia - Loudetia flavida* Pure low closed grassland
2.5. *Pavetta edentula - Pellaea calomelanos* Low// short thicket
2.5.a. *Ehretia rigida - Pavetta edentula* Low// short thicket
2.5.b. *Gerbera piloselloides - Pavetta edentula* Low// short thicket
2.5.c. *Ficus glumosa - Pavetta edentula* Low// short thicket

Figure 37: TWINSPAN classification dendrogram of the plains vegetation type

Table 26.a (Appendix J) reflects those species included in the phytosociological table at constancy levels of more than 33% per cluster. Diagnostic species groups indicate those species with very high fidelity (low percentage) and separability per cluster (Table 26.b). Estimated cover abundance and number of relevés per cluster are displayed in Table 26.c. Each cluster represents a specific abstract plant community with its own set of species and environmental attributes.

2.1.1. Southeastern Mpumalanga Plains Vegetation Type

This plains vegetation type (Figure 37) also reflects the influence of soil water availability, but less profoundly than in the case of the previous two vegetation types. Instead of separating the wetland communities of the aquatic ecosystem from the communities of the terrestrial ecosystem, the TWINSPAN algorithm distinguishes between an aquatic to cool, moist terrestrial ecosystem and a warm, dry terrestrial ecosystem, reflecting different altitudes and clay content. The set of clusters associated with the aquatic to cool, moist terrestrial ecosystem consists of eleven clusters and the second set associated with the warm, dry terrestrial ecosystem consists of seven clusters (Figure 37).

Unnamed igneous and metamorphic rocks underlie these eighteen abstract plant communities. The dominant terrain group is **plains with moderate relief** and the dominant terrain type is **strongly undulating plains**. Classified within the GIS surface models, **footslope or valley bottom (0 - 12% slope) category**, it represent a **flat (0 - 8%)** environment. Cultivation has an impact on this vegetation type, as erosion is not a problem on slopes of 0 - 15%, these being suitable for **crop growth**, with slopes of 0 - 3% available for **annual cropping**.

1. Aquatic to cool, moist terrestrial ecosystem (Figure 37)

As would be expected from wetland communities, associated with aquatic ecosystems, they occur in association with a clayey soil textures, while the cool, moist terrestrial communities are distributed on clayey soils, above 1000 m.a.s.l. **Surface rock is limited.** These communities are:
1.1. *Senecio affinis - Imperata cylindrica* pure low closed grassland community
1.2. *Wahlenbergia undulata - Eragrostis plana* pure low closed grassland community
1.3. *Helichrysum pilosellum - Eragrostis plana* pure low closed grassland community
1.4. *Conyza canadansis - Eragrostis plana* pure low closed grassland community
1.5. *Salix babylonica - Setaria sphacelata* low// short bushland community
1.6. *Pennisetum sphacelatum - Paspalum dilatatum* pure low closed grassland community
1.7. *Vernonia natalensis - Themeda triandra* pure low closed grassland community
1.7.a. *Crabbea acaulis - Vernonia natalensis* low// short sparse shrubland sub-community
1.7.b. *Microchloa caffra - Vernonia natalensis* pure low closed grassland sub-community
1.8. *Cucumis zeyheri - Hyparrhenia hirta* low// short sparse shrubland community
1.8.a. *Helichrysum cephaloideum - Cucumis zeyheri* low// short thicket sub-community

1.8.b. *Cephalanthus natalensis - Cucumis zeyheri* low// short sparse shrubland sub-community
1.9. *Cymbopogon validus - Panicum natalense* low// short sparse woodland community

Communities 1.1 through 1.6 represent the wetland communities of the aquatic ecosystem (Environmental Division 1.1 - Figure 37). They are associated with terrain type natures of which **80% or more of the area has slopes of less than 8%, at local relief of 90 - 150 m.** Associated with the subjectively sampled **valley bottoms**, during **February 1995**, they have **slopes of 0 - 2°**, which never receive perpendicular insolation. The dominant soil form is **Katspruit**.

Communities 1.1 and 1.2 (Environmental division 1.1.1) are two riparian wetland communities associated with the dry, warm terrestrial ecosystem environment. They are underlain by **unnamed metamorphic gneiss** from the **Cryptozoic Eon**, within the **International Archaean Erathem**, more specifically of **Swazian age**. The dominant terrain type nature represents areas of which **50 - 80% have slopes of less than 8% and local relief of 150 - 300 m**. These two communities were sampled at elevations up to **1 200 m.a.s.l.** They occur mainly within **local climate zone 118s**, which receives an annual average precipitation of **894.1 mm**. The dominant insolation attitude is **gentle, southeast facing** in association with slopes of **2 - 25°**, which receive perpendicular insolation, during **summer mornings on east to southeast facing slopes**. Both of them are found within land type **Fa166**, at altitudes not below **900 m.a.s.l.** The soil texture of the **A horizon is coarse sand to loam sand** and soil depth ranges from **300 - 500 mm**. Physiognomically it is associated with **low// short bushland** and these communities represent vegetation units found within Acocks **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland**. Slopes of 4 - 7% should be used for **ley or special tillage**.

1.1. *Senecio affinis - Imperata cylindrica* pure low closed grassland community
GENERAL DESCRIPTION: This community is found next to non-perennial drainage lines (streams), which occasionally flood their levees. The coarse sediment settles closer to the streambed, while the finer sediment settles further away. They are generally found in association with the next community, which occurs in the streambed itself.
GEOLOGICAL ENVIRONMENT: The **igneous** lithological units, which underlay this community, are from the younger **Randian** erathem. Both of the lithological units, basalt from the Nsuze Group of the Pongola Sequence and Mpluze Granite quarts monzonite, are potential sources of clay particles.
GEOMORPHOLOGICAL ENVIRONMENT: This community is also associated with the **moderately undulating plains** terrain type. The corresponding nature of terrain type is A3 (Chapter III, paragraph 3.3.A). Subjectively sampled within valley bottoms (Chapter II, paragraph 2.3.1), it occured within the slope range associated with footslopes and valley bottoms (Chapter III, paragraph 3.3.B). Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 3%, 61° from North and 1284 m.a.s.l.
CLIMATIC ENVIRONMENT: Samples were taken during the summer months of 1994 and 1995 at elevations of between 900 to 1700 m.a.s.l. Mean annual precipitation is 872 mm. **Flat to gentle,**

easterly facing insolation attitudes are associated with this community (Chapter III, paragraph 3.2.3.B).

PEDOLOGICAL ENVIRONMENT: Although this community is associated with the land type of the dry, warm terrestrial ecosystem, Fa166, it also occurs within the Ac and Ad soil patterns. Katspruit is the only soil form present and the A horizon has a fine, medium sand clay to medium, coarse sandy clay loam texture. The soil depth ranges from 300 to 600 mm. Surface stones or rocks, when present, cover up to 15% of the surface area.

FLORISTIC DATA: Diagnostic species group A contains the characteristic species of this community, i.e. *Cliffortia nitidula* and *Senecio affinis*. Both these species have an average (3) constancy and very high (V) fidelity. *Senecio affinis* was selected as the characteristic species as it is easily recognised in the field. *Verbena brasiliensis* and *Persicaria lapathifolia* are species from transitional diagnostic species group D; both are exotics associated with moist conditions (Van Wyk & Malan 1988). *Imperata cylindrica* (Species Group AA) was selected as the constant species rather than *Themeda triandra* (Constant Species Group Z), because it has a higher constancy (4) than the latter and lower (average (III)) fidelity as well as higher estimated cover abundance. Other species from species group AA, associated with wetland ecosystems, are *Arundinella nepalensis* and *Phymaspermum athanasioides*. The following species of species group AD, associated with sandy clay textures on igneous rocks at altitudes above 1000 m, are *Eragrostis plana*, *Hyparrhenia hirta*, *Commelina africana*, *Hypochoeris radicata*, *Paspalum dilatatum*, *Cyperus esculentus* and *Eulalia villosa*. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was twenty-six. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Occurring in a generally flat environment (Chapter II, paragraph 2.6.3), suitable for crop growth. Some of its land uses are annual cropping and ley or special tillage.

DISCUSSION: Depending on the frequency and duration of flooding, this community represents either a seasonal herbaceous swamp or edaphic grassland. It is marginally overutilised as indicated by the presence of species such as *Phymaspermum athanasioides*, *Melinis repens*, *Eragrostis plana*, *Hypochoeris radicata* and *Tagetes minuta*. Soil moisture is sufficient to maintain a tall grass such as *Hyparrhenia hirta* or a woody species such as ***Diospyros lycioides***, even though the soil texture is sandy loam, and therefore the water table is probably relatively close to the surface. It is possible in the case of this community that *Eulalia villosa* might have been mistakenly identified and should rather be *Ischaemum fasciculatum*. According to Van Oudtshoorn (1991), the former seldom occurs in moist areas.

1.2. *Wahlenbergia undulata - Eragrostis plana* pure low closed grassland community

GENERAL DESCRIPTION: The non-perennial streambed in which this community occurs has low levees and is covered from levee to levee with herbaceous vegetation. It seldom floods and the current generally flows slow and low. Surface water occurs for short periods.

GEOLOGICAL ENVIRONMENT: Mainly underlain by unnamed metamorphic gneiss of Swazian age, it is also found in association with lithological units from the previous community. An additional source of clay is the Volksrust Formation shale of the Karoo Sequence.

GEOMORPHOLOGICAL ENVIRONMENT: The dominant terrain type is strongly undulating plains, and the associated nature of terrain type is B4. Subjectively sampled within valley bottoms, it occured within the slope range associated with footslopes and valley bottoms of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 5%, 86° from North and 1214 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during February of 1995 at elevations of between 1000 to 1200 m.a.s.l. On average it receives 894.1 mm precipitation annual. Stands of this community occur within gentle, southeast facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: It has the same pedological environment as the previous community except that it is more regularly inundated. Where present the B horizon tends toward the fine to coarse sandy clay loam texture. No surface rock occurs.

FLORISTIC DATA: Characterised by the species from diagnostic species group B, of which *Wahlenbergia undulata* has the highest constancy (V) and, together with all the other species, has a very high (V) fidelity. Other species in this diagnostic species group are Leersia hexandra, Paspalum urvillei, *Schoenoplectus corymbosus*, Miscanthus junceus and *Sesbania* species The two transitional species from the previous community associated with diagnostic species group D also occur. Eragrostis plana instead of Setaria sphacelata is selected as the constant species, because it has a higher constancy (5) than the latter as well as a higher estimated cover abundance. Species from species group AA, which did not occur in the previous community, are *Mariscus congestus*, *Kyllinga alba*, *Coleochloa setifera* and *Cyperus rupestris*. These species prefer moist conditions but can also survive periods of drought (Van Wyk & Malan 1988). Only three species from species group AC did not occur in the previous community, i.e. *Conyza podocephala*, *Scabiosa columbaria* and Setaria nigrirostris. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was thirty-six. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found within a flat area suitable for crop growth, with slopes less than 15%. Land use possibilities are annual cropping, ley or special tillage crops and rotation of ley and crops.

DISCUSSION: The sandy clay texture of this community is the result of water-related processes. Mostly fine textured sediment is washed into the system by the slow flowing stream, as larger particles are too heavy for such a weak current. This fine sediment deposit is further enhanced during periods of saturation, when heavier particles are pulled deeper into the soil profile by gravity while the fine particles remain suspended. After the water table has lowered and water evaporated, the fine particles remain at the top and the coarse material at the bottom. Heavy or larger particles brought into the community during flooding, are covered or removed by the same process. Although potentially overutilised by livestock or game, the absence of permanent water prevents this from happening. Where this community and the previous community are poorly developed, they are easily destroyed by cultivation.

Communities 1.3 to 1.6 (Environmental division 1.1.2) are wetland communities which occur within the cool, moist terrestrial ecosystem on clayey soils at altitudes above 1 000 m.a.s.l. Compared to the previous two communities, they are associated with perennial streams or non-perennial streams with faster flowing currents, resulting in deep streambeds with more defined levees. Furthermore they occur on flat slopes of 0 - 2°, which never receives perpendicular insolation, and at altitudes above 1150 m.a.s.l. on generally deeper soils of 450 mm or more. They represent vegetation units within Acocks' North-eastern Sandy Highveld.

Communities 1.3 and 1.4 (Environmental division 1.1.2.1) are underlain by sedimentary rocks. They have been subjectively sampled on footslopes having none to southerly aspects, with some surface rock, along drainage lines of faster but still temporary flow. In contrast, communities 1.5 and 1.6 are associated with permanent flowing or inundated streambeds, underlain by **igneous** rock. They were subjectively sampled on valley bottoms of northerly aspect. They have no surface rock and occur at altitudes of **1700 m.a.s.l.**

1.3. *Helichrysum pilosellum - Eragrostis plana* pure low closed grassland community

GENERAL DESCRIPTION: This community represents the second of the three zones found along fast flowing, temporary drainage lines. The first zone is the streambed, with no or very little vegetation, the second is just beside the streambed on the levees and beyond, and the third zone is the area furthest away and only becomes inundated during floods.

GEOLOGICAL ENVIRONMENT: Lithological units from both the Phanerozoic and Cryptozoic Eon underlie these drainage lines and their associated community. They represent two types of petrological ...s, sedimentary Volksrust Formation shales of the Ecca Group from the Karoo Sequence and **igneous** Nsuze Group basalt from the Pongola Sequence and **Randian erathem.**

GEOMORPHOLOGICAL ENVIRONMENT: This community is found within terrain types which reflect moderately to strongly undulating plains. The nature of terrain type includes level land classes A and B and relief classes three and four. Subjectively sampled within footslopes and valley bottoms, these two terrain units occur on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 1°, 1%, 67° from North and 1620 m.a.s.l.

CLIMATIC ENVIRONMENT: Predominantly sampled during April 1995 at altitudes above 1100 m.a.s.l. Found within climate zone 57, and receiving 725 mm precipitation on average annual, this community occurrs within flat, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: Due to the strong influence of water in this community, it occurs within several soil patterns: Ac, Bb and Fa at altitudes above 1150 m.a.s.l. Except for the Katspruit, Griffin and Hutton soil forms also occur. The A horizon soil texture is medium to coarse sand loam to sandy clay loam to sandy clay. That of the B horizon is fine to coarse sandy clay loam to sandy clay. The soil depth exceeds 300 mm. Surface rockiness does not exceed 23%, either as stones or rocks.

FLORISTIC DATA: Only one species is characteristic of this community, *Helichrysum pilosellum* of diagnostic species group C. It has a very high (V) fidelity and average (III) constancy. The transitional species from diagnostic species group D also occur in this community. *Eragrostis plana* ,from species group AC, has a very high (5) constancy and average (III) fidelity and estimated cover abundance, compared to *Themeda triandra* and *Setaria sphacelata* (Constant Species Group Z). Species associated with wetland ecosystems (Species group AA) which are present in this community are *Hyparrhenia dregeana*, *Mariscus congestus*, *Arundinella nepalensis* and *Cyperus rupestris*. *Helichrysum rugulosum* and *Crepis hypochoeridea* are two species from species group AC, which are associated with sandy clay textures on igneous rocks at altitudes above 1000 m and which did not occur in the previous two communities. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was twenty-six. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's Moist Sandy Highveld Grassland and North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Classified within the adapted pasture classes, flat (0 - 8% slope) category, it is suitable for crop growth (0 - 15% slope), especially annual cropping (0 - 3% slope).

DISCUSSION: Slow lateral release of ground water from sandy loam soils enables these drainage lines to flow faster for longer periods than drainage lines of the previous community. The fast flowing currents, regular floods and periods of deep standing water prevent vegetation from establishing in the streambeds of these drainage lines. Soil moisture content of the levees, depending on the level of the water in the streambed, alternates between saturation and wilting point. The shape and condition of these levees is constantly altered by the force of the water, as indicated by the presence of species associated with disturbance: *Eragrostis plana*, *Conyza podocephala* and *Sporobolus africanus*.

1.4. *Conyza canadensis* - *Eragrostis plana* pure low closed grassland community

GENERAL DESCRIPTION: This community represents zone three along drainage lines of the same type as the previous community. It is distinguished from the previous community on the basis of location and species composition.

GEOLOGICAL ENVIRONMENT: Sedimentary Vryheid Formation arenite of the Ecca Group, Karoo Sequence of the Phanerozoic erathem and more specifically Palaeozoic system in age, underlay this community. This coarse grained sediment was deposited during the Phanerozoic Eon.

GEOMORPHOLOGICAL ENVIRONMENT: The dominant terrain type is strongly undulating plains and its associated nature of terrain type is A3. Subjectively sampled on footslopes, it occurs on slopes associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 4%, 128° from North and 1670 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during February 1995 at elevations of between 1600 to 1700 m.a.s.l. It is found within climate zone 56, and receives on average annual 733.4 mm precipitation. Flat, no aspect insolation attitudes maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: This community was sampled within the Ac soil pattern, more specifically in land type Ac39, at altitudes not below 1650 m.a.s.l. Griffin (orthic A horizon, yellow-brown apedal B horizon, red apedal B horizon) is the dominant soil form, while Avalon (orthic A horizon, yellow-brown apedal B horizon, soft plinthic B horizon) and Katspruit also occur. The presence of the first two soil forms indicates changes in the water table level, with an increase in soil moisture content deep within the soil profile. The soil depth ranges from 450 to 1200 mm or more. Surface rockiness is limited at 5% and is not larger than either pebbles or stones.

FLORISTIC DATA: Diagnostic species group E contains the characteristic species of this community. *Conyza canadensis* has the highest constancy (4) and very high (V) fidelity, together with all the other species in this species group. Other species in species group E are Bothriochloa bladhii, *Conyza canadensis*, *Centella* species and Hemarthria altissima. *Oenothera rosea* and *Cirsium vulgare* from transitional diagnostic species group G is also present. Once again, Eragrostis plana was selected to represent the constant species, rather than species from constant species group Z. The same reasons apply as in the case of the previous two communities, although it should be mentioned that both Themeda triandra and Setaria sphacelata are well represented in this community. The following three species of species group AA, associated with wetland ecosystems, did not occur in the previous community: *Monopsis decipiens*, Helictotrichon turgidulum and Agrostis eriantha. The following species from species group AC occur in this community but not the previous one *Haplocarpha scaposa*, Eragrostis capensis, *Hypochoeris radicata*, *Verbena venosa*, *Solanum elaeagnifolium* and *Pelargonium luridum*. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was thirty. This community also represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's Moist Sandy Highveld Grassland.

WILDLIFE MANAGEMENT: Predominantly found within the adapted pasture classes, flat category, some samples occurred within the medium category. Both these classes are within the range of the erosion limitation class, slopes suitable for crop growth on slopes of 0 - 15%. Annual cropping on slopes of 0 - 3% would be the most suitable land use, while steeper slopes of 8 - 12% could be used for rotation of ley or crops.

DISCUSSION: If this community, along a source of irrigation, is not destroyed by cultivation, it is overutilised by livestock. This impact is not as severe as it might be, however, because of the temporary nature of the fast flowing streams, but disturbances such as trampling and overutilisation do occur. The presence of species such as *Oenothera rosea*, *Cirsium vulgare*, Eragrostis plana, *Hypochoeris radicata*, *Verbena venosa* and *Solanum elaeagnifolium* support this hypothesis (Van Oudtshoorn 1991, Van Wyk & Malan 1988).

1.5. *Salix babylonica - Setaria sphacelata* low// short bushland community

GENERAL DESCRIPTION: Physiognomically different from the previous riparian wetland communities. This community is associated with permanent flowing streams or small rivers. The streambed is wider and deeper than in the case of the previous two communities, but the levees are not necessarily better developed.

GEOLOGICAL ENVIRONMENT: This community is underlain by sills or larger dykes of the youngest igneous rock found within this vegetation type, the Karoo dolerites of Mesozoic age in the Phanerozoic erathem.

GEOMORPHOLOGICAL ENVIRONMENT: The terrain type of this community is strongly undulating plains, and the associated nature of terrain type is A3. Subjectively sampled within valley bottoms, it occurs on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 5%, 182° from North and 1704 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during February 1995 at elevations above 1600 m.a.s.l. It is found within climate zone 56, which receives on average annual 733.4 mm precipitation. Stands of this community occur within flat insolation attitudes facing all aspects.

PEDOLOGICAL ENVIRONMENT: This community occurs within the Ac soil pattern at altitudes not less than 1650 m.a.s.l. The dominant soil form is Katspruit; another soil form, which occurs in association with streambeds, is Rensburg. The latter differs from the Katspruit in that a vertic **A horizon** occurs on top of a G horizon, instead of an orthic A horizon. Vertic soils are associated with high clay content. This is confirmed by the soil texture, which is fine sand clay to clay for both horizons. Soil depth is 1200 mm or more. No surface rock occurs.

FLORISTIC DATA: The woody species, ***Salix babylonica*** is characteristic of this community. It is an exotic which has become naturalised (Palgrave 1983). Of all the species in diagnostic species group F, it has the highest constancy (5) and very high fidelity (V). *Sium repandum* and *Berula erecta* are two species from the same species group with very high fidelity and a high (4) constancy. The transitional species from diagnostic species group G are also present. *Setaria sphacelata* from constant species group Z has a very high constancy (4) and low fidelity (II), and is also the only species present from this species group. The following species from species group AA did not occur in the previous community: *Imperata cylindrica*, *Mariscus congestus*, *Arundinella nepalensis* and *Coleochloa setifera*. Only the following three species from species group AC are prominent in this community: *Eragrostis plana*, *Paspalum dilatatum* and *Cyperus esculentus*. Physiognomically it is associated with low// short bushland. The average number of species per relevé was twenty-seven. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's Moist Clay Highveld Grassland.

WILDLIFE MANAGEMENT: It qualifies for inclusion in two of the adapted pasture classes, flat and medium. According to the erosion limitation classification it is suitable for crop growth. Annual cropping and rotation of ley and crops are two land uses which could be applicable to this community.

DISCUSSION: Due to the presence of deep soils and the absence of rock, this community is often destroyed by cultivation. The Karoo dolerites are the source of the clay, due to the *in situ* weathering of the rock in this predominantly flat environment. Streambeds are wide and deep as a result of the continual removal of sediment by the faster flowing permanent currents. Permanent currents are possible because of the movement of excess water from the adjacent mountain and hill landforms, by means of temporary streams or lateral flow.

1.6. *Pennisetum sphacelatum - Paspalum dilatatum* pure low closed grassland community

GENERAL DESCRIPTION: This community represents the temporarily inundated flat area adjacent to the previous community. It becomes inundated as a result of floods.

GEOLOGICAL ENVIRONMENT: Igneous Mpluze Granite quarts monzonite of Swazian age, underlay this community.

GEOMORPHOLOGICAL ENVIRONMENT: The terrain type is moderately undulating plains and the nature of terrain type is A3. It was sampled subjectively within valley bottoms and footslopes, and occurs on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 0°, 1%, 113° from North and 1654 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during February 1995 at elevations of between 1600 to 1700 m.a.s.l. It is found within climate zone 54, and receives annual average precipitation of not less than 872 mm. Flat, north facing insolation attitudes maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: This community occurs within the Ad soil pattern at altitudes not less than 1550 m.a.s.l. Katspruit is the dominant soil form while Hutton also occurs. The A horizon is medium to coarse sandy clay loam, while the B horizon, when present, tends towards medium to coarse sandy clay loam to sandy clay. The soil depth range from 600 to 1200 mm or more. No surface rocks occur.

FLORISTIC DATA: Pennisetum sphacelatum is the only species which differentiates this community from the previous communities of the wetland communities (Diagnostic species group H). It is characteristic because it has a high (5) constancy and very high (V) fidelity. According to Van Oudtshoorn (1991), it is a species common to moist areas, such as vleis and other drainage areas. It prefers deep, heavy (fine textured) soils or any other moist soils. Paspalum dilatatum (Species Group AC) is the constant species rather than Setaria sphacelata (constant species group Z). It also prefers moist conditions and has a very high (5) constancy and average (III) fidelity. Two species from species group AA, which were not present in the previous community are: *Kyllinga alba* and Agrostis eriantha. *Helichrysum rugulosum* and *Hypochoeris radicata* are two species from species group AC, species associated with sandy clay textures on igneous rocks at altitudes above 1000 m, which were not present in the previous community. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was twenty-two. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: The primary land use is annual cropping on slopes of 0 - 3%, which qualify for inclusion in the flat adapted pasture class category and crop growth erosion limitation category.

DISCUSSION: The connecting factors between this and the previous community are soil depth and moist content, as confirmed by the presence of Pennisetum sphacelatum, Setaria sphacelata and Paspalum dilatatum. Deep soils are the result of *in situ* weathering on gentle slopes, with limited transport of soil particles by surface runoff. High soil water content is the result of enough water being available to maintain the permanent streams. Soil moisture content towards the top of the soil profile decreases with increasing soil depth. Yellow-brown apedal B horizons occur within very deep soils, red apedal B horizons are found in deep soils and there are saturated G horizons on shallow soils or close to the stream.

The moist, cool terrestrial ecosystem is represented by communities 1.7 to 1.9 (Environmental division 1.2). They are mainly underlain by fine grained **igneous** rock from the Phanerozoic Eon, the source of the clayey soil texture at altitudes above 1 200 m.a.s.l. Community 1.9 (Environmental division 1.2.2) is separated from communities 1.7 and 1.8 (Environmental division 1.2.1) by its underlying metamorphic rock.

Community 1.7 (Environmental division 1.2.1.1) is separated from community 1.8 (Environmental division 1.2.1.2) on the basis of altitude, perpendicular insolation and percentage rock.

1.7. *Vernonia natalensis* - *Themeda triandra* pure low closed grassland community

GENERAL DESCRIPTION: This community occurs within all the terrain morphological units except valley bottoms at altitudes above 1600 m.a.s.l. It never receives perpendicular insolation. Surface rock is below thirty percent.

GEOLOGICAL ENVIRONMENT: Lithologic units of different petrological origin underlay this community, of which the majority are from the **Phanerozoic** Eon and igneous such as **Karoo dolerite.**

GEOMORPHOLOGICAL ENVIRONMENT: The dominant terrain group is plains with moderate relief. It includes slightly, moderately and strongly undulating plains. A wide range of nature of terrain types are associated with this community but the dominant nature of terrain type is A3. Sampled subjectively within all the terrain morphological units except valley bottoms, most of the relevés are associated with midslopes and crests on slopes of less than 100%. Average values based on quantitative data for slope (°, %), aspect and altitude range from: 1 - 3°, 2 - 5%, 32 - 66° from North and 1634 - 1723 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during 1995 at elevations **above 1600 m.a.s.l.** The annual average precipitation is below 840 mm within a variety of local climate zones. Most of the relevés occurred within **climate zone 56**, with an average annual precipitation of **733.4 mm.** This community **always experiences insolation**, within **flat, no aspect** insolation attitudes.

PEDOLOGICAL ENVIRONMENT: This community and its sub-communities occur within both the Ac and Fa soil pattern, but land type **Ac 39** had the highest frequency. The majority of relevés were not sampled below 1500 - **1650** m.a.s.l. As would be expected of a vegetation unit which covers such a large area, it is associated with a wide variety of soil forms, of which Hutton is dominant. Soil texture of both the A and **B horizons** tends towards the **fine to medium sandy clay loam,** sandy loam to **sandy clay.** Soil depth ranges from **450 - 1200 mm**. Less than thirty percentage surface rock is present and covers the spectrum of sizes.

FLORISTIC DATA: The species of diagnostic species group I are characteristic of this community. Of the two species in this species group, *Vernonia natalensis* has the highest average constancy (3) and a very high fidelity (V). The other species in this species group is *Anthospermum rigidum*. *Themeda triandra* is the constant species from constant species group Z, with a very high average constancy (5) and low fidelity (II). *Setaria sphacelata* from constant species group Z is also present in this community. The following species from species group AB, species associated with terrestrial ecosystems, occur in this community: *Heteropogon contortus*, *Berkheya setifera*, *Eragrostis curvula*, *Acalypha angustata*, *Eragrostis chloromelas* and the woody species ***Rhus discolor***. Species group AC, associated with sandy clay textures on igneous rocks at altitudes above 1000 m, contains the following species *Eragrostis plana*, *Helichrysum rugulosum*, *Hyparrhenia hirta*, *Haplocarpha scaposa* and *Hypochoeris* *radicata*. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé ranges from thirty-six to forty-one. This community represents a vegetation unit found within Acocks' **North-eastern Sandy Highveld** and Low and Rebelo's **Moist Sandy Highveld Grassland**.

WILDLIFE MANAGEMENT: Slopes included in the adapted pasture classes categories of flat and medium are associated with this community. It is therefore, suitable for crop growth and a wide variety of land uses.

DISCUSSION: This community and its sub-community occurs on the initial surface which remains during the process of pediplanation. It therefore represents the plains that existed before the current landscape rejuvenation. This hypothesis is confirmed by the attributes of both the geological and pedological environment. The majority of lithological units are of the Phanerozoic eon, with the youngest being igneous rock of different ages. As denudation continues, older and older rock is exposed, until the basement rock of the Cryptozoic eon is reached. At the same time the area of the initial surface shrinks, until only inselbergs or nothing is left. The end result is a plain underlain by rock older than the previous initial surface at lower altitudes. Soils classified within the Ac soil pattern are associated with well developed soil profiles in older landscapes than soils of the Fa soil pattern, which are associated with pedologically young landscapes. Bonheim, Avalon, Griffin, Clovelly, Hutton and Shortlands are all examples of well developed soil forms from the Ac soil pattern, while Mayo, Milkwood, Glenrosa and Mispah are examples of soil forms from the Fa soil pattern.

1.7.a. *Crabbea acaulis - Vernonia natalensis* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: A sub-community whose physionomical difference is only recognised on close inspection. The woody species elements which occur within this sub-community are small shrubs associated with the sporadic occurrence of surface rocks.

GEOLOGICAL ENVIRONMENT: Additional lithological units underlying this sub-community are sedimentary shale and arenite of the Ecca Group in the Karoo Sequence, from the international Palaeozoic erathem instead of the Mesozoic erathem.

GEOMORPHOLOGICAL ENVIRONMENT: This community is associated with the plains with moderate relief terrain group and its terrain type is strongly undulating plains. The nature of this terrain type includes level land classes B and C and relief class four. It was subjectively sampled within scarps on slopes associated with crests and midslopes. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 5%, 66° from North and 1634 m.a.s.l.

CLIMATIC ENVIRONMENT: Most of the relevés found within this sub-community were sampled during February 1995 at elevations of between 1600 to 1700 m.a.s.l. Average annual precipitation seldom exceeds 733.4 mm. This is a community of flat, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: As well as within the two soil patterns mentioned in the description of the community, this sub-community also occurs within the Ea soil pattern. Soils of the Ea soil pattern indicate land with high base status (eutrophic), dark coloured and/or red soils, usually clayey, associated with basic parent materials. The majority of relevés did not occur below 1600 m.a.s.l. Mispah and Glenrosa, together with their two melanic counterparts Milkwood and Mayo in association with rocks, are the dominant soil forms. The A horizon soil textures range from fine to medium sandy clay loam to sandy clay. Soil depth ranges from 200 to 400 mm. There is thirty percent surface rock, generally the size of rocks.

FLORISTIC DATA: Diagnostic species group J differentiates this sub-community from the other sub-community, and includs the species *Crabbea acaulis*, *Aristida congesta* subsp. *barbicollis* and *Cymbopogon excavatus*. *Crabbea acaulis* has an average constancy (3) and very high (5) fidelity. The following species from species group AB occur in this sub-community: ***Diospyros lycioides***, *Aristida junciformis*, *Ledebouria ovatifolia*, *Schkuhria pinnata*, *Oenothera tetraptera*, ***Asparagus laricinus*** and ***Rhus dentata***. Species also present in this sub-community from species group AC are: *Conyza podocephala*, *Hibiscus aethiopicus*, *Verbena venosa*, *Solanum elaeagnifolium* and *Pelargonium luridum*. Except for *Hibiscus aethiopicus* and *Pelargonium luridum*, these species are all exotic (Van Wyk & Malan 1988). Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé was forty-one. This community represents a vegetation unit also found within Acocks' Piet Retief Sourveld and Low and Rebelo's **Moist Clay Highveld Grassland**.

WILDLIFE MANAGEMENT: Two land uses which could be applied to this sub-community in the absence of surface rock, are rotation of ley and crops (8 - 12% slopes) and permanent cover crops (13 - 20% slopes).

DISCUSSION: The irregular surface created by surface rock increases infiltration, in spite of the higher clay content of the A horizon. Water accumulates behind the rocks instead of being lost as a result of surface runoff, thereby allowing the water to infiltrate at the rate controlled by the clay content. Trees are able to grow amongst the rocks only in those areas where the soil is deep enough to store the accumulated water. This results in widely spaced trees of small size and low cover. These hypothesises are further supported by the occurrence of most of the woody species component at the centre and on the down slope of the surface rock distribution.

1.7.b. *Microchloa caffra - Vernonia natalensis* pure low closed grassland sub-community

GENERAL DESCRIPTION: This grassland sub-community has an overall stronger distribution than the previous sub-community. It covers those areas between the valley bottoms and crest which are not conspicuously tree dominated.

GEOLOGICAL ENVIRONMENT: The previous sub-community was mainly associated with lithological units from the Phanerozoic eon, whereas some units from the Criptozoic eon underlay this sub-community. Although igneous rock dominates this community and its sub-communities, sedimentary rock such as mudstone, shale and arenite are also present.

GEOMORPHOLOGICAL ENVIRONMENT: Except for the dominant terrain group, this sub-community also occurs within plains with low relief and terrain types described as slightly or moderately undulating plains. The nature of the terrain type of this community is A3. Predominantly a community of subjectively sampled midslopes and crests, it occurs on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 1°, 2%, 32° or 63° from North for the moderate relief plains and 1723 or 1672 m.a.s.l for the low and moderate relief plains respectively.

CLIMATIC ENVIRONMENT: Sample plots were done during January 1995, at elevations above 1600 m.a.s.l. Average annual precipitation is above 733.4 mm. Stands of this communty are associated with flat, no aspect insolation attitudes.

PEDOLOGICAL ENVIRONMENT: The majority of relevés were sampled within the Ac soil pattern at altitudes above 1650 m.a.s.l. Hutton is the dominant soil form, but other soil forms associated with deep soils are Griffin and Clovelly. Both the A and B horizons are dominated by fine to medium sandy clay loam to sandy clay particles. Soil depth is more than 450 mm. Surface rock covers less than twenty percent and ranges from gravel to rock.

FLORISTIC DATA: Only one species is characteristic of this sub-community, Microchloa caffra (diagnostic species group K). It has an average (3) constancy and very high (V) fidelity. According to Van Oudtshoorn (1991), this grass seldom dominates grassland, but can increase as a result of overutilisation. Eragrostis racemosa, Tristachya leucothrix and *Hypoxis rigidula* are species from species group AB which occur in this sub-community but not in the previous one. *Scabiosa columbaria* (species group AC) occurs in this sub-community but not in the previous sub-community. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was thirty-three and thirty-six for low and moderate plains respectively. This community represents vegetation units found within Acocks' Themeda Veld to Highland Sourveld Transition, North-eastern Sandy Highveld and Piet Retief Sourveld and Low and Rebelo's Moist Clay Highveld Grassland, Moist Sandy Highveld Grassland and North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Slopes associated with this sub-community are less steep than those of the previous sub-community. Depending on the slope and percentage rock, the following land uses could be applied to this sub-community: annual cropping, ley or special tillage and rotation of ley and crops.

DISCUSSION: The rockiness associated with this sub-community covers too small an area to effectively accumulate water to support the growth of trees. In the absence of an irregular surface, runoff increases to such an extent that not enough water infiltrates the soil profile, resulting in only enough soil moisture to maintain grasses. Water that eventually does infiltrate percolates to such a depth within the deep soils, that it is soon beyond the reach of even deep rooted trees.

1.8. *Cucumis zeyheri - Hyparrhenia hirta* low// short sparse shrubland community

GENERAL DESCRIPTION: This community occurs within all the terrain morphological units, except valley bottoms at altitudes between 1000 - 1600 m.a.s.l. It receives perpendicular insolation; the percentage surface rock is above thirty.

GEOLOGICAL ENVIRONMENT: The previous community was mainly underlain by lithological units of Phanerozoic eon, whereas this community is underlain by igneous rock of the Cryptozoic eon. These units are unnamed granite, Amsterdam Formation tuff, Usushwana Complex gabbro and Karoo dolerite. The latter is from the Phanerozoic eon.

GEOMORPHOLOGICAL ENVIRONMENT: This community is distributed within one terrain group, plains with moderate relief, which stretch over two terrain types: moderately and strongly undulating plains. The nature of terrain types associated with this communty are A3 and level land classes B and

C with relief class 4. Subjectively sampled within all terrain units except valley bottoms and footslopes, it occured on slope of less than 12% associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude range: 3 - 4°, 4 - 7%, 115 - 229° from North and 1407 - 1445 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during the first two months of 1995 at elevations of between 1100 and 1700 m.a.s.l. It receives an annual average precipitation of above 840 mm. This is a community of gentle, south facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: Three soil patterns are associated with this community: Ac, Ba and Fa. Of these three the highest occurred at an altitude of 1630 m.a.s.l. Surface rock is prominent in this community in areas where the Mispah and Hutton soil forms also occur. The A horizon's soil texture is mainly fine to medium sandy loam to sandy clay loam and that of the B horizon fine to coarse sandy clay loam to sandy clay. Shallow and deep soils form a mosaic, ranging in depth from 200 - 450 mm and 500 - 1200 mm. Surface rock covers more than thirty percent in the form of rocks.

FLORISTIC DATA: The characteristic species of this community are represented by diagnostic species group L: *Cucumis zeyheri* and *Zornia milneana*. Of these two species *Cucumis zeyheri* has the highest average constancy (3) and very high (V) fidelity. *Hyparrhenia hirta* is the constant species (species group AC) because it has a very high (5) constancy, high fidelity (IV) and high estimated cover abundance, compared to the two species in constant species group Z, *Themeda triandra* and *Setaria sphacelata*. *Melinis repens* and ***Rhoicissus tridentata*** are two species from species group AB associated with terrestrial ecosystems, which did not occur in the previous community. Only one other species from this species group occurs in both sub-communities, ***Diospyros lycioides***. Including the constant species, the following species from species group AC (species associated with sandy clay textures on sedimentary rocks at altitudes above 1000 m) are *Helichrysum rugulosum*, *Commelina africana*, *Hypochoeris radicata* and *Hibiscus aethiopicus*. Of these species, only *Commelina africana* did not occur in the previous community. Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé ranges between fifty and fifty-seven. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Piet Retief Sourveld and Low and Rebelo's Moist Clay Highveld Grassland and North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is associated with a flat environment, suitable for crop growth, with a land use typical of this area, being ley or special tillage (4 - 7% slope).

DISCUSSION: This community and its sub-community occur on the new plains, which developed as a result of the current landscape rejuvenation, through the process of pediplanation. The following environmental factors confirm this hypothesis: it occurs at lower altitudes than the previous community, on top of more lithological units from the Cryptozoic eon, and mainly within the Fa soil pattern. Sufficient soil moisture to maintain tall grasses and trees are most probably the accumulated effect of surface rock, runoff and lateral flow. The surface rock creates an irregular surface, which increases infiltration. As this community occurs downslope and at lower altitudes, it receives additional moisture in the form of runoff and lateral flow within the soil.

1.8.a. *Helichrysum cephaloideum - Cucumis zeyheri* low// short thicket sub-community

GENERAL DESCRIPTION: A typical example of this sub-community is found next to the road, just before entering Amsterdam, when driving from Piet Retief. Physiognomically it consists of small trees and shrubs which dominate this grass-covered landscape, in association with large rocks. They grow amongst the rocks, while forbs and grasses dominate the open areas between the rocks. A closed canopy is found where a number of trees occur together but the overall appearance is that of widely spaced clusters.

GEOLOGICAL ENVIRONMENT: The main lithological unit associated with this sub-community is igneous Amsterdam Formation Tuff of the Randian erathem in the Cryptozoic eon.

GEOMORPHOLOGICAL ENVIRONMENT: Its distribution includes the moderately undulating plains terrain type, of which the nature of terrain type includes level land classes B and C and relief class four. Subjectively sampled within scarps, it occured within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 4%, 115° from North and 1406 m.a.s.l.

CLIMATIC ENVIRONMENT: This sub-community was sampled during January and February 1995 at elevations toward the lower range of the community at 1200 m.a.s.l. The annual average precipitation it receives is above 840 mm. Stands of this community occur on gentle insolation attitudes facing a variety of aspects.

PEDOLOGICAL ENVIRONMENT: Sampled within both the Fa and Ac soil pattern, at altitudes not above 1450 m.a.s.l., the dominant soil forms are a combination of Mispah and Hutton. The A horizon soil texture is described as fine to medium sandy loam to sandy clay loam and that of the B horizon as fine to coarse sandy clay loam to sandy clay. Soil depth ranges between 400 and 500 mm or deeper. Surface rock covers more than 57% of the area, and consists of large rocks.

FLORISTIC DATA: Diagnostic species group M contains the differentiating species of this sub-community including *Helichrysum cephaloideum*, *Turbina oblongata*, ***Athrixia phylicoides***, *Asclepias affinis*, *Berkheya zeyheri*, *Cyanotis speciosa*, *Haemanthus humilis*, *Eucomis autumnalis*, *Harpochloa falx* and *Asparagus virgatus*. Of these species, *Helichrysum cephaloideum* has the highest constancy (3) and a very high fidelity (V). The following species from species group AB occur in this sub-community: *Melinis repens*, *Berkheya setifera*, *Eragrostis curvula*, *Tristachya leucothrix*, *Acalypha angustata*, *Bulbostylis burchellii*, *Pellaea calomelanos*, *Panicum natalense*, *Gladiolus elliotii*, *Senecio venosus* and ***Rhus dentata***. *Haplocarpha scaposa* and *Conyza podocephala* (species group AC), associated with sand clay soil textures on igneous rocks at altitudes above 1000 m, are unique to this sub-community. Physiognomically it is associated with low// short thicket, depending on the development of the woody species component, but this sub-community could also qualify as: low// short sparse shrubland, bushland and woodland. The average number of species per relevé was fifty-seven. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's **North-eastern Mountain Grassland**.

WILDLIFE MANAGEMENT: In the absence of a large percentage of rock, this sub-community could be used for annual crops and ley or special tillage.

DISCUSSION: The woody species in this sub-community are able to form widely spaced, dense, closed canopy clusters, due to the presence of sufficient soil moisture. The presence of enough soil moisture is supported by the presence of species such as Harpochloa falx, Tristachya leucothrix and Panicum natalense which, according to Van Oudtshoorn (1991), prefer moist conditions. Once again the source of soil moisture is related to the presence of rocks, infiltration and lateral flow towards the lower altitudes.

1.8.b. *Cephalanthus natalensis - Cucumis zeyheri* low// short sparse shrubland sub-community

GENERAL DESCRIPTION: The woody species ***Cephalanthus natalensis*** which, according to Palgrave (1983), occurs in montane forest, scrub, among rocks and in open mountain grassland, indicates the presence of this sub-community at higher altitudes than the previous sub-community. This sub-community is associated with both scrub and rocks. The rocks cover a lower percentage of the area, but are smaller in size than in the previous sub-community, while the scrublike appearance is the result of the sparse occurrence of shrubs amongst these rocks.

GEOLOGICAL ENVIRONMENT: Igneous Karoo dolerite from the Mesozoic erathem within the Phanerozoic eon underlay this sub-community.

GEOMORPHOLOGICAL ENVIRONMENT: This sub-community only occurs within the strongly undulating plains terrain type. The nature of terrain type nature is A3. Subjectively sampled within scarps and crests, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 4°, 7%, 229° from North and 1445 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January 1995 at elevations approaching the higher range of the community at 1600 m.a.s.l. The average annual precipitation is less than 840 m. Gentle insolation attitudes facing either north or south maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: Most of the relevés from this sub-community were sampled within the Ba soil pattern at an elevation above 1630 m.a.s.l. The Ba soil pattern forms part of a survey done by Coetzee *et al.* (1993a & b) and was not included in the current survey. These soils are associated with a plinthic catena, containing soil forms such as Avalon, Westleigh, Dresden and Glencoe. The other relevés were sampled within the Fa soil pattern, resulting in the absence of a dominant soil form, although Glenrosa occurred in combination with rocks, Mispah, Hutton and Avalon. Soil texture of the A horizon is described as coarse sand to sandy loam and that of the B horizon as fine to medium sandy clay loam to sandy clay. Soil depth is more than 900 mm. Surface rock is thirty-two percent, and is the size of small rocks.

FLORISTIC DATA: The differentiating species (diagnostic species group N) of this sub-community are: ***Cephalanthus natalensis***, ***Vangueria infausta***, *Oxalis purpurea*, *Lactuca capensis*, *Oldenlandia herbacea*, *Gnidia buchellii*, *Anthospermum streyi*, *Lantana rugosa*, *Phyllanthus parvulus*, *Clutia cordata*, *Hypoxis iridifolia*, *Vernonia oligocephala*, *Argyrolobium wilmsii*, *Monsonia angustifolia*, *Mariscus rehmannianus*, *Cheilanthes hirta*, *Trachyandra* species, *Cheilanthes viridis*, *Gomphrena celosioides*, *Aster bakeranus*, *Hypoxis argentea* and *Commelina erecta*. Of these species, ***Cephalanthus natalensis*** has a very high (5) constancy and very high (V) fidelity. The following species from species group AB did not occur in the previous sub-community: ***Rhus discolor***, *Schkuhria pinnata*, *Eragrostis gummiflua*, *Oenothera tetraptera*, ***Asparagus laricinus***, *Richardia brasiliensis*, *Eriosema cordatum*, *Tagetes minuta*, *Bidens pilosa* and ***Lippia javanica***. *Eragrostis plana*, *Eragrostis capensis*, *Paspalum dilatatum*, *Scabiosa columbaria*, *Pelargonium luridum*, *Setaria nigrirostris* and *Crepis hypochoeridea* (species group AC) occur in this sub-community but not in the previous sub-community. Physiognomically it is associated with low// short sparse shrubland. The average number of species per relevé was fifty. This community represents a vegetation unit found within Acocks' North-eastern Sandy Highveld and Low and Rebelo's Moist Clay Highveld Grassland.

WILDLIFE MANAGEMENT: Only one land use is possible within this sub-community in the absence of rock and that is ley or special tillage on slopes of 4 - 7%.

DISCUSSION: A drier sub-community than the previous sub-community, it receives less rain, has less rock to retain water and is exposed to perpendicular insolation at higher altitudes. Soil water retention is further reduced by the presence of a somewhat sandier soil texture as indicated by the presence of the species *Eragrostis gummiflua* (Van Oudtshoorn 1991). Coarse textured soils store less water than fine textured soils. The coarse soil texture, especially in the A horizon, is most probably due to the loss of finer particles to the B horizon by illuviation.

1.9. *Cymbopogon validus - Panicum natalense* low// short sparse woodland community

GENERAL DESCRIPTION: This community occurs on the levees of permanent flowing rivers, within the newly formed plains as part of the pediplanation process. These low altitude rivers are broad and relatively deep and occur towards the centre of the plains. A continous layer of trees and shrubs is absent but, when present, ***Combretum erythrophyllum*** is dominant.

GEOLOGICAL ENVIRONMENT: This community is underlain by metamorphic unnamed gneiss from the **Archaean erathem of the Cryptozoic eon or Precambrian system**.

GEOMORPHOLOGICAL ENVIRONMENT: It occurs within the strongly undulating plains terrain group. The nature of terrain type includes level land classes B and C and the relief class four. Subjectively sampled within footslopes and midslopes, it occured within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 6%, 156° from North and 1225 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during the first months of 1994 and 1995 at elevations of between 1100 and **1200 m.a.s.l.** The annual average precipitation is in excess of 843 mm. **Gentle**, south-east to south facing insolation attitudes are associated with this community.

PEDOLOGICAL ENVIRONMENT: The rivers associated with this community cut through Ab and Fa soil patterns at altitudes below 1200 m.a.s.l. The following soil forms are associated with these soil patterns: Hutton, Shortlands, Mispah and Glenrosa. Coarse sandy to sandy loam describes the texture of the A horizon and sandy clay, clay loam and clay describes the B horizon. Depending on the soil form involved, soil depth ranges between 300 - 400 mm and 900 mm or more. Surface rock covers only 10%, either as stones or rocks.

FLORISTIC DATA: Diagnostic species group O contains the characteristic species of this community. All the species in this species group have an average (3) constancy and very high (V) fidelity. These species are *Cymbopogon validus* (the highest estimated cover abundance), *Clematis brachiata*, *Melinis* nerviglumis, **Combretum erythrophyllum**, *Sonchus wilmsii*, Ctenium concinnum and *Eriosema kraussianum*. Of all the species with high (4) constancy in this community Panicum natalense has the second lowest fidelity compared to *Hypoxis rigidula* and **Lippia javanica** (Species group AB). The two species, Themeda triandra and Setaria sphacelata from the constant species group Z, have even lower fidelity values than Panicum natalense, but their constancy values are low. Diheteropogon amplectens, Monocymbium ceresiiforme, Loudetia simplex, *Helichrysum nudifolium*, *Dicoma zeyheri* and **Acacia sieberiana** are other species from species group AB, occuring in this but not in the previous community. Only three species from species group AC occur in this community, Paspalum dilatatum, *Cyperus esculentus* and Eulalia villosa. Physiognomically it is associated with low// short sparse woodland. The average number of species per relevé was thirty-one. This community represents a vegetation unit found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland.**

WILDLIFE MANAGEMENT: The dominant adapted pasture category associated with this community is flat, and is suitable for crop growth, mainly for annual cropping.

DISCUSSION: The rivers associated with this community are drainage lines, which started the process of pediplanation as a result of landscape rejuvenation. They remove the sediment and maintain the process of pediplanation. When the entire remaining initial surface has been removed, the river altitude would represent the new initial surface level before another episode of landscape rejuvenation. It's associated riparian fringe has most probably been destroyed by cultivation. Trees are able to grow because their roots can reach deeper than those of the herbaceous layer. It is possible in the case of this community that Eulalia villosa might have been mistakenly identified and should rather be *Ischaemum fasciculatum*. The former seldom occurs in moist areas (Van Oudtshoorn 1991).

All the wetland communities described within the cool, moist terrestrial ecosystem on sandy clay textures above 1000 m, belong to a riparian wetland category known as riparian fringe. Of these, communities 1.1 - 1.4 were herb dominated and 1.6, 1.7 and 1.9 were tree dominated.

2. Warm, dry terrestrial ecosystem communities (Figure 37)

Communities 2.1 to 2.5 represent the warm, dry terrestrial ecosystem, below 1000 m.a.s.l. on sandy loam soil textures. These communities are underlain by **unnamed metamorphic gneiss** of **Swazian** age from the **Precambrian system** or the **Archaean erathem** of the **Cryptozoic Eon**. The overall terrain group is plains with moderate relief, with a terrain type described as strongly undulating plains. These plains are associated with a terrain type nature of which **50 - 80% of the area has slopes of less than 8% and local relief of 150 - 300 m**. These communities were sampled at elevations of between **900 and 1000 m.a.s.l.** The most prominent **local climate zone is 118s**, which receives an annual average precipitation of **894.1 mm**. Perpendicular insolation during summer occurs on **slopes of 2 – 25°**. All of these communities are distributed throughout land type **Fa166** at altitudes above **900 m.a.s.l. Glenrosa** is the dominant soil form and the **A horizon has a coarse sand to sandy loam texture**. Soil depth ranges from **300 - 400 mm**. These communities represent vegetation units found within Acocks' **Piet Retief Sourveld** and Low and Rebelo's **North-eastern Mountain Grassland**. They are:

2.1. *Indigofera cryptantha* - *Heteropogon contortus* low// short sparse woodland community
2.2. *Phragmites australis* - *Hyperthelia dissoluta* pure short closed grassland community
2.3. *Peroüs patens* - *Hyperthelia dissoluta* pure short closed grassland community
2.4. *Crabbea angustifolia* - *Loudetia flavida* pure low closed grassland community
2.5. *Pavetta edentula* - *Pellaea calomelanos* low// short thicket community
2.5.a. *Ehretia rigida* - *Pavetta edentula* low// short thicket sub-community
2.5.b. *Gerbera piloselloides* - *Pavetta edentula* low// short thicket sub-community
2.5.c. *Ficus glumosa* - *Pavetta edentula* low// short thicket.

These communities occur on plains that have reached the final stage of pediplanation. Lithological units from the Phanerozoic eon (covered shield) have been removed, and those of the Cryptozoic eon (exposed shield) have been uncovered. In the absence of a new landscape rejuvenation phase, these plains are maintained by deep weathering and stripping of the associated basement rock from the Swazian erathem.

Communities 2.1 to 2.4 (Environmental division 2.1) are distinguished from community 2.5 (Environmental division 2.2) on the basis of percentage surface rock and terrain morphological unit. Community 2.5 and its sub-communities have above 70 percent **rock** or boulder cover and occur mainly on **crests.**

2.1. *Indigofera cryptantha* - *Heteropogon contortus* low// short sparse woodland community
GENERAL DESCRIPTION: The presence of the woody species, ***Acacia sieberiana***, is of significance to this community with its park-like appearance.
GEOLOGICAL ENVIRONMENT: Metamorphic unnamed gneiss from the Swazian erathem.
GEOMORPHOLOGICAL ENVIRONMENT: Subjectively sampled within **crest, scarp, midslope and valley bottom**, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 4%, 16° from North and 1032 m.a.s.l.
CLIMATIC ENVIRONMENT: It was sampled during May 1994 on elevations below **1200 m.a.s.l.** Stands of this community are associated with **flat to gentle, north facing** insolation attitudes.
PEDOLOGICAL ENVIRONMENT: Glenrosa is the dominant soil form. The A horizon has a coarse sand to loam sand or sand loam texture. **Rocks** cover up to 34% of the surface.
FLORISTIC DATA: This community is characterised by diagnostic species group P. *Indigofera cryptantha* has the highest constancy (4) and fidelity (V) of the species associated with this diagnostic species group. The other species in this diagnostic species group are *Leonotis microphylla*, *Pseudarthria hookeri*, ***Cussonia paniculata***, *Cyphia elata* and ***Lippia rehmannii***. *Heteropogon contortus* in species group AB has a very high constancy (5) and average fidelity (III) compared to other species found within this community. It also has a higher average estimated abundance. This species, according to Van Oudtshoorn (1991) prefers well-drained soils, a trend confirmed within this

phytosociological table and those of the previous landforms. The only species present from constant species group Z, is Themeda triandra. Other species from species group AB, species associated with terrestrial ecosystems, are Melinis repens, Eragrostis chloromelas, **Diospyros lycioides**, **Rhoicissus tridentata**, **Asparagus laricinus**, **Euclea crispa**, **Lippia javanica** and **Acacia sieberiana**. The following species from species group AD, species associated with sandy loam textures on metamorphic rocks at altitudes below 1000 m, occur in this community: Aristida congesta, Trachypogon spicatus, Hyperthelia dissoluta, **Maytenus heterophylla**, **Aloe marlothii**, **Diospyros whyteana**, **Ziziphus mucronata**, Bothriochloa insculpta and Panicum maximum. Physiognomically it is associated with low// short sparse woodland. The average number of species per relevé was forty. This community represents a vegetation unit found within Acocks' Lowveld Sour Bushveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: The only adapted pasture class associated with this community is flat, and it is within range of the crop growth erosional limitation class. Depending on slope, in areas where rocks do not occur, the following land uses could be applied: annual cropping and rotation of ley or special tillage.

DISCUSSION: The link between this community and the previous community, must be the presence of a localised clay content higher than that of the surrounding area, which is indicated by the presence of **Acacia sieberiana**. In the previous community, this species did not occur on the levees of the river but rather some distance away, in the area where fine sediment will accumulate after flooding. It's distribution away from drainage lines is most probably determined by the frequency, area and depth of lithocutanic B horizon tongues associated with the Glenrosa soil form. The ability to maintain trees is further enhanced by sources of increased soil moisture such as rocks and lateral flow towards lower altitudes.

The next three communities, 2.2, 2.3 and 2.4, are all grassland communities (Environmental division 2.1.2). Community 2.2 (Environmental division 2.1.2.1) is a community associated with riparian wetlands known as floodplain vlei. The other two communities (Environmental division 2.1.2.2) represent drier conditions away from drainage lines.

2.2. *Phragmites australis - Hyperthelia dissoluta* pure short closed grassland community

GENERAL DESCRIPTION: This riparian wetland community occurs along the permanent rivers, whereever the current is slowed down and the water table is stable. This community's distribution has increased due to man made structures such as bridges and weirs.

GEOLOGICAL ENVIRONMENT: Metamorphic unnamed gneiss from the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: This community differs from the previous community, in that it was subjectively sampled within valley bottoms on slope within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 4°, 7%, 114° from North and 1026 m.a.s.l.

CLIMATIC ENVIRONMENT: Samples were taken during March and May 1994 at elevations below 1100 m.a.s.l. This community occurs within gentle, north facing insolation attitudes.

PEDOLOGICAL ENVIRONMENT: The dominant soil form is Katspruit. Katspruit soils are associated with areas which are partially to permanently inundated. The A horizon has a coarse sand to loam sand or sand loam texture. Soil depth ranges from 300 - 500 mm.

FLORISTIC DATA: A single species, *Phragmites australis*, in diagnostic species group Q is characteristic because it is easy to identify and has the highest estimated cover abundance. Both *Setaria sphacelata* and *Themeda triandra* from constant species group Z occur in this community; *Themeda triandra* has the highest constancy (5). In spite of this, *Hyperthelia dissoluta* is considered to be the constant species because it has the same constancy and higher fidelity (IV) and higher estimated cover abundance. *Aristida sciurus*, *Schkuhria pinnata* and *Tagetes minuta* are three species from species group AB which did not occur in the previous community. *Pogonarthria squarrosa* and *Ceratotheca triloba* (species group AD), species associated with sandy loam textures on metamorphic rocks at altitudes below 1000 m, were absent from the previous community. Physiognomically it is associated with pure short closed grassland. The average number of species per relevé was twenty-nine. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: Contrary to expectation this community occurs in both the flat and medium adapted pasture categories. These slopes are included in the crop growth erosion limitation class. The dominant land use category is annual cropping on slopes of 0 - 3%.

DISCUSSION: Patches of this community occur along the edges of permanent pools, in front of the inside turn of river bends and where rivers cross shallow depressions in the earth's surface. Large areas of this community are uncommon and are usually associated with man made structures. This explains the occurrence of this community within a steeper environment than expected. River channels are generally narrower when passing underneath bridges, and this results in water accumulating behind the bridge, reducing the speed of the current and expanding the riverways. This type of reed-dominated riparian floodplain vlei wetland community is often artificially created to control effluent from mining and industry (Cowan 1995, Denny 1985).

2.3. *Perotis patens - Hyperthelia dissoluta* pure short closed grassland community

GENERAL DESCRIPTION: This grassland dominates the slopes between the tree-dominated areas. It represents the largest community found within the warm, dry terrestrial ecosystem of the exposed shield plains.

GEOLOGICAL ENVIRONMENT: Metamorphic unnamed gneiss from the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: It was subjectively sampled within midslopes on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 4%, 60° from North and 1007 m.a.s.l.

CLIMATIC ENVIRONMENT: Sampled during March and May 1995 at elevations from 900 - 1100 m.a.s.l. Gentle, east facing insolation attitudes maintain stands of this communty.

PEDOLOGICAL ENVIRONMENT: Hutton and Glenrosa soils occur in this community of which the latter is dominant. The A horizon soil texture is coarse sand to sandy loam. Soil depth ranges from 300 - 400 mm. Surface rock only covers four percent, and is the size of stones.

FLORISTIC DATA: Only Perotis patens (diagnostic species group R) is characteristic of this community. It has a very high (5) constancy and fidelity (V). Both Themeda triandra and Setaria sphacelata, from constant species group Z, occur in this community. The following species from species group AB occurs in this community but not the previous community: Eragrostis racemosa, Eragrostis chloromelas, *Bulbostylis burchellii*, Eragrostis gummiflua and *Richardia brasiliensis*. Hyperthelia dissoluta is the constant species, it has a very high (5) constancy and lower (IV) fidelity than Pogonarthria squarrosa (species group AD). Furthermore the former also has a higher average estimated cover abundance than the latter. Trachypogon spicatus, *Dicoma anomala*, Sporobolus africanus, Trichoneura grandiglumis and *Dicerocaryum eriocarpum* (species group AD) associated with sandy loam textures on metamorphic rock at altitudes below 1000 m, were absent from the previous community. Physiognomically it is associated with pure short closed grassland. The average number of species per relevé was thirty-two. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community is found across two of the adapted pasture classes, flat and medium. It is suitable for crop growth of which three types of land uses could be applied, annual cropping, ley or special tillage and rotation of ley and crops.

DISCUSSION: Areas associated with this community are drier than adjacent areas due to the lower percentage of surface rock, its exposure to perpendicular insolation and lower clay content. The absence of surface rock reduces the percentage of irregular surface, which would increase infiltration of precipitation. Areas exposed to perpendicular insolation are warmer resulting in higher evapotranspiration, which reduces soil moisture even further. The lack of fine material in the overall well drained, sandy soils reduces the water retention ability of the soils. The latter hypothesis is supported by the presence of Perotis patens, Pogonarthria squarrosa, Eragrostis racemosa, Eragrostis chloromelas, Eragrostis gummiflua, Trachypogon spicatus, Trichoneura grandiglumis and absence of Themeda triandra and Setaria sphacelata (Van Oudtshoorn 1991).

2.4. *Crabbea angustifolia - Loudetia flavida* pure low closed grassland community

GENERAL DESCRIPTION: This occurs higher up the midslopes, tapering off before reaching the crest. This community is not easily distinguished from the previous community from a distance.

GEOLOGICAL ENVIRONMENT: Metamorphic unnamed gneiss from the Swazian erathem.

GEOMORPHOLOGICAL ENVIRONMENT: It was subjectively sampled within the following terrain morphological units: midslope, scarp and crest within the slope range associated with footslopes and valley bottoms. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 3%, 77° from North and 1060 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during January and March 1994 on elevations towards the upper range of the previous community at 1200 m.a.s.l. Stands of this community occur within flat insolation attitudes facing either north or south.

PEDOLOGICAL ENVIRONMENT: Huttons and Glenrosa soils occur in this community, of which the latter is dominant. The A horizon soil texture is coarse sand to sandy loam. Soil depth ranges from 300 - 400 mm. The percentage surface rock is high at 24%, generally the size of stones.

FLORISTIC DATA: *Crabbea angustifolia* is the only characteristic species of this community (Diagnostic species group S). The constant species is represented by *Loudetia flavida*, with the highest constancy (5) of all the species in this community and high (IV) fidelity. It's estimated cover abundance is also higher than that of *Themeda triandra* (constancy (4) (constant species group Z). *Tristachya leucothrix*, *Diheteropogon amplectens*, *Panicum natalense*, *Gladiolus elliotii*, *Monocymbium ceresiiforme*, *Loudetia simplex*, *Eriosema cordatum* and *Dicoma zeyheri* are all species from species group AB which occur in this but not in the previous community. *Bewsia biflora* and *Schizachyrium sanguineum* (species group AD) are present in this community but not in the previous community. Physiognomically it is associated with pure low closed grassland. The average number of species per relevé was thirty-three. This community represents a vegetation unit found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: The tendency toward more gentle slopes than the previous community is confirmed by it's inclusion in only the flat category of the adapted pasture classes. In the absence of stones, this is further supported by its classification within only one prospective land use category, annual cropping (0 - 3%).

DISCUSSION: Two factors prevent this community from being cultivated, the presence of rocks and it's distance from water. The soil moisture within this community is somewhat higher than that of the previous community but not adequate to support trees. Increased soil moisture is the result of higher infiltration and less runoff due to the larger irregular surface created by the stones and the gentler slope. Lack of perpendicular insolation raises the soil moisture content even more. According to Van Oudtshoorn (1991) most of the grasses present within this community prefer rocky areas on slopes with shallow, poor soils where water accumulates.

2.5. *Pavetta edentula - Pellaea calomelanos* low// short thicket community

GENERAL DESCRIPTION: The distribution of this community correlates with large rocks and boulders along the crest of the strongly undulating plains.

GEOLOGICAL ENVIRONMENT: Two types of petrological units are associated with this community: metamorphic and igneous. Both of them are of Swazian age. The igneous Onverwacht lava is a source of finer particles, while the metamorphic unnamed gneiss is a source of coarser material.

GEOMORPHOLOGICAL ENVIRONMENT: Subjectively sampled within **crests**, it occured on slopes of less than 12%. Average values based on quantitative data for slope (°, %), aspect and altitude ranges from: 2 -5°, 3 - 9%, 99 - 146° from North and 993 - 976 m.a.s.l.

CLIMATIC ENVIRONMENT: It was sampled during March 1994 at elevations of between 900 to 1000 m.a.s.l. Gentle insolation attitudes facing north and south maintain stands of this community.

PEDOLOGICAL ENVIRONMENT: Glenrosa is the dominant soil form. The soil texture is coarse sandy to sandy loam. Soil depth ranges from 300 - 400 mm. Surface rock covers seventy percent or more of the area. Rock sizes range from large rocks to boulders to rock sheets.

FLORISTIC DATA: ***Pavetta edentula*** and ***Dombeya rotundifolia*** (Diagnostic species group T) are the characteristic species of this community. Of these two species, ***Pavetta edentula*** has the highest constancy (5) and very high fidelity (V). The constant species, *Pellaea calomelanos* (species group

AB), has the highest average constancy (5) of all the species which occur in this community, and high (IV) fidelity. ***Rhoicissus tridentata***. (species group AB), ***Maytenus heterophylla*** and ***Aloe marlothii*** (species group AD) also occur in this community. Physiognomically it is associated with low// short thicket. The average number of species per relevé ranges from thirty-four to fifty-six. This community and sub-communities represents vegetation units found within Acocks' Piet Retief Sourveld and Low and Rebelo's North-eastern Mountain Grassland.

WILDLIFE MANAGEMENT: This community was classified within two of the adapted pasture classes, flat and medium. Although impossible to cultivate, it would have been suitable for crop growth and subjected to either on of the following land uses: annual cropping, ley or special tillage, rotation of ley and crops and permanent cover crop.

DISCUSSION: The large rocks, boulders and rock sheets associated with this community are the products of the deep weathering and stripping which produced the surrounding plains. They form a mosaic of areas at different stages of the deep weathering and stripping cycle. Adequate moisture to maintain trees is the result of increased runoff from the rocks, the quick infiltration of this runoff into the sandy soils between the cracks and crevasses, and the accumulation of the water at the bottom of these cracks and crevasses.

2.5.a. *Ehretia rigida - Pavetta edentula* low// short thicket sub-community

GENERAL DESCRIPTION: A prominent feature of this sub-community is large boulders and rocks. The plains around these rocky outcrops are dotted with widely spaced trees, and shrubs amongst the cracks and crevasses. The shrubs and thorn trees form a closed canopy.

GEOLOGICAL ENVIRONMENT: Igneous Onverwacht lava underlays this sub-community.

GEOMORPHOLOGICAL ENVIRONMENT: This sub-community occurs, more toward the midslopes and footslopes of the undulating plains. Average values based on quantitative data for slope (°, %), aspect and altitude are 3°, 6%, 123° from North and 923 m.a.s.l.

CLIMATIC ENVIRONMENT: This community is associated with **gentle, south facing** insolation attitudes.

PEDOLOGICAL ENVIRONMENT: Large rocks cover up to seventy percent of the area.

FLORISTIC DATA: The differentiating species of this sub-community occur in diagnostic species group U. They are ***Ehretia rigida***, ***Euclea natalensis***, *Cyphostemma lanigerum*, *Albuca* species and ***Acacia robusta***. Of these species, ***Ehretia rigida*** has the highest estimated cover abundance of all the species in this diagnostic species group with their high (4) constancy and very high (V) fidelity. ***Combretum apiculatum***, ***Acacia nilotica*** and ***Acacia karroo*** are three woody species from transitional diagnostic species group W which are present. The fern *Pellaea calomelanos* is considered to be the constant species of this sub-community (Species group AB). It has a very high (5) constancy and high (IV) fidelity. Another species from species group AB, associated with terrestrial ecosystems is ***Rhoicissus tridentata***. Aristida congesta subspecies congesta, *Solanum panduriforme*, ***Ziziphus mucronata***, ***Sclerocarya birrea*** and ***Zanthoxylum capense*** (species group AB) are associated with sandy loam textures on metamorphic rock at altitudes below 1000 m, and occur in this sub-community. The average number of species per relevé was thirty-four.

WILDLIFE MANAGEMENT: This sub-community is found within a flat area. It is suitable for crop growth in general, with slopes less than 15%, more specifically for ley or special tillage crops.

DISCUSSION: The presence of species such as ***Ehretia rigida***, ***Euclea natalensis***, ***Acacia robusta***, ***A. nilotica*** and ***A. karroo*** indicate the presence of fine textured soils and salts (Scholes 1997; Van Wyk 1984). These conditions occur due to this sub-community's presence further down the slope of the undulating plains on fine-grained basic to ultrabasic, high magnesium lavas (Walraven 1989b). A combination of *in situ* weathering and illuviation increases the percentage of fine textured material and salts associated with this sub-community. Soil moisture availability is increased by the large percentage surface rock, which accumulates in runoff and increases the infiltration.

2.5.b. *Gerbera piloselloides* - *Pavetta edentula* low// short thicket sub-community

GENERAL DESCRIPTION: Where the previous sub-community occurred further down the slope from the crest, this sub-community occurs on the steep area just before the crest flattens out. It has a higher percentage surface rock, in the form of rock sheets. The trees do not form a closed canopy.

GEOLOGICAL ENVIRONMENT: Two types of petrological units, unnamed metamorphic gneiss and the lavas of the previous sub-community, are associated with this sub-community.

GEOMORPHOLOGICAL ENVIRONMENT: It's distribution stretches across the midslope to crest area within the strongly undulating plains of this vegetation type. Average values based on quantitative data for slope (°, %), aspect and altitude are 5°, 9%, 146° from North and 954 m.a.s.l.

CLIMATIC ENVIRONMENT: Stands of this sub-community occur within gentle insolation attitudes facing a wide variety of aspects.

PEDOLOGICAL ENVIRONMENT: This sub-community has the highest percentage surface rock of all the sub-communities associated with the *Pavetta edentula* - *Pellaea calomelanos* low// short thicket community, at 85% or more. Rock sheets form the most prominent component of surface rock.

FLORISTIC DATA: Diagnostic species group V contains the differentiating species of this sub-community. Species in this diagnostic species group have an average (3) constancy and very high (V) fidelity. *Gerbera piloselloides* was chosen as the characteristic species because, of the three species with a constancy of 57%, it is the easier to identify. Other species in this species group are <u>*Aristida diffusa*</u>, *Xerophyta retinervis*, ***Elephantorrhiza elephantina*** and ***Faurea saligna***. Of these, the following three should also easily be identified: *Xerophyta retinervis*, ***Elephantorrhiza elephantina*** and ***Faurea saligna***. All three species from the transitional species group, diagnostic species group W, which occurred in the previous sub-community, occur in this sub-community. ***Combretum apiculatum***, the only deciduous broad-leafed tree in this transitional species group, has the highest constancy (4). The species from transitional diagnostic species group Y also present in this sub-community are *Kalanchoe paniculata*, ***Ozoroa paniculosa***, ***Acacia caffra***, <u>*Setaria lindenbergiana*</u> and *Acalypha capensis*. Both the grasses from constant species group Z, <u>*Themeda triandra*</u> and <u>*Setaria sphacelata*</u>, occur in this sub-community. Species from species group AB, associated with terrestrial ecosystems, which did not occur in the previous sub-community but are present in this community, are <u>*Heteropogon contortus*</u>, <u>*Melinis repens*</u>, <u>*Tristachya leucothrix*</u>, <u>*Diheteropogon amplectens*</u>, <u>*Panicum natalense*</u>, *Senecio venosus*, ***Asparagus laricinus***, <u>*Loudetia simplex*</u> and *Helichrysum nudifolium*. <u>*Trachypogon*</u>

spicatus, Hyperthelia dissoluta, Loudetia flavida, *Dicoma anomala*, Cymbopogon plurinodis, Bewsia biflora, *Ceratotheca triloba* and Schizachyrium sanguineum (species group AD), associated with sandy loam textures on metamorphic rock at altitudes below 1000 m, occur in this sub-community but not in the previous one. The average number of species per relevé was forty-eight.

WILDLIFE MANAGEMENT: Relevés associated with this sub-community occurred within all three of the adapted pasture classes, flat, medium and steep. The majority was within the crop growth class of the erosion limitation classification, within the steeper categories of the land use classification, ley or special tillage, rotation of ley and crops and permanent crop. This confirms the occurrence of this sub-community within a steeper environment than the previous.

DISCUSSION: The location of this sub-community results in increased runoff. More rock is exposed due to the fine material being removed while the heavier coarse material remains. The canopy structure is open because less soil is available for trees to grow in while grasses dominate the shallow open soil areas. The coarse textured and nutrient poor, rocky conditions are confirmed by the absence of certain species from the previous sub-community and the presence of certain grasses, forbs and **trees** in this sub-community: Aristida diffusa, *Xerophyta retinervis*, ***Faurea saligna***, Aristida congesta subsp. barbicollis. *Xerophyta retinervis*, ***Faurea saligna***, ***Combretum apiculatum***, Kalanchoe *paniculata*, ***Ozoroa paniculosa***, Setaria lindenbergiana, Setaria sphacelata, Heteropogon contortus, Melinis repens, Tristachya leucothrix, Diheteropogon amplectens, Panicum natalense, *Senecio venosus*, Loudetia simplex, Helichrysum *nudifolium*, Trachypogon spicatus, Loudetia flavida, *Dicoma anomala* and Bewsia biflora (Van Oudtshoorn 1991, Van Wyk & Malan 1988, Van Wyk 1984).

2.5.c. *Ficus glumosa - Pavetta edentula* low// short thicket.

GENERAL DESCRIPTION: This sub-community is found on the crest of the strongly undulating plains. Crests represent relatively flat environments. Surface rock is still prominent. The presence of the following easily identifiable genera make it relatively easy to recognise this sub-community: ***Ficus*** species, ***Ozoroa*** species, ***Erythrina*** species and ***Euphorbia*** species Depending on the size of this sub-community the canopy could be either open or closed.

GEOLOGICAL ENVIRONMENT: Unnamed metamorphic gneiss underlay this sub-community

GEOMORPHOLOGICAL ENVIRONMENT: The highest number of relevés from this sub-community was sampled on the crest. Average values based on quantitative data for slope (°, %), aspect and altitude are 2°, 3%, 99° from North and 976 m.a.s.l.

CLIMATIC ENVIRONMENT: Stands of this community occur within flat insolation attitudes with no aspect.

PEDOLOGICAL ENVIRONMENT: Surface rock covers up to 79% of the area, mostly as boulders.

FLORISTIC DATA: The differential species of this sub-community are found within diagnostic species group X. All the species in this diagnostic species group have a very high (V) fidelity while constancy ranges from a low (2) to very high (5). ***Ficus glumosa*** was selected to represent the characteristic species because it has both a very high constancy and fidelity and belongs to an easy identifiable genus. This species belongs to the group of indigenous rock-splitting figs and is strongly associated with rocks (Palgrave 1983, Van Wyk 1984). A second candidate for the position of characteristic species would be ***Combretum molle.*** It has the same constancy and fidelity as the previous species and a higher estimated cover abundance on average, but is not as easily identified in the absence of seed or flowers. Other species from the diagnostic species group X are: ***Psidium guajava***, ***Ozoroa sphaerocarpa***, ***Ficus ingens***, ***Euclea schimperi***, *Crassula vaginata*, *Sarcostemma viminale*, ***Erythrina lysistemon***, *Geigeria burkei*, *Gerbera ambigua*, ***Tetradenia riparia***, ***Annona sengalensis***, ***Bauhinia galpinii***, ***Psychotria capensis,*** *Stachys natalensis*, ***Englerophytum magalismontanum***, *Ipomoea alba*, *Tephrosia longipes*, ***Maytenus undata***, *Rhynchosia caribaea*, *Amaranthus hybridus*, ***Lippia scaberrima***, *Thunbergia neglecta*, *Lotononis foliosa*, ***Lannea discolor***, *Striga elegans*, ***Euphorbia ingens*** and ***Pappea capensis.*** All the species from transitional diagnostic species group Y and constant species group Z occur in this sub-community. The following species from species group AB did not occur in the previous sub-community: <u>*Eragrostis curvula*</u>, *Bulbostylis burchellii*, <u>*Aristida junciformis*</u>, *Ledebouria ovatifolia*, <u>*Aristida sciurus*</u>, <u>*Eragrostis gummiflua*</u>, *Richardia brasiliensis* and ***Euclea crispa.*** <u>*Aristida congesta*</u> subsp. <u>*congesta*</u>, <u>*Trichoneura grandiglumis*</u>, *Solanum panduriforme*, *Dicerocaryum eriocarpum*, ***Ziziphus mucronata***, ***Sclerocarya birrea*** and <u>*Panicum maximum*</u> (species group AD), associated with sandy loam textures on metamorphic rock at altitudes below 1000 m, did not occur in the previous sub-community. The average number of species per relevé was fifty-six.

WILDLIFE MANAGEMENT: This sub-community is found within a flat area. It is suitable for crop growth in general, more specifically for annual crops and ley or special tillage crops.

DISCUSSION: Deep soils are the key to this sub-community. Two process contribute to the occurrence of deep soils: *in situ* weathering of the underlying metamorphic rock in the flat environment, and soil being trapped in the crevices and joints between the large boulders. Adequate moisture to maintain **trees** is the result of quick infiltration and reduced runoff in the coarse textured soils. These hypothesises are confirmed by the presence of certain species listed in diagnostic species group X and species group AD (Palgrave 1983, Van Oudtshoorn 1991; Van Wyk 1984).

The species at the bottom of the phytosociological table species list, occurred between one and ten percent of the 405 plots surveyed, but not in this vegetation type of 151 plots. They are ***Cussonia spicata***, *Hemizygia macrophylla*, <u>*Digitaria diagonalis*</u>, ***Protea caffra***, *Sphenostylis angustifolia*, *Diospyros galpinii* and *Ipomoea ommaneyi.* Their inclusion is based on the hypothesis that their absence should indicate lack on some environmental factor in the plains vegetation type. Both the woody species listed are associated with high altitude mountainous areas (Palgrave 1983, Van Wyk 1984). Very little or no information is available on the forbs, making it impossible to find any factor of significance.

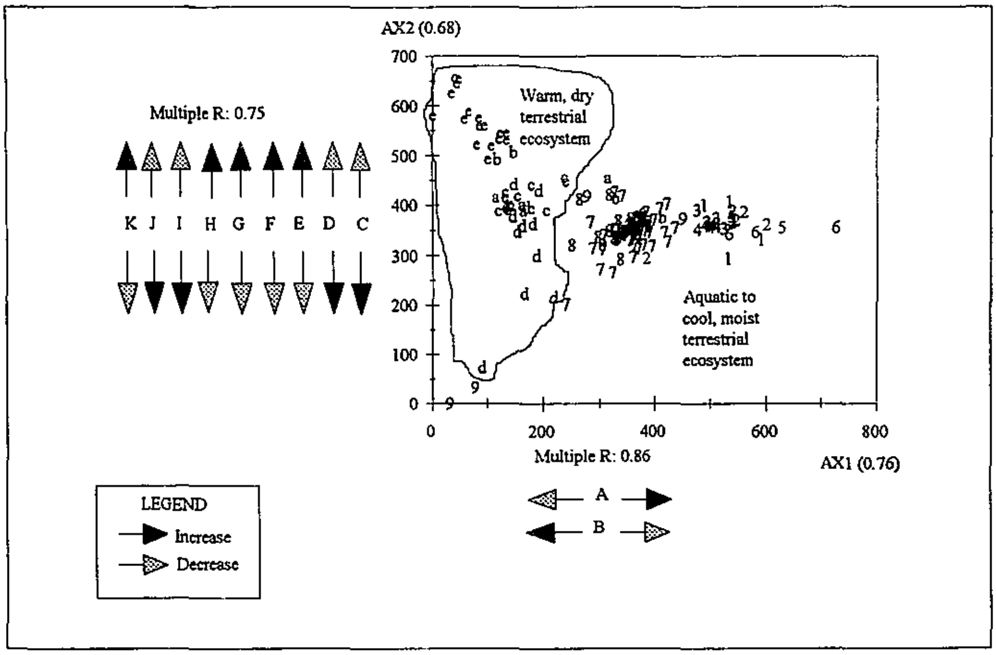
2.2. Ordination

Environmental trends were identified by means of DECORANA and multiple regression analysis (Figure 38). The communities of the warm, dry terrestrial ecosystem were assigned letters in chronological sequence and that of the aquatic to cool, moist terrestrial ecosystem, numbers. The indirect ordination plot only reflects those variables of the different environments of which the trends were statistically significant (P-value < ∝ at ∝ = 0.5). The table associated with the figure reflects the statistical parameters supplied by the multiple regression analysis. Of these parameters only the coefficients and P-value fields were of value. Environmental variables with low P-value were included, while the coefficients indicated whether a positive or negative correlation exists between the environmental variable gradient and the floristic data. Based on these criteria, two environmental variables were of significance in regard to the AX1 axis and nine for the AX2 axis.

The environmental variables associated with the AX1 axis reflect the environmental gradients, which exist between the two main ecosystems separated by the TWINSPAN classification. Soil water availability increases from the warm, dry terrestrial ecosystem to the aquatic to moist, cool terrestrial ecosystem. This trend correlates well with the TWINSPAN classification and Braun-Blanquet refinements, as most of the riparian wetland communities were classified within the aquatic to cool, moist terrestrial ecosystem. The second variable, petrological units, reflects the age difference between the two ecosystems. The older metamorphic rock is associated with the warm, dry terrestrial ecosystem, while the younger igneous and sedimentary rock is associated with the aquatic to cool, moist terrestrial ecosystem.

The variables of the AX2 axis reflect the environmental trends which occur between the two ecosystems. Digital terrain model height decreases from the aquatic to the cool, moist terrestrial ecosystem to the warm, dry, terrestrial ecosystem. The lower areas of the warm, dry, terrestrial ecosystem are associated with more advanced stages of pediplanation. This is confirmed by the decrease in percentage slope from the former ecosystem to the latter. Due to the different processes of pediplanation associated with the two ecosystems, percentage rock cover increases from the aquatic to the cool, moist terrestrial ecosystem and further towards the dry, warm terrestrial ecosystem. Contrary to expectation, the altitudinal classes have a positive coefficient instead of negative coefficient, as is the case with the digital terrain model heights. An independent test using only altitudinal class values and the AX2 values confirmed the predicted result.

A possible explanation for this contradiction is that it reflects the changes in altitude from the wetland communities (communities 1.1 to 1.4, 1.6, 1.7, 1.9 & 2.2) to the various terrestrial communities. This hypothesis is supported by the next variable, as slope angle also has a positive coefficient. It is common knowledge that wetlands occur in flat areas where water may accumulate, while the



Symbols	Variables	Coefficients	Standard Error	t Statistic	P-value < Alpha@0.05	Lower 95.00%	Upper 95.00%
AX1	Intercept	-697.643666	775.901881	-0.899139	0.370020	-2233.875389	838.588058
A	Soil water availability	46.025021	6.685981	6.883809	0.000000	32.787243	59.262799
B	Petrological units	-29.174747	12.867259	-2.267363	0.024797	-54.651024	-3.698470
AX2	Intercept	1979.559159	627.781212	3.153263	0.001951	736.596052	3222.522265
C	Digital terrain model heights (m.a.s.l.)	-1.230565	0.302766	-4.064410	0.000077	-1.830020	-0.631109
D	Slope angle (%)	-23.013692	7.171031	-3.209259	0.001628	-37.211833	-8.815550
E	Percentage rock cover	0.755870	0.240852	3.138312	0.002046	0.278999	1.232741
F	Altitudinal classes (100 m intervals)	8.788224	2.994458	2.934829	0.003863	2.859404	14.717043
G	Slope angle (°)	35.489853	13.324168	2.663570	0.008576	9.108928	61.870779
H	Insolation attitudes	19.001607	7.144324	2.659679	0.008672	4.856342	33.146871
I	Insolation exposure	-153.014247	60.720786	-2.519965	0.012783	-273.237176	-32.791318
J	Terrain type	-15.839385	6.596168	-2.401301	0.017561	-28.899339	-2.779432
K	Aspect (Azimuths)	0.173079	0.081796	2.115981	0.035998	0.011128	0.335029

Figure 38: DECORANA ordination scatter diagram showing the two ecosystems, their communities and most significant environmental trends (Eigen values)

occurrence of standing water decreases with an increase in slope. The result of the classification confirms this trend, as most of the wetlands associated with open water along drainage lines occurred within the aquatic to the cool, moist terrestrial ecosystem. The change from cool and moist to warm and dry climatic conditions is further motivated by the increase in insolation attitude from the aquatic to cool, moist terrestrial ecosystem to dry, warm terrestrial ecosystem.

Low insolation attitude values represent flat areas with no aspect, which are exposed to sunlight all year long, but never receive perpendicular insolation. High insolation values, on the other hand, indicate steep, north facing areas which receive perpendicular insolation all year long. This in turn is interpreted as areas with deep to very deep soils, with oversaturated soils or surface water, compared to shallow to very shallow soils either at field capacity or permanent wilting point. Exposure to insolation should be interpreted in the inverse as, while the value decreases from the aquatic to the cool moist terrestrial ecosystem towards the warm, dry terrestrial ecosystem, exposure to insolation actually increases from seasonal to permanent.

The different geological types furthermore resulted in the aquatic to the cool, moist terrestrial ecosystem having a terrain type consisting of strongly undulating plains with prominent scarps compared to that of the warm, dry terrestrial ecosystem which consist mainly of midslopes and crests. The last variable, aspect, highlights the difference between the ecosystems and their respective geological environments. The aquatic to the cool, moist terrestrial ecosystem being generally north facing due to the tilt of the sediments and that of the warm, dry terrestrial ecosystem south to south easterly due to the general slope towards the sea.

2.3. General

It is clear from the results that the eighteen clusters selected from the TWINSPAN classification which conform to the conditions set are separable and of informational value. Eleven of these clusters represent abstract vegetation communities found within the aquatic to cool moist terrestrial ecosystem of the Southeastern Mpumalanga Plains Vegetation Type. The other seven represent abstract vegetation communities from the warm, dry terrestrial ecosystem.

The TWINSPAN classification did not separate wetland communities from the dry, terrestrial communities, as with the previous two vegetation types. Wetlands were included with the cool, moist terrestrial ecosystem because of the association of this ecosystem with fine textured soils. All of these wetlands are associated with drainage lines of different water regimes.

Although altitude separates the two ecosystems, the driving force behind this difference is the geological environment. Within these two ecosystems, the distribution of different physiognomic units and their associated communities is largely determined by soil texture and percentage surface rock, as indicated by their location along the slope of the strongly undulating plains.

Most of the woodland communities occurred within the warm, dry terrestrial ecosystem associated with the metamorphic rock from the exposed shield at lower altitudes, while the grassland communities occurred within the cool, moist terrestrial ecosystem associated with the sedimentary and igneous rock of the covered shield at higher altitudes.

CHAPTER VIII - POTENTIAL APPLICATIONS OF GPS, REMOTE SENSING AND GIS IN WILDLIFE MANAGEMENT

1. Introduction

Phytosociology forms the basis of wildlife management. It is the equivalent of stocktaking in business. In the same way that stocktaking forms an integral part of a business management plan, the results from a phytosociological study form part of an environmental management plan. The results describe what there is to management, how it is influenced and what is it's potential use. Furthermore the results are used to monitor and evaluate the management strategy, in the same way that regular stock taking and auditing shows a business where it is heading.

During the last part of the twentieth century, technology has developed which assists in the gathering and management of this information. Global Positioning Systems (GPS) and remote sensing platforms (aeroplanes and satellites) enable the capturing of environmental data during surveys, while Geographical Information Systems (GIS) are used to store, analyse and represent the data on a computer. In the early days, this technology was expensive and only available to the researchers at academic or military institutions, but this has changed with the development of the microchip and the end of the cold war.

The aim of this chapter is to describe the possibilities of this technology in wildlife management. To achieve this aim, examples from the current study, and examples and possible applications cited from literature (Johnson 1969, Lintz & Simonett 1976, Cracknell & Hayes 1991, Eastman 1997) will be used.

2. Global Positioning Systems (GPS)

Global Positioning Systems (GPS) were developed for the United States Military; it enables a user to determine his position on the globe without the use of a map. The information is provided by a network of satellites, which transmit signals to the receiver of the user. Receivers provide the position in four dimensions: latitude, longitude, altitude and time. The information is available to the user in a wide range of co-ordinate systems (e.g. geographic, UTM, user defined, etc.) and units (e.g. metric, feet, degrees minute seconds, degrees minutes, etc.).

GPS receivers available to the general public are subjected to selective availability, which means they are only able to receive signals from the satellites with a certain amount of error, resulting in inaccuracies of up to 100 m. In the absence of selective availability, GPS receivers are capable of accuracies of millimetres. To achieve this sub-metre accuracy with only selective availability, two options are available.

Differential GPS and/or real-time GPS use the same principles but different accessories. Both make use of a base station of known geographical position. GPS measurements are taken for the same period at the base station and the receiver. The difference between the GPS receiver measurement and that of the base station is calculated and applied to that of the receiver. A base station could be a trigonometrical beacon or a network of points provided by commercial institutions. This is differential GPS and the only accessories needed are a computer or two and access to fax machines or the Internet. Real time GPS measurements are provided by a radio which accompanies the GPS receiver. The radio transmits the GPS measurements to the nearest base station, which in turn transmits the corrected GPS measurements back to the radio. Therefore the measurements displayed by the GPS receiver are real time and accurate up to the sub-metre. This information can then be stored and downloaded to a computer for further analysis or to return to the exact spot during future surveys. Of the two options, the former is more time consuming and the latter the more expensive.

During the current study use was made of a commercial GPS receiver to determine the positions of the plots surveyed. The inaccuracy associated with this type of receiver was negligible due to the small scale (extensive area) involved and the purpose of the study. Plots surveyed represented samples from larger homogenous units occurring in stands throughout the study area. Exact boundaries for these stands are unknown, therefore their distribution is correlated to certain environmental entities. The co-ordinates provided by the GPS receiver made it possible to extract additional information from existing environmental databases or to plot the different plots and/or associated communities along known environmental gradients. This type of exercise was in the past very cumbersome or basically impossible for very large data sets but, due to the advances in digital technology, it could take up to a few hours or minutes depending on how well the research facilities are set-up.

Ultimately the best option is the use of real time GPS receivers. No restrictions are placed on the size of the study area and in the case of endangered or newly identified species, researcher could return to exactly the same spot. No stakes or markers would be needed for monitoring. The minimum requirements of such a GPS receiver are that it must be powered from either batteries or a vehicle, and it should have both the hardware and software to interface with a personal computer. Deluxe models should conform to these requirements and be fully compatible with Geographical Information System software. An example of the function of such a GPS receiver is in navigating both the direction and length of a transect while at the same time storing information concerning points along the transect.

As well as determining unknown locations, GPS receivers can be used to navigate towards known positions, making it a very important tool in the planning of surveys. Samples could be randomly distributed within homogenous units and a GPS used to navigate the surveyor to the exact locality, preventing samples from being placed *ad hoc* or across ecotones. This way objectivity is increased and the probability of sampling outliers lowered. Another use of GPS receivers is in the tracking of fauna or other mobile items which need to be monitored continuously.

No discussion on the application and possibilities of GPS receivers would be complete without mentioning some common disadvantages and problems. The signals received by GPS receivers are of the same frequency as sunlight; therefore any object which might block sunlight would also be able to block a GPS receiver from receiving signals. This could be a big problem in forest. There are certain times of the day which are optimal to use a GPS receiver, when four or more satellites are continuously available above the horizon in that specific area, giving quicker and more accurate updates. Rates charged by real time GPS solution providers are high, but should decrease as competition and demand increases. Certain companies developing GPS receivers are looking at ways to improve measurements without making use of base stations. Some of these receivers already obtain sub-meter accuracy on fixed positions.

In conclusion, any research done on large scale (small areas) using commercial GPS receivers should be treated sceptically, unless differential corrections were made. The use of real time GPS receivers should be promoted in wildlife management as it decreases the possibility of human error. Institutions responsible for making decisions regarding the environment should be made aware of the difference in the value of data collected with commercial GPS receivers or real time GPS receivers. A probable error of 100 metres could result in the destruction of a sensitive area or non-comparable data from different monitoring surveys.

3. Remote sensing

3.1. The human eye

The most common remote sensing platform is our own bodies and the most common sensor, our eyes. Our eyes are sensitive to a certain range of frequencies from the electro-magnetic spectrum, provided by the sun and reflected from objects in our view. This range of frequencies is defined as visible light. Making use of the difference in visible light, it is possible to distinguish between different objects using colour differences and pattern recognition. Therefore, in the days before cameras, aeroplanes, scanners and satellites, different environmental entities were identified using colour (electro-magnetic frequencies) and structure (pattern recognition). Differences were quantified using measurements such as composition, height and density. Obvious limitations are the distance of sight and the duration of daylight, and it is easier to recognise differences in the vertical dimension than the horizontal dimension. It is the latter which is normally needed in planning.

3.2. Photography

The discovery of the camera made it possible to capture the reflections from the environment for future reference instantaneously. It enables pattern recognition in both the vertical and horizontal dimension. The latter was hampered at first by man's inability to get into the air but, once that hurdle was overcome, aerial photography was developed as a discipline in its own right. Initially only black and white photographs were available, but with the development of technology, colour photographs became available and, eventually, infra-red. The latter is outside the visible light electro-magnetic spectrum. Examples of remote sensing using photographs in the vertical dimension are photographs of individuals and groups, and fixed point monitoring to show changes in structure and composition of environmental entities. Aerial photographs taken from aeroplanes made the recognition of differences in the horizontal dimension easier. Surveys are used to determine the informational value of these homogenous units, using the same parameters as before. A wide range of aerial photographic products are available to parties interested in the environment, from small scale 1: 50 000 black and white stereographic pairs with three dimensional capabilities to large scale 1: 10 000 ortho black and white photographs with 5 m contour intervals. Colour aerial photographs at these scales are also available but less common because they are more expensive. Infrared photographs are even less common because they are yet more expensive. These are used for special purposes (productivity measurements and vegetation health). Limitations associated with aerial photographs are that the area captured on film is limited, most of the photographs are taken during the winter to limit cloud cover, made-to-order aerial photographs are expensive, and government supplied aerial photographs are cheap but generally outdated and, until recently, were not compatible with digital technology.

The development of commercially available flatbed colour scanners has made it possible to convert analogue hardcopy photographs to digital images, which can be viewed and manipulated by means of a variety of graphic packages. Another tool for converting the data captured on photographs to digital information for use in computers, is a digitizer board. Features in photographs are followed using a cursor on the board, resulting in the image being drawn on the screen of the computer. However this is time consuming work, which requires patience and a steady hand, while the hardware and software used are expensive. Furthermore, these images are dimensionless unless imported into graphic software capable of returning dimension to it. Once the image has dimension, it could be reproduced at different scales. Another development in photography is digital cameras, which are capable of almost the same resolution of analogue cameras.

3.3. Satellite imagery

Technology involving radar, infrared and aerial photography were put to use during the Second World War to determine the location of the enemy. After the Second World War, the cold war and the space race started. Rockets and satellites were developed with the purpose of defending, spying and attacking the enemy rapidly over vast distances. This resulted in the development of sensors or scanners capable of capturing information reflected from the earth at a variety of spatial and spectral resolutions. Initially this technology was only available to military and related research institutions but, with the end of the cold war and the beginning of global environmental awareness, this information is becoming public domain. It is possible to obtain satellite data at different spatial and spectral resolutions, gathered during the last few decades for almost next to nothing on the Internet. Unfortunately, the most recent information is still only available at a price out of reach of most parties interested in the environment. This issue should be addressed, as it is unacceptable that such vital information for the survival of the human race and protection of biodiversity is unavailable to the researchers, decision makers and policy makers of the world. The man in the street, although incapable of using and interpreting this information, should have the right to know that persons who are capable of using and interpreting the information, have access to this data, for use in his best interest.

Satellite imagery is obtained by means of two sensing techniques, passive and active, from two types of unmanned satellites, polar or near polar orbiting and geostationary. In a passive system the remote sensing instrument simply receives whatever radiation happens to arrive and selects the radiation of the particular wavelength range that it requires. In an active system the remote sensing instrument itself generates radiation, transmits it towards a target, receives the reflected radiation from the target, and extracts information from the return signal. Near-polar orbiting satellites cover different sections of the earth continuously and the same area after a fixed period depending on the length of their orbits. The satellite moves in a north to south direction, while the scanner captures the data from west to east. Geostationary satellites, on the other hand, orbit on the equatorial plane at such a height from the earth that they cover a fixed point on the earth. To have a continuous coverage of the earth along the equatorial plane, geostationary satellites are spaced at fixed intervals around the globe. It should be kept in mind that the passive sensors are only capable of capturing data during day time while an active sensor can also capture data during the night.

In selecting satellite imagery, three parameters should be considered: spatial resolution, spectral resolution and image restoration (corrections). Spatial resolution as applied to satellite imagery means that area of which data is captured by the sensor before moving on to the next area of the same size along it's scan line. This is also referred to as the instantaneous field of view (IFOV) and is summarised by a single value in the image. Examples of the spatial resolution of some commonly used satellite imagery are 30 & 80 metres (LANDSAT) and 10 & 20 metres (SPOT). This means that an image of 10 metre spatial resolution is capable of providing information concerning 100 m^2 or one hundredth of a hectare (0.01 ha). Aerial photographs are capable of much better spatial resolution than satellite images, but comparable maps at the scale of 1: 50 000, could be created from satellite images of 10 or 20 metre resolution, with some image enhancement, even larger scale maps could be produced from these images. This brings satellite images well within the scale range of 1: 10 000 to 1: 50 000, which is traditionally used in wildlife management. During discussion with individuals at Satellite Applications

Centre, Hartebeesthoek, mention was made of the possibility of acquiring satellite images at 2 metre spatial resolution in the near future.

Spectral resolution defines the sensor's capability of capturing different sections of the electro-magnetic spectrum. This would depend on the type of sensor and the range of frequencies or band selected by the developer for capture. The most common bands selected are blue, green, red, near infrared, mid-infrared and thermal infrared. Black and white or panchromatic images are also available. Some of the uses of these bands which are of interest to wildlife management are delineation of water bodies, capturing of vegetation cover and differences, biomass and even animal census, while information from active sensors is used to determine soil moisture and texture.

False colour composite images are often seen. These are created by taking what appear to be black and white images of different bands and assigning the visible colours red, green and blue to each of these images. If each image should be viewed individually, the white areas will appear the brightest and the black areas the darkest. This represents areas of strongest and weakest reflectance of that specific band. To be able to interpret these false colour composite images, the relation of the band to different environmental phenomena must be understood. Plants absorb the colour red, resulting in very little reflectance. On the black and white image vegetated areas would appear black or dark red if the colour red were assigned to it. Near infrared is reflected by plants, white areas therefore representing highly vegetated areas in black and white or brightly green in false colour. If the third image captured the visible colour green, reflected by plants, the same principle would apply. In combination, areas covered by water will appear black or dark because no reflectance occurred in these areas, while areas of low plant cover appear more red and those with high plant cover bright green. Furthermore, by making use of the same bands captured at different times or of different bands, it would be possible to distinguish between permanent open water areas, wetlands (areas of seasonal inundation) and terrestrial areas. This pattern recognition or homogenous unit distinguishing capability of satellite imagery provides the most basic need in wildlife management. Homogenous units are used to test the hypothesis of the presence of different ecosystem and vegetation communities, determination of species richness and biodiversity, biomass and carrying capacity, making it possible to map areas of varying sensitivity or different ecological potential.

Satellite images require image restoration, because of the influence of the atmosphere and of the sensor on the quality of the data. Two types of correction are distinguished radiometric and geometric. These corrections could be applied by either the distributor or the end user and will influence the cost of the data.

To conclude, satellite imagery definitely has the potential to be used in wildlife management. This statement is confirmed by the many textbooks and journals which cover this subject. With ever-increasing pressure on natural resource, institutions concerned with decision making in the environment should not accept reports based on data not using the most recent remotely sensed information available. Unfortunately for this study, the 1: 250 000 land cover maps based on Landsat Thematic Mapper satellite imagery and provided by the Satellite Applications Centre, were made available too late. These maps, in conjunction with a GPS receiver, could have had a significant influence on the planning, sampling size and results of this study.

4. Geographic Information System (GIS)

Geographic Information Systems (GIS) is software developed for the purpose of acquisition, storage, analysis and display of geographic data. It is therefore capable of storing any object with spatial dimensions. This includes natural and man-made entities. Data is stored in themes or layers. Different themes could be created for the same area on the earth, depending on the purpose of the project. Generally in the discipline of wildlife management, a theme could be created for each of the following environmental attributes: geology, soil, vegetation, contours, drainage lines, sample points and man-made infra structure.

More often than not, GIS is used only for the purpose of producing maps, a function which could have been fulfilled by almost any good quality graphics program. The strength of GIS lies in its ability to assist individuals in environmental decision making. Its analytic capabilities enable it to determine correlations between different environmental factors to select the best possible area for a specific purpose, and in natural disaster risk management and planning of environmentally related projects. Solutions are provided graphically either as maps or graphs, depending on which make the most sense. Accuracy and problem solving solutions depend on the quality of the data stored as well as the level of technical knowledge. Therefore GIS solutions should be placed under the same scrutiny as statistical results because GIGO: the famous computer principle "Garbage In, Garbage Out!"

Two types of file formats are used in GIS data storage: object orientated (vector) and raster. In vector format files, the data consists of points and lines or combinations of lines to create polygons. These types of files could be imported to or exported from other software packages such as AutoCAD or Coral Draw. In raster format files, the GIS features, consisting of points, lines and polygons, are represented by individual or groups of blocks in a grid. Related import and export file types from other software packages are bitmap and tif. Generally only one type of feature is saved per theme, e.g. rivers represented by lines in a theme called rivers. Raster systems are better for modelling and analyses than vector systems, which have smaller data files, and also produce better maps. In general, the attributes associated with the feature in the theme such as name, height, surface, quality, etc., are linked to it by means of a table. The tables used are similar in structure to those used in spreadsheets, enabling import and export of data from existing databases.

During this study, both types of GIS systems were used, IDRISI, which is raster based and Arc-Info/View, which is vector based. Arc-Info, which generated contour vector data at 100 m intervals, was used to create a digital terrain model (DTM) in IDRISI. The DTM was used to calculate slopes and aspect. Slopes were reclassified to represent pasture, erosional and land use classes. Using IDRISI's modelling capabilities, an insolation attitude model was created by combining slopes which receive perpendicular insolation or not with aspects exposed to the sun or not. Data was extracted for the sampling points, using the GPS co-ordinates, the DTM, the original slope and aspect images, the reclassified images and the modelled image. Additional data were extracted for the sample points by means of their GPS co-ordinates in Arc-View from the 1: 1 000 000 Geological coverage, from self digitised 1: 250 000 Land type maps, and from 1: 1 000 000 Terrain morphological map. The results were presented as maps, enhanced by the map composition capabilities of these two packages.

Finally, it could be stated that the use of GIS made it possible to calculate attributes related to the environment within hours, which in the past would have taken days, depending on the size of the sample. Although the techniques and models used were elementary, the possibilities were only restricted by available sources of data, time and technical knowledge.

5. Conclusion

Advancement in technology plays an important role in wildlife management. Technology is already available to greatly improve decision making in wildlife management and related disciplines. It's use should be demanded by those involved in environmental decision making. The excuse of high costs should no longer be accepted to the detriment of the country and it's natural and human resources.

Future potential environmental decision-makers should be educated about the capabilities of these technological aids. This would enable them to be sceptical about results and aware of possible irregularities. Only then would technology become **an aid** towards the correct answer, instead of the correct answer.

CHAPTER IX - DISCUSSION

The aim of the study was to classify and map a section from the Grassland Biome between Belfast – Barberton – Piet Retief – Wakkerstroom making use of existing methods and latest technology.

1. Methods and technology

The subjective and semi-qualitative Braun-Blanquet method in conjunction with the objective cluster analysis program TWINSPAN provided the results. Applying a set of criteria to the TWINSPAN results made it possible to select clusters which are separable, informative and capable of being mapped at scales larger than 1: 10 000 000. Developments in computer hardware and software enabled the transfer of data between mainframes and desktop computers and the processing of large data sets. It was therefore possible to calculate constancy and fidelity values for the species in the phytosociological tables using a spreadsheet, selecting diagnostic and constant species from criteria based on these values and arranging them in a hierarchical order. This approach improved objectivity, increased efficiency and highlighted both the community and continuum concepts within vegetation science.

The use of Geographical Information System (GIS) software enabled the collection of existing data to provide solutions to the hypotheses made during the study. Furthermore, the modelling capabilities of the software enabled the extraction of data which was often estimated incorrectly during field surveys, while the combined effects of some known environmental factors (slope, aspect, insolation) could be visually displayed and queried.

2. Results

It is possible to categorise the results of this study into three topics:

- The plant communities of the Belfast – Barberton – Piet Retief – Wakkerstroom area
- Environmental trends which influence physiognomic and floristic distribution in the terrestrial and wetland ecosystems of the Belfast – Barberton – Piet Retief – Wakkerstroom area
- The transition between the Grassland and Savanna Biomes in the Belfast – Barberton – Piet Retief – Wakkerstroom area

2.1. The plant communities of the Belfast – Barberton – Piet Retief – Wakkerstroom area

Coetzee *et al.* (1993a & b) did a survey of the undulating plains of the Belfast – Barberton – Piet Retief – Wakkerstroom area, within the Ad, Ba, Bb and Ca soil patterns. He identified the following terrestrial plant communities within the undulating plains:

1. The *Acacia karroo-Diospyros lycioides* Vegetation unit
2. The *Themeda triandra-Eragrostis plana* Vegetation unit
2.1. The *Eragrostis plana – Setaria sphacelata* Grassland
2.2. The *Eragrostis plana – Hyparrhenia hirta* Grassland
2.3. The *Eragrostis plana – Aristida junciformis* Grassland
2.3.1. The *Aristida junciformis – Tristachya leucothrix* Variation
2.3.2. The *Aristida junciformis – Commelina africana* Variation
2.4. The *Eragrostis plana – Eragrostis patentissima* Grassland
2.5. The *Eragrostis plana – Eragrostis chloromelas* Grassland
3. The *Aristida junciformis- Panicum natalense* Vegetation unit
4. The *Digitaria tricholaenoides-Setaria nigrirostris* Vegetation unit
4.1. The *Digitaria tricholaenoides – Brachiaria bovonei* Grassland
4.2. The *Digitaria tricholaenoides – Berkeya setifera* Grassland
5. The *Themeda triandra-Trachypogon spicatus* Grassland
5.1. The *Trachypogon spicatus – Loudetia densispica* Grassland
5.2. The *Trachypogon spicatus – Heteropogon contortus* Grassland
5.3. The *Trachypogon spicatus – Hyparrhenia hirta* Grassland
5.4. The *Trachypogon spicatus – Eulalia villosa* Rocky outcrops
5.4.1. The *Eulalia villosa – Cymbopogon excavatus* Variation
5.4.2. The *Eulalia villosa – Monocymbium ceresiiforme* Variation

These plant communities were associated with the following environmental attributes:

Geology: intrusive and sedimentary rocks
Altitude: 1300 – 1800 m
Soil patterns: Ba, Bb, Ca and Ad
Average annual rainfall: 611 – 957 mm
Rockiness: < 10 - 60%
Soil depth: 50 – 700 mm
Clay content: < 10 – 25%
Utilisation

Within the same undulating plains he identified the following wetland communities:

1. The *Cynodon dactylon-Cyperus marginatus* Pans.
2. The *Sacciolepis typhura-Cyperus esculentus* Pans.
3. The *Phragmites australis-Typha capensis* Wetland.
4. The *Eleocharis palustris-Leersia hexandra* Wetland.
4.1. The *Eleocharis palustris – Typha capensis* Variation

4.2. The *Eleocharis palustris – Schoenoplectus corymbosus* Variation

4.3. The *Eleocharis palustris – Juncus oxycarpus* Variation

4.4. The *Eleocharis palustris – Gladiolus papilio* Variation

5. The *Arundinella nepalensis-Rhus pyroides* Wetland.

5.1. The *Rhus pyroides – Ischaemum fasciculatum* Variation

5.2. The *Rhus pyroides – Hypparhenia hirta* Variation

6. The *Arundinella nepalensis-Miscanthus junceus* Wetland.

7. The *Arundinella nepalensis-Juncus effusus* Wetland.

7.1. The *Juncus effusus – Eragrostis patentissima* Variation

7.2. The *Juncus effusus – Paspalum dilatatum* Variation

8. The *Cyperus fastigiatus-Polygonum salicifolium* Wetland.

9. The *Imperata cylindrica-Kyllinga erecta* Wetland.

10. The *Acacia mearnsii-Hyparrhenia tamba* Wetland.

They are associated with the following environmental attributes:

Wetland type: pans, vleis and drainage lines (rivers and streams)

Soil texture: sandy or clayey

Hydrology: stagnant, waterlogged, slow-flowing, fast-flowing

Channel configuration: width and depth

During the current study three vegetation types were identified:

a. **Southeastern Mpumalanga Mountains Vegetation Type**

1. Terrestrial ecosystem communities

1.1 *Loudetia flavida - Heteropogon contortus* Pure short closed grassland community

1.2. *Schistostephium crataegifolium - Themeda triandra* Low// short sparse shrubland community

1.2.a *Faurea speciosa - Schistostephium crataegifolium* Low// short sparse shrubland sub-community

1.2.b. *Helichrysum dasycephalum - Schistostephium crataegifolium* Low// short sparse shrubland sub-community

1.3. *Cussonia paniculata - Themeda triandra* Low// short thicket community

1.4. *Crabbea acaulis - Themeda triandra* Pure low closed grassland community

1.5. *Anthospermum rigidum - Themeda triandra* Pure low closed grassland community

1.6. *Melinis repens - Hyparrhenia hirta* Low// short sparse shrubland community

1.7. *Zanthoxylum capense - Themeda triandra* Low// short sparse woodland community

1.8. *Acacia karroo - Heteropogon contortus* Low// short thicket community

1.9. *Rhus pentheri - Hyparrhenia hirta* Low// short sparse woodland community

1.10. *Hyperthelia dissoluta - Heteropogon contortus* Woodland (*Sensu lato*) community

1.10.a. *Annona senegalensis - Hyperthelia dissoluta* Low// short thicket sub-community

1.10.b. *Sutera aurantiaca - Hyperthelia dissoluta* Low// short sparse shrubland sub-community

1.11. *Englerophytum magalismontanum - Heteropogon contortus* Low// short thicket community

2. Wetland plant communities

2.1. *Eriosema salignum - Hyparrhenia hirta* Short closed grassland community

2.2. *Schizostylis coccinea* - *Eragrostis plana* Low// short bushland community
2.3. *Combretum erythrophyllum* - *Setaria sphacelata* Low// short bushland community
2.4. *Setaria nigrirostris* - *Themeda triandra* Pure low closed grassland community
2.5. *Helichrysum harveyana* - *Setaria sphacelata* Pure low closed grassland community
b. **Southeastern Mpumalanga Hills and Lowlands Vegetation Type**
1. Wetland plant communities
1.1 *Cliffortia nitidula* - *Setaria sphacelata* Pure low closed grassland community
1.2. *Miscanthus junceus* - *Cyperus esculentus* Pure low closed grassland community
1.2.a. *Arundinella nepalensis* - *Miscanthus junceus* Pure low closed grassland sub-community
1.2.b. *Sporobolus africanus* - *Miscanthus junceus* Pure low closed grassland sub-community
1.3. *Oenothera tetraptera* - *Paspalum dilatatum* Pure low closed grassland community
2.Terrestrial ecosystem communities
2.1. *Helichrysum nudifolium* - *Hyparrhenia hirta* Pure low closed grassland community
2.1.a. *Paspalum scrobiculatum* - *Helichrysum nudifolium* Low// short sparse shrubland sub-community
2.1.b. *Indigofera comosa* - *Helichrysum nudifolium* Pure short closed grassland sub-community
2.2. *Pentanisia angustifolia* – *Themeda triandra* Pure low closed grassland community
2.2.a. *Helichrysum cephaloideum* - *Pentanisia angustifolia* Pure low closed grassland sub-community
2.2.b. *Clutia monticola* - *Pentanisia angustifolia* Low// short sparse shrubland sub-community
2.3. Oxalis purpurea - *Helichrysum rugulosum* Pure low closed grassland community
2.4. *Aloe marlothii* - *Hyparrhenia hirta* Low// short thicket community
2.5. *Diheteropogon amplectens* – *Themeda triandra* Low// short thicket community
2.6. *Tetraselago wilmsii* - *Commelina africana* Low// short sparse shrubland community
2.7. *Sporobolus pectinatus* - *Tristachya leucothrix* Low// short sparse shrubland community
c. **Southeastern Mpumalanga Plains Vegetation Type**
1. Wetlands to cool, moist terrestrial ecosystem communities
1.1. *Senecio affinis* - *Imperata cylindrica* Pure low closed grassland community
1.2. *Wahlenbergia undulata* – *Eragrostis plana* Pure low closed grassland community
1.3. *Helichrysum pilosellum* – *Eragrostis plana* Pure low closed grassland community
1.4. *Conyza canadensis* – *Eragrostis plana* Pure low closed grassland community
1.5. *Salix babylonica* - *Setaria sphacelata* Low// short bushland community
1.6. *Pennisetum sphacelatum* - *Paspalum dilatatum* Pure low closed grassland community
1.7. *Vernonia natalensis* – *Themeda triandra* Pure low closed grassland community
1.7.a. *Crabbea acaulis* - *Vernonia natalensis* Low// short sparse shrubland sub-community
1.7.b. *Microchloa caffra* - *Vernonia natalensis* Pure low closed grassland sub-community
1.8. *Cucumis zeyheri* - *Hyparrhenia hirta* Low// short sparse shrubland community
1.8.a. *Helichrysum cephaloideum* - *Cucumis zeyheri* Low// short thicket sub-community

1.8.b. *Cephalanthus natalensis - Cucumis zeyheri* Low// short sparse shrubland sub-community
1.9. *Cymbopogon validus - Panicum natalense* Low// short sparse woodland community
2. Warm, dry terrestrial ecosystem communities
2.1. *Indigofera cryptantha - Heteropogon contortus* Low// short sparse woodland community
2.2. *Phragmites australis - Hyperthelia dissoluta* Pure short closed grassland community
2.3. *Perotis patens - Hyperthelia dissoluta* Pure short closed grassland community
2.4. *Crabbea angustifolia - Loudetia flavida* Pure low closed grassland community
2.5. *Pavetta edentula - Pellaea calomelanos* Low// short thicket community
2.5.a. *Ehretia rigida - Pavetta edentula* Low// short thicket sub-community
2.5.b. *Gerbera piloselloides - Pavetta edentula* Low// short thicket sub-community
2.5.c. *Ficus glumosa - Pavetta edentula* Low// short thicket sub-community

These three vegetation types were associated with 31 environmental attributes within four broad categories (geology, geomorphology, climate and pedology). The attributes of the geomorphology (altitude, relief, slope) determined the boundaries of the three vegetation types. The attributes of the geology (petrology, lithology, chronostratigraphy and stratigraphy), climate (climate zones, average annual precipitation, slope, aspect and insulation attitudes) and pedology (soil pattern, soil form, soil depth and rockiness) determined the communities and sub-communities of the terrestrial communities. Basically the same attributes used by Coetzee *et al.* (1993a & b) for his wetland communities applied to the wetlands of the current study, emphasising the overriding effect of water in wetland systems. The main difference was the absence of the endoheric pans within the area of the current study.

When the two studies were compared, the following anomalies became evident:

1. The vegetation could be classified into the communities of the terrestrial ecosystems and those of the aquatic (wetland) ecosystems.
2. Intrusive (igneous) and sedimentary rock are the main petrologic units influencing the vegetation.
3. Rockiness and soil texture are the main environmental determinants of terrestrial communities, and soils inundated to field capacity are the main environmental determinants of the wetland communities.
4. Soil water availability is an overall determinant of plant community distribution.
5. The plant communities in high rainfall areas reflect the influence of the landforms rather than the soil patterns.
6. When comparing the plant communities and general environmental factors classified within each study, it is evident that certain species are diagnostic and associated with certain environmental factors, irrespective of the researcher or his approach.

Difference in the results of the two studies can be attributed to:

1. The scope of each study. The study by Coetzee *et al.* (1993a & b) covered only four soil patterns within one landform category, the undulating plains. The current study covered eight soil patterns within three landform categories, mountains, hills and lowlands, and undulating plains.
2. The different approach towards the Braun-Blanquet method. Coetzee *et al.* (1993a & b) focused on smaller variations reflected by the species while the current study made used of a more objective

approach based on sets of criteria concerning plant communities, and the fidelity and constancy values of the species.

3. The plant community level differences are a result of the difference in scope. The current study recognised the three landform categories as three different vegetation types with different communities and sub-communities while Coetzee researched a single landform category, distinguishing between vegetation units, communities and variations.

4. Due to the extent and time constraint of the current study not all the species sampled were identified, resulting in species with limited distribution being omitted causing loss of variations.

To conclude, the results of the study by Coetzee *et al.* (1993a & b) represented a different community to the current study's Southeastern Mpumalanga Plains Vegetation Type, specifically within the cool, moist terrestrial ecosystem communities at altitudes above 1000 m.a.s.l. on predominantly sedimentary rock. The comparison of the wetland communities from the two studies would have been made easier if the current study had combined the wetlands from the different vegetation types. Treatment by the current study of the wetlands reveals their occurrence and dominance within the different landforms, with the endoheric pan wetlands being typical of the high altitude plinthic catena soils (Ba – Bd soil patterns) within the undulating plains of the interior away from the escarpment.

2.2. Environmental trends which influence physiognomic and floristic distribution in the terrestrial and wetland ecosystems of the Belfast – Barberton – Piet Retief – Wakkerstroom area

The distribution and floristic composition of vegetation reflects two main ecosystems, namely terrestrial and aquatic (wetlands). This is confirmed by the results from the current study, Coetzee's (1993a & b) study, and global research (Strahler & Strahler 1987). Within these two major ecosystems, depending on the scale of research or management, smaller ecosystems or habitats could be recognised which corresponded to plant communities and their distribution. In a pristine environment, these plant communities would represent areas of biodiversity, due to the interaction between plants, their environment and animals, but today most of the plant communities represent only the boundaries of former habitats. The animals of these habitats have been replaced by livestock, and the plants destroyed or replaced by exotics. Cultivation, opencast mining, forestry, overpopulation and insensitive or uneducated people are a threat to our natural resources and it's communities. It is only through an understanding of the environmental trends which influence these ecosystems, and the role it fulfils in the survival of mankind, that it can be protected and managed for the benefit of all.

2.2.1. Terrestrial ecosystem

Terrestrial ecosystems are those areas in which the root zone of the soil is not temporarily or permanently oversaturated or inundated by water. This does not, however mean that water does not fulfil an important role in this ecosystem. Water reaches this ecosystem through precipitation, with the rate of infiltration and the capability of the soil to store water determining the soil moisture content or soil water balance. Figure 39 is a dendrogram showing the environmental attributes which influence the distribution of the two major physiognomic plant communities occurring in the study area: woodlands and grasslands.

The woodland communities are associated with dystrophic to mesotrophic soils in areas of high rainfall or low soil water deficiencies. Evergreen broadleaf forests occur in mountainous areas, on southern slopes. They have closed canopies, which is an indication of adequate soil moisture. It is well known that soils of forests are well-drained and nutrient-poor, with nutrients being supplied by the decomposing of the leaf litter on the forest floor. Thorn trees occur in association with fine textured lithological units such as igneous dolerite, which produce clayey soils with small capillary cavities and good water retention. The lack of closed canopies and the park-like appearance of the thorn tree woodland communities are an indication of the lower soil water availability when compared to the forests. When the thorn trees occur in low-lying areas with low rainfall, lateral flow and runoff from high lying areas supply the soil water. In high lying areas on ridges and outcrops, the cracks and fissures amongst the rocks increases the infiltration, making soil water available over extended periods. Deciduous broadleaved trees occur on coarse-textured lithological units such as granite, which produce deep, sandy soils with poor water retention. Trees are capable of dominating these areas because of their root systems, which extend towards the water table through the sand and through fissures and cracks of rock outcrops. They tend to form closed canopy clusters. Where they do occur continuously it is in association with a tropical rather than a sub-tropical climate, or under the influence of maritime air. Broadleaved trees make use of the first rains of the season and avoid the drought of the winter through shedding their leaves. In comparison, the fine textured soils of thorn trees only reached capacity by the end of the rainy season, making soil moisture available to the trees well into the winter.

Grassland communities are associated with mesotrophic to eutrophic soils in areas of low rainfall or high soil water deficiencies. Tall grass dominated grassland occurs in areas of deep, nutrient-rich, clayey soils. These areas are generally in the low-lying areas adjacent to rivers. The availability of soil water over an extended period enables the plants to grow taller. Tall grass dominated grasslands are common towards the east of the country below the escarpment, forming a mosaic with thorn tree covered areas before reaching the broadleaf woodlands of the coast with it's moist maritime air. In comparison, short grass dominated grasslands occur on shallow, nutrient poor, sandy soils at high

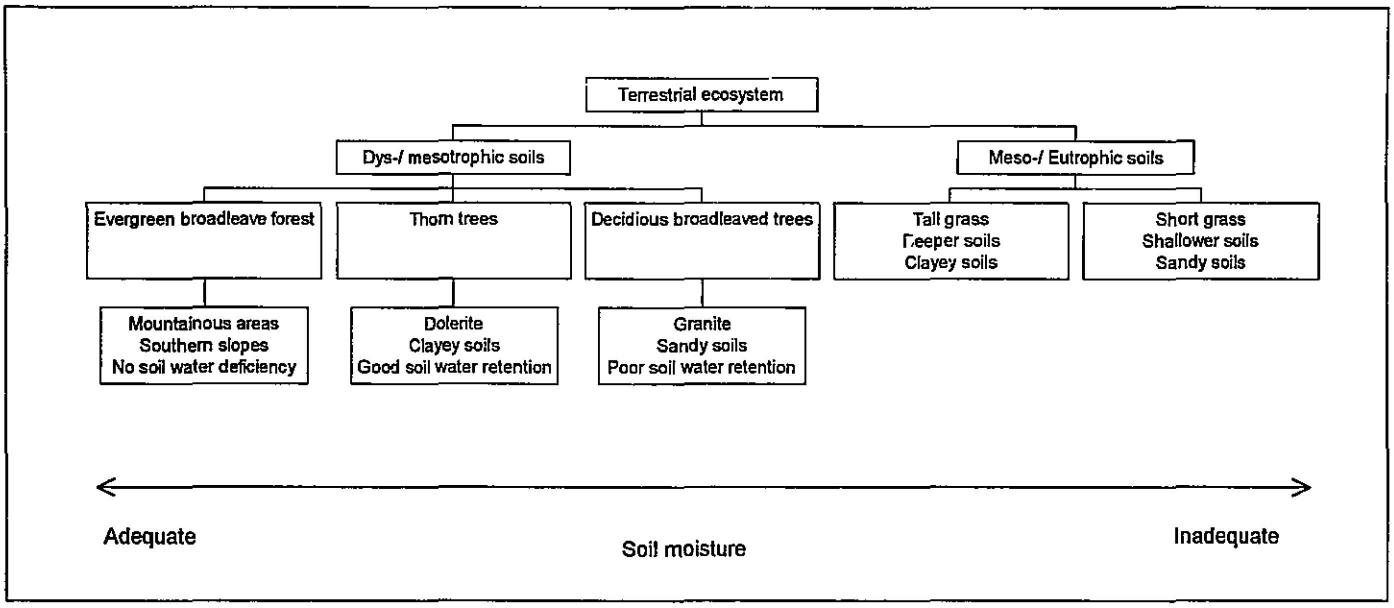


Figure 39: Dendrogram reflecting the physiognomic classification and soil-water availability relationships

altitudes and on steep, exposed slopes. The combination of soil depth and slope results in low infiltration and wilting point in spite of receiving orographic precipitation. Short grass dominated grassland or steppe occurs generally towards the west of the country above the escarpment, where it grades into the karroid veld of the Nama Karoo biome. It has a lower average precipitation compared to the east of the country.

These trends associated with the terrestrial ecosystems repeat themselves at global (Chapter III, paragraph 2.5.1), continental, regional and local scale (Chapter III, paragraph 3.5.1). Therefore it is possible to find areas of short grass on the crests of mountains surrounded by woodlands and scattered woodlands within a sea of grass, contributing to plant and animal diversity.

2.2.2. Aquatic ecosystems

In the terminology of a landlocked environmental scientist, aquatic ecosystems are referred to as wetlands and defined as areas of seasonally or permanently inundated soils (Chapter III, paragraph 2.5.2). Official definitions from the Department of Environmental Affairs and Tourism and the RAMSAR convention include the oceans and man-made structures. Wetlands are areas of high biodiversity, providing habitat to aquatic, semi-aquatic and terrestrial species of both fauna and flora. They control water quantity and quality, making water slowly available and attenuating floods while removing sediment and recycling nutrients. They are used and often abused by humans for business, relaxation and research or education.

The current study only surveyed the exoheric riparian wetlands which occurred within the study area (Chapter III, paragraph 3.5.2). These wetlands are associated with drainage lines (Figure 40). Riparian fringe wetlands are either tree or grass dominated, depending on their location along the drainage line. In the lower course of the drainage line on the plains towards the coast, rivers dominate with wide streambeds and medium to high levees. If the flow of water is perennial or fast flowing, the levees are covered with the broadleaf tree *Combretum erythrophyllum*. Alternatively, where the flow of the river is non-perennial or slow flowing, the levees are covered with the thorn tree *Acacia karroo*.

Along the upper course of the drainage line in the mountainous areas, streams with narrow streambeds and low to medium levees dominate. Where the flow of the stream is perennial or fast flowing, *Cliffortia nitidula* or *Diospyros lycioides* shrubland occurs. If the flow of the stream is non-perennial or slow flowing, grasses dominate the levee and the herb *Schistostylis coccinea* often occurs. Along drainage lines in broad valleys with large floodplains or in areas where man-made infrastructures such as bridges and dams restrict flow, floodplain vleis occur. These wetlands are reed dominated. Where the soils are permanently inundated, reed swamps occur. *Phragmites australis* dominates the reed swamps and is an indicator of stable water levels seldom exceeding 5 metres.

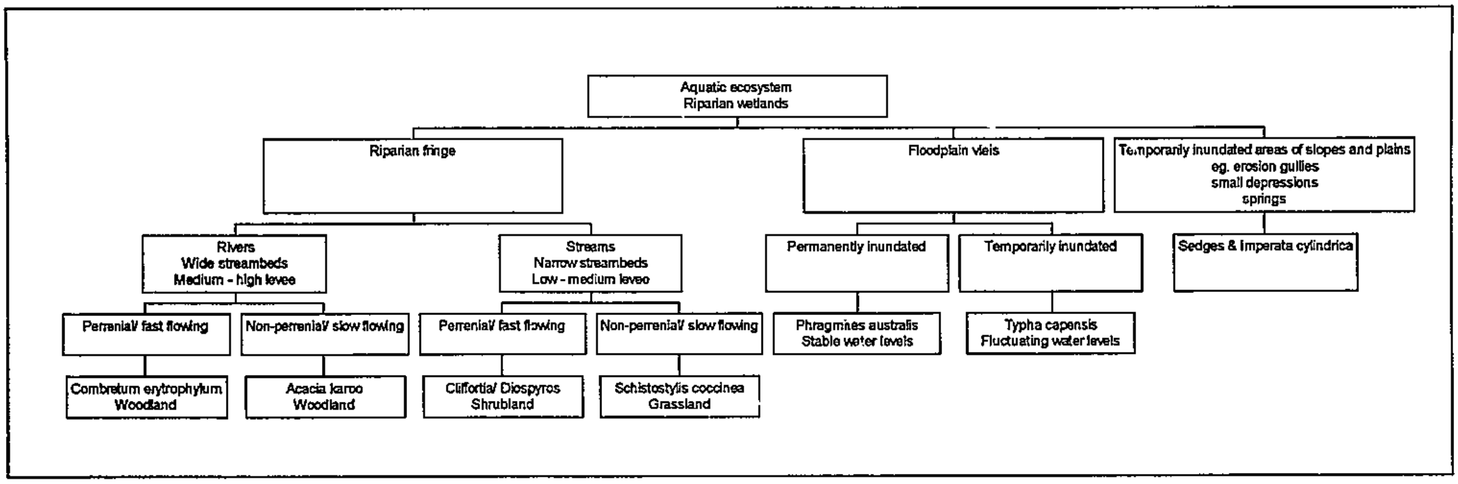


Figure 40: Dendrogram reflecting the physiognomy and soil water availability of the aquatic ecosystem

In areas of temporarily inundated soils, reed marshes occur. *Typha capensis* dominates these marshes and indicates fluctuating water levels. These two variations often occur in zones along the same drainage line, with *Phragmites australis* closer to the streambed or open water and *Typha capensis* alongside it towards the grassy floodplain. The grassy floodplain only becomes seasonally inundated during floods.

Along the gentle to flat slopes of hills and plains, erosion gullies, small depressions and springs occur. These areas only become inundated temporarily and are dominated by sedges and the grass *Imperata cylindrica*. With the exception of the springs, this wetland is associated with disturbance caused by humans and their livestock on their way to existing wetlands used as a water source or point.

Few of the wetlands surveyed were in a pristine state, especially in the forestry areas where it was often difficult to find or recognise the wetlands because they were replaced by grassland. In agricultural areas, dams alter the flow and increase evaporation while lands are often cultivated to the edge of the streambeds and their levees trampled by livestock. Close to settlements, litter and rubble occur in the wetlands while clothes and cars are often washed within the streambeds at low-level bridges. Depending on the type of mine, the wetland water is either extracted or supplemented, altering the flow regime and chemical composition and increasing sediment loads, while stream channels are often diverted or destroyed. All these activities impact negatively on the fauna and flora of the wetlands and eventually on mankind. Potable water becomes scarce and expensive, with few places left for fishing and recreation.

2.3. The transition between the Grassland and Savanna Biomes in the Belfast – Barberton – Piet Retief – Wakkerstroom area

Current maps of the biomes of South Africa indicate that the Grassland Biome extends well in to Swaziland (Chapter III, paragraph 3.5.1). The study area is therefore currently included in the Grassland Biome. From a global perspective, the Savanna Biome extends further west, resulting in the study area being included in the Savanna Biome or occuring on the edge of it (Chapter III, paragraph 2.5.1). It is therefore possible for vegetation communities to exist which represent a transition between these two biomes.

The results of this study indicated that grassland communities dominate the high altitude plains and mountainous areas to the west while woodlands dominate the hills and low altitude plains to the east. It is below and along the escarpment, amongst the hills and towards the low altitude plains, that the existence of a transitional vegetation community is suggested. This concept is not new, Acocks (1988) described three False Grassland Types (Bankenveld to Sour Sandveld transition, Piet Retief Sourveld and Northern Tall Grassland) in approximately the same area. Coetzee (1993 c) and Bredenkamp and Van Rooyen (in: Low and Rebelo 1996) described False Grassland Types as a mosaic of grassland

and woodland communities resulting from differences in local climate, these differences being based on altitude and degree of exposure. The results from the current study reflect the same trends especially within the Southeastern Mpumalanga Hills and Lowlands Vegetation Type and the Southeastern Mpumalanga Plains Vegetation Type.

On a global scale an open-park thorn tree – tall grass savanna formation is recognised as part of the Savanna Biome. This formation is described as a transitional formation from broadleaf savanna to pure grassland. Communities from the current phytosociological study of the Southeastern Mpumalanga high altitude grasslands, which contain elements or characteristics from this transitional formation are:

- 1.9. *Rhus pentheri - Hyparrhenia hirta* Low// short sparse woodland community (Southeastern Mpumalanga Mountains Vegetation Type)
- 1.9. *Cymbopogon validus - Panicum natalense* Low// short sparse woodland community community (Southeastern Mpumalanga Plains Vegetation Type)
- 2.1. *Indigofera cryptantha - Heteropogon contortus* Low// short sparse woodland community (Southeastern Mpumalanga Plains Vegetation Type)

From figure 41, based on the results from the current study, it is apparent that the thorn tree – tall grass savanna formation occurs within the ecotone from the Grassland Biome to the Savanna Biome. The thorn tree associated with this formation in the study area is *Acacia sieberiana* and the tall grasses are *Hyparrhenia hirta* and *Hyperthelia dissoluta*.

The open-park appearance and localised distribution of the trees effectively reflect the transition from wet tropical closed canopy woodland areas under the influence of maritime air in the east, and the dry sub-tropical grassland areas under the influence of continental air in the west. Elements and localised stands of this community are common along the escarpment, and this is true for areas to the north and south of the current study area (personal observations). It is suggested that runoff from the adjacent high relief areas supplements the soil water sufficiently to maintain trees, but not enough for closed canopies to form. The actual and historical distribution of this community is difficult to determine due to current and historical human activities such as cultivation and settlement. A practice related to these activities is bush clearing by means of fire and tree felling which result in stands remaining in areas not suitable to human activities on outcrops, away from permanent surface water and in low human-density areas.

Further support for the hypothesis of this formation belonging to the savanna, is the occurrence of bornhardts and castle kopjes of igneous and metamorphic rock, which are common in the Savanna Biome to the north (Chapter III, paragraph 2.3.B). These bornhardts and castle kopjes are covered by tree species from the following families of the Savanna Biome: Euphorbiaceae, Anarcardiaceae, Combretaceae and Fabaceae. Large streams and rivers in the area reflect the same vegetation zonation common to the riparian wetlands of the Savanna Biome, with tree-dominated levees or

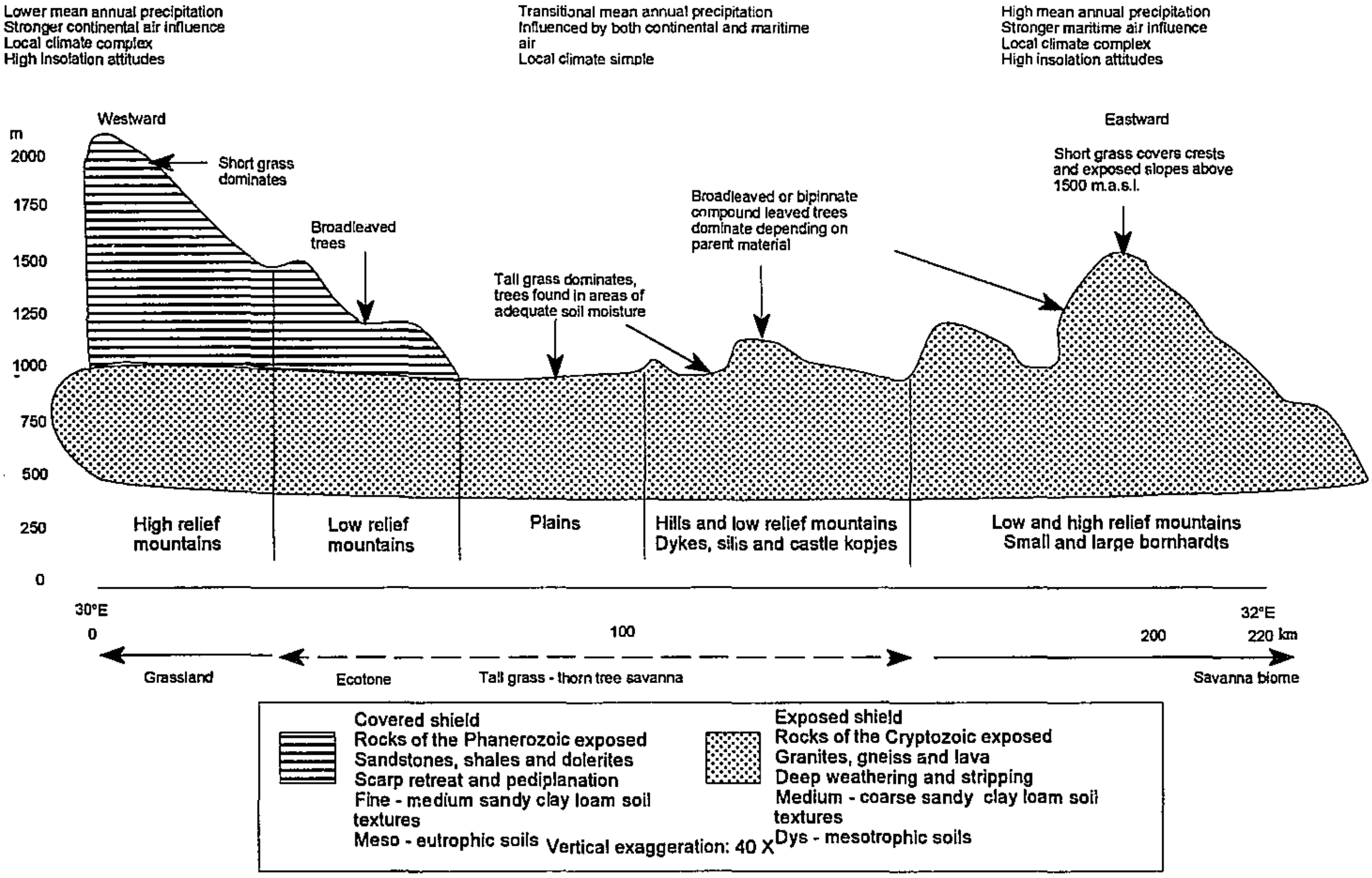


Figure 41: Drawing reflecting the main environmental trends and vegetation distribution

riparian fringes. Although not within the scope of this study, a historical review of the distribution of fauna associated with the Savanna Biome (giraffe, kudu, blue wildebeest and impala), will most probably confirm the link of this area with the Savanna Biome.

It is therefore suggested that this area should be included in the Savanna Biome, instead of the Grassland Biome as is currently the practice. Furthermore the boundary between the Grassland Biome and the Savanna Biome should follow the boundary between the covered and exposed shield as depicted by rocks from the Phanerozoic and the Cryptozoic Eonthems (Chapter III, paragraph 2.1).

CHAPTER X - CONCLUSION

It was concluded during this phytosociological study of the southeastern Mpumalanga high altitude grassland, between the towns of Belfast – Barberton – Piet Retief – Wakkerstroom in the Grassland Biome, that three vegetation types exist. The vegetation of the three vegetation types reflects the influence of landform on the composition and distribution of plants. Landform slope configuration influences rainfall infiltration, runoff and soil depth which, in combination with aspect and insolation, determine the soil water balance in a specific area. Areas of low soil water deficiencies are capable of supporting woodlands while those of high soil water deficiencies support grasslands. Within the boundaries of a specific landform, two ecosystems, namely terrestrial and wetland (aquatic), are found.

The Southeastern Mpumalanga Mountain Vegetation Type consists of ten terrestrial communities with four sub-communities and five wetland communities. Grassland communities dominate this vegetation type, with it's dramatic changes in relief, very steep slopes, high runoff and high insolation. Two stands of this vegetation type are found in association with the mountainous area of the escarpment and the Barberton Mountains.

The Southeastern Mpumalanga Hills and Lowlands Vegetation Type consists of two wetland communities with two sub-communities, and seven terrestrial communities with four sub-communities. A mixture of grassland and woodland communities is found within this vegetation type. Depending on the parent material, the hills and lowlands are either relics of the scarp retreat and pediplanation, or of deep weathering and stripping. The landform configuration consists of gentle slopes and less dramatic relief changes, resulting in increased infiltration and less insolation.

The Southeastern Mpumalanga Plains Vegetation Type with its fourteen communities and seven sub-communities are also found within two stands. One of the stands represents undulating plains at altitudes above 1000 – 1500 m.a.s.l. on sedimentary rock and the other, undulating plains below 1000 m.a.s.l. on igneous rock. Deep, well-developed soils are the result of flat slopes and moderate relief changes. Soil texture exerts a strong influence on soil water availability, while insolation differences between aspects are less significant. Woodlands dominate the stand at lower altitudes with grasslands more prominent on the plains above the escarpment.

Results from the DECORANA analysis and multiple regression confirmed the significance of soil water availability in plant distribution while, depending on the relevant landform, other environmental attributes (slope, soil texture etc.) become significant. It is therefore concluded that the Braun-Blanquet approach and scale, in conjunction with the TWINSPAN classification and criteria related to cluster analysis, resulted in the successful classification, description and mapping of the vegetation of the southeastern Mpumalanga high altitude grasslands. The results provide an in-depth look at the ecological process governing the area which could be used in wildlife management and conservation policies. Finally, a suggestion is made to change the Grassland – Savanna Biome boundary towards the west based on the presence of the thorn tree – tall grass savanna formation within the study area. Furthermore the boundary between the Grassland Biome and the Savanna Biome should follow the boundary between the covered and exposed shield as depicted by rocks from the Phanerozoic and the Cryptozoic Eonthems.

PHYTOSOCIOLOGY OF THE MPUMALANGA HIGH ALTITUDE GRASSLANDS

By

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MAGISTER SCIENTIAE
in
Wildlife management
1999

SUMMARY

A phytosociological study covering approximately 12 000 km² was completed within Southeastern Mpumalanga high altitude grasslands. The towns of Belfast, Barberton, Piet Retief and Wakkerstroom represented the four corners of the area. The study formed part of the Grassland Biome Project sponsored by the Department of Environmental Affairs and Tourism. The Braun-Blanquet approach was applied. Grassland research results from the western side of the country, determined that soil patterns and vegetation distribution are significantly correlated. Based on these results, it was hypothesised that the same correlation would exist in the east. The eight soil patterns used during the survey as homogenous units, were Ab, Ac, Ad, Ae, Ea, Fa, Fb and Ib. A *pro rata,* randomly stratified sample size of 405 plots were used. An in-depth literature study of the environmental and other factors related to vegetation distribution, indicated on local scale that a significant correlation exists between landform and plant distribution. Two geographic information systems, Idrisi and Arc-Info/View, aided in the modelling and extraction of environmental attributes from existing databases.

A TWINSPAN classification of the complete floristic data set falsified the null hypothesis based on the soil patterns but verified the null hypothesis based on landforms. The TWINSPAN dendrogram

revealed clusters associated with three landforms (mountains, hills and lowlands, and plains) in two ecosystems, the terrestrial and the wetlands or aquatic. The three landforms represented three mapping units: Southeastern Mpumalanga Mountain Vegetation Type, Southeastern Mpumalanga Hills and Lowland Vegetation Type and Southeastern Mpumalanga Plain Vegetation Type. A second TWINSPAN classification was executed on each of the vegetation types. The resulting clusters were tested for uniqueness and informational value using a set of criteria. Those clusters which qualified were arranged in a Braun-Blanquet table to determine communities, sub-communities and variations using constancy and fidelity values. The plant communities within the vegetation types were described in terms of floristic composition and environmental attributes.

The indirect gradient analysis ordination program DECORANA was used to determine environmental trends and was confirmed by using multiple regression. Soil water availability was the most significant environmental trend between the two ecosystems and within the communities of the ecosystems in each vegetation type. Soil water availability is influenced by numerous factors, whose significance differs from one vegetation type to another.

It was concluded from this study that, in high rainfall areas, soil patterns and vegetation distribution are not significantly correlated but that landforms and vegetation distribution are significantly correlated. Landscape slope configuration or landform influences soil water availability through soil characteristics (rockiness, texture and depth) and local climatic conditions (aspect, perpendicular insolation and precipitation). It is suggested that the current Grassland - Savanna Biome boundary be changed towards the west using the boundary between the covered and exposed shields. This suggestion is supported by the presence of *Hyparrhenia hirta/Hyperthelia dissoluta – Acacia sieberiana* communities to the east of the study area in the different vegetation types which correlate significantly with the thorntree-tall grass savanna formation on a global scale.

FITOSOSIOLOGIE VAN DIE MPUMALANGA HOË LIGGENDE GRASVELD

deur

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Mede-leier: Mev. M.S. Deutschländer

Departement Plantkunde
Universiteit van Pretoria

MAGISTER SCIENTIAE
in
Natuurlewebestuur
1999

OPSOMMING

'n Fitososiologiese studie is gedoen van die Suid-oostelike Mpumalanga hoë liggende grasveld tussen die dorpe Belfast, Barberton, Piet Retief en Wakkerstroom. 'n Area van ongeveer 12 000 km² is bestudeer. Die studie is deel van die Grasveld Bioom Projek gefinansier deur die Departement van Omgewingsake en Toerisme. Die Braun-Blanquet benadering is gebruik. Resultate van grasveldnavorsing in die westelike deel van die grasveld bioom, het aangedui dat 'n betekenisvolle verband tussen grondpatrone en plantegroei verspreiding bestaan. Na aanleiding van hierdie resultate, is die hipotese gemaak dat dieselfde verband in die ooste sal voorkom. Agt grondpatrone, Ab, Ac, Ad, Ae, Fa, Fb, en Ib is as homogene eenhede beskou. 'n Eweredige ewekansige steekproefneming van 405 punte is gebruik. 'n Deeglike literatuurstudie van die omgewing en faktore wat verband hou met plantegroei verspreiding, het aangedui op lokale skale, dat 'n verband tussen landvorm en plantegroei verspreiding bestaan. Twee geografiese inligtingstelsels, Idrisi en Arc-Info/View, is gebruik in die modelering en verkryging van omgewings data vanuit bestaande databasisse.

'n TWINSPAN klassifikasie gebaseer op die volledige spesiesamestelling, het die nul hipotese oor die grondpatrone ongeldig verklaar maar die nul hipotese oor die landvorme bevestig. Die TWINSPAN dendrogram het groeperings bevat wat verband hou met drie landvorme (berge, heuwels en laaglande en vlaktes) in twee ekosisteme, terrestrieel en vleiland van akwatiese omgewings. Die drie landvorme

is beskou as drie karteerbare eenhede: Suid-oostelike Mpumalanga Berg Plantegroeitipe, Suid-oostelike Mpumalanga Heuwels en Laagland Plantegroeitipe en Suid-oostelike Mpumalanga Vlakte Plantegroeitipe. 'n Tweede TWINSPAN klassifikasie is op elk van die plantegroeitipes toegepas. Elke plantegroeitipe se groeperings is met behulp van bepaalde voorwaardes vir uniekheid en inligtingswaarde getoets. Die groeperings wat gekwalifiseer het, is met behulp van konstantheids en getrouheids waardes in 'n Braun-Blanquet tabel gerangskik in gemeenskappe, sub-gemeenskappe en variasies. Elke plantegroei tipe se gemeenskappe is beskryf in terme van floristies spesiesamestelling en omgewingsfaktore.

'n Indirekte gradientanalise ordeningsprogram DECORANA is gebruik vir die bepaling van omgewings tendense en is bevestig met behulp van veelvuldige regressies. Grondwaterbeskikbaarheid was die mees betekenisvolle omgewingstendens tussen die ekosisteme en die gemeenskappe van die plantegroei tipes. Grondwaterbeskikbaarheid word deur 'n aantal faktore beïnvloed, waarvan die belangrikheid van plantegroei tipe tot plantegroeitipe wissel.

'n Gevolgtrekking van die studie is, dat in hoë reënvalomgewings daar nie 'n betekenisvolle verband is tussen grondpatrone en plantegroei verspreiding nie maar wel tussen landvorme en plantegroei-verspreiding. Landskap hellingsamestelling of landvorme beïnvloed grondwaterbeskikbaarheid deur middel van grondeienskappe (klipperigheid, tekstuur en diepte) en lokale klimaatstoestande (aspek, loodregte bestraling en presipitasie). Daar word voorgestel dat die huidige Grasveld – Savanna Bioom grens weswaarts geskuif word om ooreen te stem met die grens tussen die bedekte en blootgestelde plate. Die voorstel word ondersteun deur die teenwoordigheid van *Hyparrhenia hirta/Hyperthelia dissoluta – Acacia sieberana* plantgemeenskappe in die ooste van die plantegroeitipes wat betekenisvol ooreenstem met die langgras-doring boom savanna formasie op globale skaal.

ACKNOWLEDGEMENTS

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To all the individuals, He provided to support, assist and motivate me:

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- Mrs M.S. Deutschländer my co-supervisor.
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- Dr K. Immelman who assisted in the use of proper grammar.

SPECIES LIST

It was compiled using TURBOVEG (Hennekens 1996) and "Plants of Southern Africa: Names and Distribution" (Arnold & de Wet 1993). Families are in alphabetic sequence within three taxons: Pteridophyta, Monocotyledonae and Dicotyledonae.

Taxon 1. Pteridophyta

Family Adiantaceae

Herbarium no Species

0136000-00600 Cheilanthes eckloniana (Kunze) Mett.

0136000-00770 Cheilanthes hirta

0136000-01480 Cheilanthes quadripinnata (Forssk.) Kuhn

0136000-01600 Cheilanthes viridis

0136800-00200 Pellaea calomelanos

Family Dennstaedtiaceae

Herbarium no Species

0153000-00100 Pteridium aquilinum (L.) Kuhn

Family Equisetaceae

Herbarium no Species

0111100-00100 Equisetum ramosissimum Desf.

Family Schizaeaceae

Herbarium no Species

0128000-00100 Mohria caffrorum

Family Selaginellaceae

Herbarium no Species

0113200-00200 Selaginella dregei (C.Presl) Hieron.

Taxon 2. Monocotyledonae

Family Alliaceae

Herbarium no Species

1046000-00200 Agapanthus campanulatus

1046000-01100 Agapanthus inapertus

1046000-01600 Agapanthus nutans Leight.

1047000-00100 Tulbaghia acutiloba Harv.

Family Amaryllidaceae

Herbarium no Species

1167000-01750 Haemanthus humilis

1167010-00400 Scadoxus puniceus (L.) Friis & Nordal

1168000-00100 Boophane disticha (L.f.) Herb.

1177000-01100 Brunsvigia natalensis Baker

1189000-00300 Crinum bulbispermum (Burm.f.) Milne-Redh. & Schweick.

1190000-00000 Ammocharis species

Family Araceae

Herbarium no Species

0748000-00100 Zantedeschia aethiopica (L.) Spreng.

0748000-00200 Zantedeschia albomaculata

Family Asparagaceae

Herbarium no Species

1113000-00350 Asparagus africanus Lam.

1113000-02200 Asparagus laricinus Burch.

1113000-03600 Asparagus setaceus (Kunth) Jessop

1113000-04300 Asparagus virgatus Baker

Family Asphodelaceae

Herbarium no Species

0985010-00000 Trachyandra species

0985010-00500 Trachyandra asperata

0989000-00000 Anthericum species

0990000-00450 Chlorophytum cooperi (Baker) Nordal

0990000-00655 Chlorophytum fasciculatum (Baker) Kativu

0990000-01630 Chlorophytum transvaalense (Baker) Kativu

0990000-01660 Chlorophytum trichophlebium (Baker) Nordal

1024000-01900 Kniphofia galpinii Baker

1026000-00800 Aloe arborescens Mill.

1026000-01500 Aloe boylei Baker

1026000-04900 Aloe ecklonis Salm-Dyck

1026000-06550 Aloe greatheadii Sch"nland var. davyana (Sch"nland) Glen &

1026000-09700 Aloe marlothii

1026000-10700 Aloe mutabilis Pillans

1026000-12500 Aloe pretoriensis Pole-Evans

1026000-15600 Aloe transvaalensis Kuntze

Family Commelinaceae

Herbarium no Species

0896000-00100 Commelina africana

0896000-00700 Commelina erecta L.

0904000-00300 Cyanotis lapidosa E.Phillips

0904000-00500 Cyanotis speciosa (L.f.) Hassk.

Family Cyperaceae

Herbarium no Species
0454000-00100 Ascolepis capensis (Kunth) Ridl.
0459000-01900 Cyperus esculentus
0459000-04000 Cyperus marginatus Thunb.
0459000-04600 Cyperus obtusiflorus
0459000-06370 Cyperus rupestris
0459030-00000 Mariscus species
0459030-00500 Mariscus congestus (Vahl) C.B.Clarke
0459030-02600 Mariscus rehmannianus C.B.Clarke
0462000-00200 Kyllinga alba Nees
0468010-00300 Schoenoplectus corymbosus (Roth ex Roem. & Schult.) J.Raynal
0471000-00600 Fimbristylis ferruginea (L.) Vahl
0471010-00400 Bulbostylis burchellii (Ficalho & Hiern) C.B.Clarke
0471020-00150 Abildgaardia ovata (Burm.f.) Kral
0512000-00300 Coleochloa setifera (Ridl.) Gilly

Family Dracaenaceae

Herbarium no Species
1110000-00200 Sansevieria hyacinthoides (L.) Druce

Family Hyacinthaceae

Herbarium no Species
1079000-00000 Albuca species
1086000-00000 Scilla species
1086000-02600 Scilla natalensis Planch.
1086000-02800 Scilla nervosa (Burch.) Jessop
1088000-00100 Eucomis autumnalis
1090010-00300 Ledebouria cooperi (Hook.f.) Jessop
1090010-01100 Ledebouria ovatifolia (Baker) Jessop
1090010-01200 Ledebouria revoluta (L.f.) Jessop

Family Hypoxidaceae

Herbarium no Species
1230000-00100 Hypoxis acuminata Baker
1230000-00300 Hypoxis argentea
1230000-01800 Hypoxis galpinii Baker
1230000-02100 Hypoxis hemerocallidea Fisch. & C.A.Mey.
1230000-02250 Hypoxis iridifolia Baker
1230000-04100 Hypoxis rigidula

Family Iridaceae

Herbarium no Species
1265000-06500 Moraea pubiflora N.E.Br.
1295000-04200 Aristea woodii N.E.Br.
1299000-00100 Schizostylis coccinea Backh. & Harv.
1303000-01400 Dierama medium N.E.Br.
1306010-00600 Crocosmia paniculata (Klatt) Goldblatt
1311000-03300 Gladiolus crassifolius Baker
1311000-03550 Gladiolus dalenii Van Geel
1311000-04000 Gladiolus ecklonii
1311000-04300 Gladiolus elliotii Baker
1311000-14100 Gladiolus woodii Baker
1314000-00000 Lapeirousia species
1315000-01100 Watsonia densiflora Baker

Family Orchidaceae

Herbarium no Species
1434000-00900 Disa cooperi Rchb.f.
1648000-02700 Eulophia ovalis

Family Poaceae

Herbarium no Species
9900100-00200 Ischaemum fasciculatum Brongn.
9900170-00100 Urelytrum agropyroides (Hack.) Hack.
9900210-00100 Hemarthria altissima (Poir.) Stapf & C.E.Hubb.
9900280-00100 Elionurus muticus (Spreng.) Kunth
9900370-00050 Imperata cylindrica (L.) Raeusch.
9900380-00500 Miscanthus junceus (Stapf) Pilg.
9900460-03700 Sorghum versicolor Andersson
9900530-00200 Eulalia villosa (Thunb.) Nees
9900630-00100 Bothriochloa bladhii (Retz.) S.T.Blake
9900630-00150 Bothriochloa insculpta (A.Rich.) A.Camus
9900680-00400 Schizachyrium sanguineum (Retz.) Alston
9900710-00000 Andropogon species
9900710-00200 Andropogon appendiculatus Nees
9900710-00350 Andropogon chinensis (Nees) Merr.
9900710-00500 Andropogon eucomus Nees
9900710-00900 Andropogon huillensis Rendle
9900710-01600 Andropogon schirensis A.Rich.
9900720-00200 Cymbopogon excavatus (Hochst.) Stapf ex Burtt Davy
9900720-00400 Cymbopogon plurinodis (Stapf) Stapf ex Burtt Davy
9900720-00600 Cymbopogon validus (Stapf) Stapf ex Burtt Davy
9900730-00100 Hyparrhenia anamesa Clayton
9900730-00200 Hyparrhenia collina (Pilg.) Stapf
9900730-00300 Hyparrhenia cymbaria (L.) Stapf
9900730-00400 Hyparrhenia dichroa (Steud.) Stapf
9900730-00500 Hyparrhenia dregeana (Nees) Stapf
9900730-00600 Hyparrhenia filipendula
9900730-01000 Hyparrhenia hirta (L.) Stapf
9900730-02100 Hyparrhenia tamba (Steud.) Stapf
9900731-00100 Hyperthelia dissoluta (Nees ex Steud.) Clayton
9900750-00100 Monocymbium ceresiiforme (Nees) Stapf
9900780-00100 Trachypogon spicatus (L.f.) Kuntze
9900800-00100 Heteropogon contortus (L.) Roem. & Schult.

9900810-00100 Diheteropogon amplectens (Nees) Clayton
9900810-00200 Diheteropogon filifolius (Nees) Clayton
9900830-00100 Themeda triandra Forssk.
9900890-00600 Digitaria brazzae (Franch.) Stapf
9900890-01000 Digitaria diagonalis
9900890-01400 Digitaria eriantha Steud.
9900890-01500 Digitaria eylesii C.E.Hubb.
9900890-02700 Digitaria monodactyla (Nees) Stapf
9900890-04100 Digitaria ternata (A.Rich.) Stapf
9900890-04400 Digitaria tricholaenoides Stapf
9900940-00200 Alloteropsis semialata
9901040-01300 Brachiaria nigropedata (Ficalho & Hiern) Stapf
9901040-01700 Brachiaria serrata (Thunb.) Stapf
9901070-00100 Paspalum dilatatum Poir.
9901070-00200 Paspalum notatum Fl gg,
9901070-00550 Paspalum scrobiculatum L.
9901070-00600 Paspalum urvillei Steud.
9901100-00500 Urochloa panicoides P.Beauv.
9901120-00100 Echinochloa colona (L.) Link
9901160-00800 Panicum coloratum
9901160-02800 Panicum maximum Jacq.
9901160-03100 Panicum natalense Hochst.
9901160-03900 Panicum schinzii Hack.
9901280-01200 Setaria lindenbergiana (Nees) Stapf
9901280-01350 Setaria megaphylla (Steud.) T.Durand & Schinz
9901280-01500 Setaria nigrirostris (Nees) T.Durand & Schinz
9901280-02455 Setaria sphacelata
9901280-03200 Setaria verticillata (L.) P.Beauv.
9901340-00250 Melinis nerviglumis (Franch.) Zizka
9901340-00275 Melinis repens
9901390-00300 Pennisetum clandestinum Chiov.
9901390-01300 Pennisetum sphacelatum (Nees) T.Durand & Schinz
9901590-00200 Leersia hexandra Sw.
9901730-00100 Arundinella nepalensis Trin.
9901740-00450 Tristachya leucothrix Nees
9901750-00100 Trichopteryx dregeana Nees
9901751-00300 Loudetia flavida (Stapf) C.E.Hubb.
9901751-00600 Loudetia simplex (Nees) C.E.Hubb.
9901970-01200 Helictotrichon turgidulum (Stapf) Schweick.
9902140-00100 Phragmites australis (Cav.) Steud.
9902430-00500 Agrostis eriantha
9902430-01050 Agrostis montevidensis Spreng. ex Nees
9902620-00050 Aristida adscensionis L.
9902620-00400 Aristida bipartita (Nees) Trin. & Rupr.
9902620-00800 Aristida congesta Roem. & Schult. ssp. barbicollis (Trin. & Rupr.) De Winter
9902620-00850 Aristida congesta Roem. & Schult. ssp. congesta
9902620-01200 Aristida diffusa
9902620-01900 Aristida junciformis
9902620-02750 Aristida scabrivalvis
9902620-03000 Aristida sciurus Stapf
9902620-03700 Aristida transvaalensis Henrard
9902740-00100 Tragus berteronianus Schult.
9902800-00200 Perotis patens Gand.
9902830-00200 Sporobolus africanus (Poir.) Robyns & Tournay
9902830-01400 Sporobolus fimbriatus (Trin.) Nees
9902830-01700 Sporobolus ioclados (Trin.) Nees
9902830-02170 Sporobolus natalensis (Steud.) T.Durand & Schinz
9902830-02500 Sporobolus pectinatus Hack.
9902830-02700 Sporobolus pyramidalis P.Beauv.
9902830-03300 Sporobolus stapfianus Gand.
9902860-00600 Eragrostis aspera (Jacq.) Nees
9902860-01200 Eragrostis biflora Hack. ex Schinz
9902860-01500 Eragrostis capensis (Thunb.) Trin.
9902860-01700 Eragrostis chloromelas Steud.
9902860-02300 Eragrostis curvula (Schrad.) Nees
9902860-03200 Eragrostis gummiflua Nees
9902860-03450 Eragrostis hierniana Rendle
9902860-05800 Eragrostis plana Nees
9902860-06500 Eragrostis pseudosclerantha Chiov.
9902860-06700 Eragrostis racemosa (Thunb.) Steud.
9902860-07500 Eragrostis sclerantha
9902860-08100 Eragrostis superba Peyr.
9902940-00100 Microchloa caffra Nees
9902960-00300 Cynodon dactylon (L.) Pers.
9902980-00100 Harpochloa falx (L.f.) Kuntze
9902990-00100 Ctenium concinnum Nees
9903010-00200 Chloris gayana Kunth
9903010-00250 Chloris mossambicensis K.Schum.
9903010-00600 Chloris virgata Sw.
9903020-00200 Eustachys paspaloides (Vahl) Lanza & Mattei
9903310-00150 Eleusine coracana
9903340-00300 Pogonarthria squarrosa (Roem. & Schult.) Pilg.
9903442-00100 Bewsia biflora (Hack.) Gooss.
9904280-00050 Bromus catharticus Vahl

Family Typhaceae

Herbarium no Species
0049000-00020 Typha capensis (Rohrb.) N.E.Br.

Family Velloziaceae

Herbarium no Species

1247010-00400 Xerophyta retinervis Baker

1247010-00800 Xerophyta viscosa Bake

Taxon 3. Dicotyledonae

Family Acanthaceae

Herbarium no Species

7914000-00400 Thunbergia atriplicifolia E.Mey. ex Nees

7914000-01150 Thunbergia neglecta Sond.

7941000-00100 Chaetacanthus burchellii Nees

7941000-00200 Chaetacanthus costatus Nees

7941000-00300 Chaetacanthus setiger (Pers.) Lindl.

7965000-00800 Ruellia patula Jacq.

7972000-00100 Crabbea acaulis N.E.Br.

7972000-00200 Crabbea angustifolia Nees

7972000-00300 Crabbea hirsuta Harv.

7973000-01500 Barleria gueinzii Sond.

7973000-03200 Barleria obtusa Nees

7985000-00200 Crossandra greenstockii S.Moore

8094000-00100 Justicia anagalloides (Nees) T.Anderson

8094000-00300 Justicia betonica L.

Family Aizoaceae

Herbarium no Species

2376000-02700 Limeum viscosum

2379000-00900 Psammotropha myriantha Sond.

Family Amaranthaceae

Herbarium no Species

2299000-00720 Amaranthus hybridus

2314000-00200 Pupalia lappacea

2328000-00100 Achyranthes aspera

2338000-00100 Gomphrena celosioides Mart.

Family Anacardiaceae

Herbarium no Species

4558000-00100 Sclerocarya birrea (A.Rich.) Hochst. ssp. caffra (Sond.) Kokwaro

4563000-00100 Lannea discolor (Sond.) Engl.

4589010-01100 Ozoroa paniculosa

4589010-01500 Ozoroa sphaerocarpa R.& A.Fern.

4594000-00800 Rhus chirindensis Baker f.

4594000-01500 Rhus dentata Thunb.

4594000-01700 Rhus discolor E.Mey. ex Sond.

4594000-02950 Rhus gerrardii (Harv. ex Engl.) Sch"nland

4594000-03900 Rhus lancea L.f.

4594000-04250 Rhus magalismontana

4594000-05300 Rhus pentheri Zahlbr.

4594000-05400 Rhus pondoensis Sch"nland

4594000-05570 Rhus pyroides

4594000-05950 Rhus rehmanniana

4594000-06040 Rhus rigida

Family Annonaceae

Herbarium no Species

2729000-00100 Annona senegalensis

Family Apiaceae

Herbarium no Species

5894000-00000 Centella species

5922000-01900 Alepidea longifolia

5922000-02900 Alepidea setifera N.E.Br.

6038000-00100 Sium repandum Welw. ex Hiern

6038010-00100 Berula erecta (Huds.) Coville

6116000-01700 Peucedanum magalismontanum Sond.

Family Apocynaceae

Herbarium no Species

6558000-00300 Acokanthera rotundata (Codd) Kupicha

6559000-00200 Carissa bispinosa

Family Araliaceae

Herbarium no Species

5872000-00400 Cussonia paniculata

5872000-00600 Cussonia spicata Thunb.

Family Asclepiadaceae

Herbarium no Species

6777000-01500 Xysmalobium undulatum (L.) Aiton f.

6778010-01500 Aspidoglossum lamellatum (Schltr.) Kupicha

6787000-00600 Gomphocarpus fruticosus (L.) Aiton f.

6787010-00000 Pachycarpus species

6787010-02700 Pachycarpus schinzianus (Schltr.) N.E.Br.

6791000-00000 Asclepias species

6791000-00200 Asclepias affinis (Schltr.) Schltr.

6791000-00700 Asclepias brevipes (Schltr.) Schltr.

6849000-00100 Sarcostemma viminale (L.) R.Br.

Family Asteraceae

Herbarium no Species

8751000-01550 Vernonia galpinii Klatt

8751000-02000 Vernonia hirsuta (DC.) Sch.Bip. ex Walp.

8751000-02400 Vernonia natalensis Sch.Bip. ex Walp.

8751000-03000 Vernonia oligocephala (DC.) Sch.Bip. ex Walp.

8751000-03075 Vernonia poskeana

8751000-03700 Vernonia staehelinoides Harv.

8751000-03900 Vernonia sutherlandii Harv.

8900000-00300 Aster bakeranus Burtt Davy ex C.A.Sm.

8900000-01400 Aster harveyanus Kuntze

8900000-02000 Aster peglerae Bolus

8900000-02500 Aster squamatus (Spreng.) Hieron.

8919000-06800 Felicia muricata

8925000-00100 Nidorella anomala Steetz
8925000-00800 Nidorella hottentotica DC.
8926000-00125 Conyza albida Spreng.
8926000-00300 Conyza bonariensis (L.) Cronquist
8926000-00400 Conyza canadensis (L.) Cronquist
8926000-01200 Conyza obscura DC.
8926000-01600 Conyza podocephala DC.
8926000-01625 Conyza scabrida DC.
8937000-00100 Tarchonanthus camphoratus L.
9006000-01870 Helichrysum aureonitens Sch.Bip.
9006000-02870 Helichrysum cephaloideum DC.
9006000-03000 Helichrysum chionosphaerum DC.
9006000-03700 Helichrysum coriaceum Harv.
9006000-04300 Helichrysum dasycephalum O.Hoffm.
9006000-07625 Helichrysum harveyanum Wild
9006000-08100 Helichrysum hypoleucum Harv.
9006000-08235 Helichrysum indicum (L.) Grierson
9006000-08500 Helichrysum kraussii Sch.Bip.
9006000-10850 Helichrysum melanacme DC.
9006000-12100 Helichrysum nudifolium (L.) Less.
9006000-13370 Helichrysum pallidum DC.
9006000-14130 Helichrysum pilosellum (L.f.) Less.
9006000-15900 Helichrysum rugulosum Less.
9006000-16900 Helichrysum setosum Harv.
9006000-21200 Helichrysum zeyheri Less.
9037000-03300 Stoebe vulgaris Levyns
9055000-00000 Athrixia species
9055000-00500 Athrixia elata Sond.
9055000-00900 Athrixia phylicoides DC.
9090000-00700 Geigeria burkei
9094000-00600 Callilepis leptophylla Harv.
9130000-00100 Acanthospermum australe (Loefl.) Kuntze
9148000-00200 Xanthium strumarium L.
9155000-00200 Zinnia peruviana (L.) L.
9237000-00100 Bidens bipinnata L.
9237000-00300 Bidens formosa (Bonato) Sch.Bip.
9237000-00500 Bidens pilosa L.
9291000-00100 Schkuhria pinnata (Lam.) Cabrera
9311000-00200 Tagetes minuta L.
9336000-00210 Phymaspermum athanasioides (S.Moore) K„llersj"
9341050-00100 Adenanthellum osmitoides (Harv.) B.Nord.
9356000-00200 Schistostephium crataegifolium (DC.) Fenzl ex Harv.
9356000-00600 Schistostephium heptalobum (DC.) Oliv. & Hiern
9358000-00300 Artemisia afra Jacq. ex Willd.
9401000-00900 Lopholaena segmentata (Oliv.) S.Moore
9411000-00000 Senecio species
9411000-00500 Senecio achilleifolius DC.
9411000-01000 Senecio affinis DC.
9411000-02900 Senecio barbertonicus Klatt
9411000-06000 Senecio consanguineus DC.
9411000-06300 Senecio coronatus (Thunb.) Harv.
9411000-09100 Senecio erubescens
9411000-13100 Senecio inaequidens DC.
9411000-13700 Senecio isatideus DC.
9411000-18300 Senecio oliganthus DC.
9411000-18800 Senecio oxyriifolius DC.
9411000-27500 Senecio venosus Harv.
9417000-09100 Euryops transvaalensis
9425000-00620 Dimorphotheca spectabilis Schltr.
9427020-00100 Chrysanthemoides monilifera
9432030-00200 Haplocarpha lyrata Harv.
9432030-00500 Haplocarpha scaposa Harv.
9434000-00600 Gazania krebsiana
9438000-01900 Berkheya carlinopsis
9438000-03300 Berkheya echinacea
9438000-06500 Berkheya radula (Harv.) De Wild.
9438000-07500 Berkheya seminivea Harv. & Sond.
9438000-07600 Berkheya setifera DC.
9438000-07700 Berkheya speciosa
9438000-09200 Berkheya zeyheri
9462000-00200 Cirsium vulgare (Savi) Ten.
9501000-00100 Dicoma anomala Sond.
9501000-02650 Dicoma zeyheri
9528000-00100 Gerbera ambigua (Cass.) Sch.Bip.
9528000-00900 Gerbera jamesonii Bolus ex Adlam
9528000-01250 Gerbera piloselloides (L.) Cass.
9572000-00400 Hypochaeris radicata L.
9595000-00300 Sonchus dregeanus DC.
9595000-00900 Sonchus nanus Sond. ex Harv.
9595000-01000 Sonchus oleraceus L.
9595000-01200 Sonchus wilmsii R.E.Fr.
9596000-00310 Lactuca inermis Forssk.
9605000-00200 Crepis hypochoeridea (DC.) Thell.

Family Boraginaceae

Herbarium no Species
7043000-00200 Ehretia rigida (Thunb.) Druce
7064000-00350 Cynoglossum hispidum Thunb.

Family Brassicaceae

Herbarium no Species
2883000-00100 Lepidium africanum

Family Campanulaceae

Herbarium no Species
8668000-00000 Wahlenbergia species
8668000-13100 Wahlenbergia undulata (L.f.) A.DC.

Family Capparaceae

Herbarium no Species

3082000-01600 Cleome monophylla L.

Family Caryophyllaceae

Herbarium no Species

2455000-00100 Polycarpaea corymbosa (L.) Lam.

2490000-00050 Silene bellidioides Sond.

2490000-00070 Silene burchellii

2502000-01400 Dianthus mooiensis

Family Celastraceae

Herbarium no Species

4626000-00100 Maytenus acuminata

4626000-00400 Maytenus heterophylla (Eckl. & Zeyh.) N.Robson

4626000-01600 Maytenus senegalensis (Lam.) Exell

4626000-01800 Maytenus undata (Thunb.) Blakelock

Family Chrysobalanaceae

Herbarium no Species

3405000-00100 Parinari capensis

Family Clusiaceae

Herbarium no Species

5168000-00100 Hypericum aethiopicum

5168000-00400 Hypericum lalandii Choisy

Family Combretaceae

Herbarium no Species

5538000-00200 Combretum apiculatum

5538000-01400 Combretum erythrophyllum (Burch.) Sond.

5538000-02100 Combretum molle R.Br. ex G.Don

5538000-03200 Combretum zeyheri Sond.

Family Convolvulaceae

Herbarium no Species

6973000-00100 Evolvulus alsinoides

6993000-01800 Convolvulus sagittatus Thunb. ssp. sagittatus var. hirtellus (Hallier f.) A.Meeuse

7003000-00200 Ipomoea alba L.

7003000-00800 Ipomoea bathycolpos

7003000-01700 Ipomoea crassipes Hook.

7003000-03500 Ipomoea ommaneyi Rendle

7008010-00100 Turbina oblongata (E.Mey. ex Choisy) A.Meeuse

Family Crassulaceae

Herbarium no Species

3166000-02100 Kalanchoe paniculata Harv.

3166000-02700 Kalanchoe rotundifolia (Haw.) Haw.

3168000-00300 Crassula alba

3168000-15950 Crassula lanceolata

3168000-30955 Crassula swaziensis Sch"nland

3168000-33500 Crassula vaginata

Family Cucurbitaceae

Herbarium no Species

8599000-01600 Cucumis zeyheri Sond.

Family Dipsacaceae

Herbarium no Species

8546000-00600 Scabiosa columbaria L.

Family Ebenaceae

Herbarium no Species

6404000-00400 Euclea crispa

6404000-00600 Euclea divinorum Hiern

6404000-00920 Euclea natalensis

6404000-01300 Euclea schimperi

6404000-01600 Euclea undulata

6406000-00200 Diospyros austro-africana

6406000-00900 Diospyros galpinii (Hiern) De Winter

6406000-01300 Diospyros lycioides

6406000-01800 Diospyros natalensis

6406000-02900 Diospyros whyteana (Hiern) F.White

Family Ericaceae

Herbarium no Species

6237000-00000 Erica species

Family Euphorbiaceae

Herbarium no Species

4299000-02100 Phyllanthus parvulus Sond.

4345000-00500 Bridelia mollis Hutch.

4348000-00200 Croton gratissimus

4407000-00150 Acalypha angustata Sond.

4407000-00300 Acalypha capensis (L.f.) Prain & Hutch.

4407000-01600 Acalypha peduncularis E.Mey. ex Meisn.

4407000-01900 Acalypha punctata

4448000-00900 Clutia cordata Bernh. ex C.Krauss

4448000-02300 Clutia monticola S.Moore

4448000-03200 Clutia pulchella

4498000-04300 Euphorbia clavarioides

4498000-06250 Euphorbia damarana L.C.Leach

4498000-13900 Euphorbia ingens E.Mey. ex Boiss.

4498000-22100 Euphorbia pulvinata Marloth

4498000-24800 Euphorbia striata

Family Fabaceae

Herbarium no Species

3446000-90300 Acacia ataxacantha DC.

3446000-90700 Acacia caffra (Thunb.) Willd.

3446000-90800 Acacia davyi N.E.Br.

3446000-92300 Acacia karroo Hayne

3446000-92850 Acacia mearnsii De Wild.

3446000-93400 Acacia nilotica

3446000-94000 Acacia robusta

3446000-94400 Acacia senegal
3446000-94600 Acacia sieberiana
3452000-00100 Dichrostachys cinerea
3467000-00100 Elephantorrhiza burkei Benth.
3467000-00200 Elephantorrhiza elephantina (Burch.) Skeels
3528000-00200 Bauhinia galpinii N.E.Br.
3536010-00200 Chamaecrista biensis (Steyaert) Lock
3536010-00500 Chamaecrista comosa
3536010-00800 Chamaecrista mimosoides (L.) Greene
3561000-00100 Peltophorum africanum Sond.
3607010-00200 Bolusanthus speciosus (Bolus) Harms
3657000-01800 Lotononis calycina (E.Mey.) Benth.
3657000-03250 Lotononis dissitinodis B.-E.van Wyk
3657000-03400 Lotononis eriantha Benth.
3657000-03800 Lotononis foliosa Bolus
3657010-00850 Pearsonia sessilifolia
3673000-02400 Argyrolobium pauciflorum
3673000-04200 Argyrolobium wilmsii Harms
3690000-00100 Trifolium africanum
3702000-03800 Indigofera comosa N.E.Br.
3702000-04700 Indigofera cryptantha Benth. ex Harv. var. cryptantha
3702000-08300 Indigofera filipes Benth. ex Harv.
3702000-10500 Indigofera hedyantha Eckl. & Zeyh.
3702000-10800 Indigofera hilaris Eckl. & Zeyh.
3718000-01000 Tephrosia capensis
3718000-04400 Tephrosia longipes
3718000-04650 Tephrosia macropoda
3718000-05100 Tephrosia multijuga R.G.N.Young
3719000-00100 Mundulea sericea (Willd.) A.Chev.
3747000-00000 Sesbania species
3747000-01200 Sesbania punicea (Cav.) Benth.
3804000-00300 Zornia linearis E.Mey.
3804000-00400 Zornia milneana Mohlenbr.
3808000-00100 Pseudarthria hookeri
3810000-00200 Alysicarpus rugosus
3870000-00900 Erythrina lysistemon Hutch.
3870000-01100 Erythrina zeyheri Harv.
3897000-00000 Rhynchosia species
3897000-01300 Rhynchosia caribaea (Jacq.) DC.
3897000-04400 Rhynchosia monophylla Schltr.
3897000-04700 Rhynchosia nitens Benth.
3897000-05700 Rhynchosia reptabunda N.E.Br.
3897000-07000 Rhynchosia totta
3898000-00000 Eriosema species
3898000-00300 Eriosema burkei Benth.
3898000-00400 Eriosema cordatum E.Mey.
3898000-00900 Eriosema kraussianum Meisn.
3898000-01600 Eriosema salignum E.Mey.
3907000-00100 Sphenostylis angustifolia Sond.

Family Flacourtiaceae

Herbarium no Species
5304000-00000 Scolopia species
5304000-00200 Scolopia mundii (Eckl. & Zeyh.) Warb.
5304000-00500 Scolopia zeyheri (Nees) Harv.
5328000-00000 Dovyalis species
5328000-00700 Dovyalis zeyheri (Sond.) Warb.

Family Gentianaceae

Herbarium no Species
6481000-01700 Sebaea grandis (E.Mey.) Steud.
6481000-02200 Sebaea leiostyla Gilg
6503000-01200 Chironia palustris
6503000-01700 Chironia purpurascens

Family Geraniaceae

Herbarium no Species
3925000-00200 Monsonia angustifolia E.Mey. ex A.Rich.
3925000-00300 Monsonia attenuata Harv.
3928000-00200 Pelargonium acetosum (L.) L'H,r.
3928000-09700 Pelargonium luridum (Andrews) Sweet

Family Gesneriaceae

Herbarium no Species
7823000-04800 Streptocarpus vandeleurii Baker f. & S.Moore

Family Greyiaceae

Herbarium no Species
4855000-00300 Greyia sutherlandii Hook. & Harv.

Family Haloragaceae

Herbarium no Species
5836000-00100 Gunnera perpensa L.

Family Illecebraceae

Herbarium no Species
2467000-00100 Pollichia campestris Aiton

Family Lamiaceae

Herbarium no Species
7212000-00200 Teucrium trifidum Retz.
7236000-00300 Acrotome hispida Benth.
7264000-01620 Leonotis ocymifolia (Burm.f.) Iwarsson var. raineriana (Vis.)
7264000-01630 Leonotis ocymifolia (Burm.f.) Iwarsson var. schinzii (G rke)
7281000-02500 Stachys natalensis
7290000-02300 Salvia runcinata L.f.
7328000-00100 Mentha aquatica L.
7339000-00400 Tetradenia riparia (Hochst.) Codd
7350000-01600 Plectranthus hereroensis Engl.
7350000-01880 Plectranthus madagascariensis
7350030-00100 Rabdosiella calycina (Benth.) Codd

7359000-00200 Syncolostemon concinnus N.E.Br.
7365000-01420 Hemizygia macrophylla (G rke) Codd
7365000-01950 Hemizygia pretoriae
7366010-00400 Becium obovatum (E.Mey. ex Benth.) N.E.Br. ssp. obovatum var. obovatum

Family Lobeliaceae

Herbarium no Species
8681000-01600 Cyphia elata Harv. var. elata
8694000-00550 Lobelia angolensis Engl. & Diels
8694000-02800 Lobelia erinus L.
8695000-00525 Monopsis decipiens (Sond.) Thulin

Family Loganiaceae

Herbarium no Species
6460000-00400 Strychnos madagascariensis Poir.
6473000-00700 Buddleja salviifolia (L.) Lam.

Family Malpighiaceae

Herbarium no Species
4219000-00450 Sphedamnocarpus pruriens

Family Malvaceae

Herbarium no Species
4998000-00250 Sida alba L.
4998000-00400 Sida cordifolia L.
4998000-00900 Sida rhombifolia L.
5007000-00100 Pavonia burchellii (DC.) R.A.Dyer
5013000-00100 Hibiscus aethiopicus
5013000-02200 Hibiscus engleri K.Schum.
5013000-02800 Hibiscus lunarifolius Willd.
5013000-05300 Hibiscus trionum L.

Family Meliaceae

Herbarium no Species
4175000-00100 Melia azedarach L.
4195000-00100 Trichilia dregeana Sond.

Family Mesembryanthemaceae

Herbarium no Species
2405033-07300 Delosperma herbeum (N.E.Br.) N.E.Br.

Family Moraceae

Herbarium no Species
1961000-00050 Ficus abutilifolia (Miq.) Miq.
1961000-00700 Ficus cordata
1961000-01000 Ficus glumosa (Miq.) Delile
1961000-01200 Ficus ingens
1961000-02450 Ficus thonningii Blume

Family Myrsinaceae

Herbarium no Species
6313000-00100 Myrsine africana L.

Family Myrtaceae

Herbarium no Species
5559000-00200 Psidium guajava L.
5583000-00100 Syzygium cordatum Hochst.
5588010-00400 Heteropyxis natalensis Harv.

Family Ochnaceae

Herbarium no Species
5112000-00450 Ochna gamostigmata Du Toit

Family Olacaceae

Herbarium no Species
2136000-00300 Ximenia caffra

Family Oleaceae

Herbarium no Species
6422000-00100 Schrebera alata (Hochst.) Welw.
6434000-00200 Olea capensis
6438000-00100 Menodora africana Hook.

Family Onagraceae

Herbarium no Species
5804000-00900 Oenothera rosea L'H,r. ex Aiton
5804000-01100 Oenothera tetraptera Cav.

Family Oxalidaceae

Herbarium no Species
3936000-05300 Oxalis depressa Eckl. & Zeyh.
3936000-18300 Oxalis purpurea L.

Family Pedaliaceae

Herbarium no Species
7778000-00500 Ceratotheca triloba (Bernh.) Hook.f.
7780000-00100 Dicerocaryum eriocarpum (Decne.) Abels

Family Periplocaceae

Herbarium no Species
6747000-00000 Raphionacme species
6747000-00100 Raphionacme burkei N.E.Br.
6747000-00500 Raphionacme galpinii Schltr.

Family Plantaginaceae

Herbarium no Species
8116000-00400 Plantago lanceolata L.
8116000-00500 Plantago longissima Decne.

Family Polygalaceae

Herbarium no Species
4273000-02900 Polygala hottentotta C.Presl
4273000-07300 Polygala uncinata E.Mey. ex Meisn.

Family Polygonaceae

Herbarium no Species
2201030-00200 Persicaria attenuata (R.Br.) Soj k ssp. africana K.L.Wilson
2201030-00600 Persicaria lapathifolia (L.) Gray
2201030-01200 Persicaria serrulata (Lag.) Webb & Moq.

2204000-00400 Oxygonum dregeanum

Family Proteaceae

Herbarium no Species

2034000-00300 Faurea saligna Harv.

2034000-00400 Faurea speciosa (Welw.) Welw.

2035000-01200 Protea caffra

Family Ptaeroxylaceae

Herbarium no Species

4157000-00100 Ptaeroxylon obliquum (Thunb.) Radlk.

Family Ranunculaceae

Herbarium no Species

2541010-00670 Knowltonia transvaalensis

2542000-00100 Clematis brachiata Thunb.

Family Rhamnaceae

Herbarium no Species

4861000-00100 Ziziphus mucronata

4875000-00100 Rhamnus prinoides L'H,r.

Family Rosaceae

Herbarium no Species

3333010-00200 Pyracantha coccinea M.Roem.

3353000-01300 Rubus rigidus Sm.

3379000-00100 Leucosidea sericea Eckl. & Zeyh.

3388000-05800 Cliffortia linearifolia Eckl. & Zeyh.

3388000-06700 Cliffortia nitidula

Family Rubiaceae

Herbarium no Species

8136060-00100 Kohautia amatymbica Eckl. & Zeyh.

8136060-00800 Kohautia cynanchica DC.

8136200-00700 Oldenlandia herbacea

8230000-00100 Cephalanthus natalensis Oliv.

8285040-00100 Hyperacanthus amoenus (Sims) Bridson

8348000-00100 Pentanisia angustifolia (Hochst.) Hochst.

8348000-00220 Pentanisia prunelloides

8351000-00200 Vangueria cyanescens Robyns

8351000-00400 Vangueria infausta

8351020-00100 Pygmaeothamnus chamaedendrum

8383000-01800 Pavetta edentula Sond.

8383000-02030 Pavetta gardeniifolia

8399000-00100 Psychotria capensis

8438000-01770 Anthospermum rigidum

8438000-01990 Anthospermum streyi Puff

8464000-00100 Richardia brasiliensis Gomes

8475000-00100 Spermacoce natalensis Hochst.

Family Rutaceae

Herbarium no Species

3991000-00100 Zanthoxylum capense (Thunb.) Harv.

Family Salicaceae

Herbarium no Species

1873000-00000 Salix species

1873000-00100 Salix babylonica L.

1873000-00570 Salix mucronata

1873000-00600 Salix mucronata Thunb. ssp. mucronata

Family Santalaceae

Herbarium no Species

2118000-00000 Thesium species

Family Sapindaceae

Herbarium no Species

4784000-00100 Pappea capensis Eckl. & Zeyh.

Family Sapotaceae

Herbarium no Species

6377020-00100 Englerophytum magalismontanum (Sond.) T.D.Penn.

Family Scrophulariaceae

Herbarium no Species

7493000-00200 Halleria lucida L.

7517000-02850 Manulea parviflora

7519000-02500 Sutera caerulea (L.f.) Hiem

7519000-08300 Sutera pallescens Hiem

7519010-01400 Jamesbrittenia aurantiaca (Burch.) Hilliard

7523000-02100 Zaluzianskya maritima (L.f.) Walp.

7558000-00600 Limosella maior Diels

Family Selaginaceae

Herbarium no Species

7568010-03000 Walafrida tenuifolia Rolfe

7568040-00400 Tetraselago wilmsii (Rolfe) Hilliard & B.L.Burtt

7616000-00100 Sopubia cana

7625000-00100 Striga asiatica (L.) Kuntze

7625000-00300 Striga bilabiata (Thunb.) Kuntze

7625000-00450 Striga elegans Benth.

Family Solanaceae

Herbarium no Species

7407000-02300 Solanum elaeagnifolium Cav.

7407000-02700 Solanum giganteum Jacq.

7407000-04000 Solanum mauritianum Scop.

7407000-04900 Solanum panduriforme E.Mey.

7407000-05300 Solanum retroflexum Dunal

7407000-06000 Solanum sisymbrifolium Lam.

7415000-00600 Datura stramonium L.

Family Sterculiaceae

Herbarium no Species

5053000-00300 Dombeya cymosa Harv.

5053000-00600 Dombeya rotundifolia

5056000-07100 Hermannia depressa N.E.Br.

5056000-20500 Hermannia odorata Aiton

5056000-28700 Hermannia transvaalensis Schinz

5059000-00100 Waltheria indica L.

Family Thymelaeaceae

Herbarium no Species

5435000-00250 Gnidia burchellii (Meisn.) Gilg

5435000-00320 Gnidia caffra (Meisn.) Gilg

5435000-00500 Gnidia capitata L.f.

5435000-02700 Gnidia kraussiana

5435000-05850 Gnidia sericocephala (Meisn.) Gilg ex Engl.

5465000-00100 Dais cotinifolia L.

Family Tiliaceae

Herbarium no Species

4953000-00400 Corchorus confusus Wild

4966000-01700 Grewia occidentalis L.

4975000-01100 Triumfetta sonderi Ficalho & Hiern

Family Ulmaceae

Herbarium no Species

1898000-00100 Celtis africana Burm.f.

Family Verbenaceae

Herbarium no Species

7138000-00100 Verbena bonariensis L.

7138000-00200 Verbena brasiliensis Vell.

7138000-00500 Verbena venosa Gillies & Hook.

7144000-00200 Lantana camara L.

7144000-00600 Lantana rugosa Thunb.

7145000-00100 Lippia javanica (Burm.f.) Spreng.

7145000-00500 Lippia scaberrima Sond.

7186000-00620 Vitex obovata E.Mey. ssp. wilmsii (G rke) C.L.Bredenkamp &

7191000-00800 Clerodendrum glabrum

7191000-01700 Clerodendrum triphyllum

Family Vitaceae

Herbarium no Species

4917000-00550 Rhoicissus tridentata

4918010-01400 Cyphostemma humile

4918010-01800 Cyphostemma lanigerum (Harv.) Desc. ex Wild & R.B.Drumm.

4918010-03300 Cyphostemma sulcatum (C.A.Sm.) J.J.M.van der Mer

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APPENDIX A

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Weather station: Volksrust

Number: 0406682B0

Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	27	22	27.3666666666667
	Longitude (E):	29	53	29.8833333333333

Height above sea level (m) [H]: 1652

Period: 1961 - 1990

Observation duration in years (°C - mm): 27 - 24

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	8.5	8							
August	11.1	25							
September	14.9	39							
October	16.4	79							
November	17.8	123							
December	19.3	123							
January	19.5	151							
February	18.7	100							
March	17.8	63							
April	14.6	41							
May	11.4	12							
June	8.3	11							
Mean annual temperature (°C)	21.7								
Mean annual precipitation (mm) [maP]		775							

Mean daily minimum, coldest month (°C)	0.5
Lowest temperature recorded (°C)	-9.7
Mean daily maximum, warmest month (°C)	25.5
Highest temperature recorded (°C)	36
Mean daily temperature variations	13.6
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [Ab]	178.3
Mean annual potenial evapotranspiration (mm) [maEp]	0
Mean annual biotemperature (°C) [maB]	14.858333333333
Standard of humidity (maEp/maP)	0
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000X6)]	24.770333333333
Latitudinal region	Tropical
maB at sea level	24-30
Altitudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	
Standard of humidity range	
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	
Associated vegetation	
Genetic climate classification based on	Air masses and frontal zones
Climate group	Low-latitude
Dominant air masses	Maritime tropical or continental tropical
Climate type	Wet-dry tropical
Latitude range	5-20° N and S
Applied climate classification based on (Macro climate)	Soil-water balance
Climate type	
Water shortage (D) >=	
Mean annual evapotranspiration [maEp] >=	
Climate sub-type	
Water storage [S=+G] in any months >	

Weather station:	Piet Retief			
Number:	0444570 6			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	27	2	27.0333333333333
	Longitude (E):	30	48	30.8
Height above sea level (m) [H]:	1253			
Period:	1961 - 1990			
Observation duration in years (°C - mm):	29 - 25			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	11.8	14	51.1	(37.1)	0.0		102.9	51.9	1.36027982899
August	13.7	20	63.9	(43.9)	0.0		124.6	60.8	1.60487883165
September	16.3	44	72.8	(28.6)	0.0		137.4	64.6	3.20232896652
October	17.4	104	79.6		24.4		143.8	64.2	7.23025583962
November	18.6	135	78.2		56.9		142.5	64.4	9.47368421053
December	20.1	149	88.5		36.4	24.1	153.5	65.0	9.71000325839
January	20.6	160	83.1		0.0	77.0	160.0	76.9	10.0025006252
February	20.2	97	72.8		0.0	24.2	137.8	65.0	7.0412311256
March	19.5	77	73.8		0.0	3.2	142.0	68.2	5.42329905621
April	16.8	60	57.1		0.0	3.0	123.0	66.0	4.87804878049
May	14.2	19	51.2	(32.2)	0.0		113.8	62.6	1.67003603762
June	11.3	13	43.6	(30.6)	0.0		97.2	53.6	1.33744855967
Mean annual temperature (°C)	18.7		815.4	(117.7)	117.7	131.4	1,578.4	763.0	62.9339951216
Mean annual precipitation (mm) [maP]		892							

Mean daily minimum, coldest month (°C)	3.7
Lowest temperature recorded (°C)	-4.9
Mean daily maximum, warmest month (°C)	26.1
Highest temperature recorded (°C)	36.5
Mean daily temperature variations	12.9
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [Ab]	200.5
Mean annual potenial evapotranspiration (mm) [maEp]	1578.4
Mean annual biotemperature (°C) [maB]	18.7083333333333
Standard of humidity (maEp/maP)	1.7695067264574
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	24.2263333333333
Latitudinal region	Tropical
maB at sea level	24-30
Altitudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	Subhumid
Standard of humidity range	1-2
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	Subhumid
Associated vegetation	Grassland
Genetic climate classification based on	Air masses and frontal zones
Climate group	Midlatitude
Dominant air masses	tropical or polar
Climate type	Dry subtropical
Latitude range	25-35° N and S
Applied climate classification based on (Macro climate)	Soil-water balance
Climate type	Wet - dry tropical
Water shortage (D) >=	200 mm
Mean annual evapotranspiration [maEp] >=	1300 mm
Climate sub-type	
Minimum monthly water storage [S=+G] <	30 mm

	Sun latitude	Sun altitude - noon
June	23.5	39.5
September	0	62.9
December	-23.5	86.5
March	0	62.9

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Weather station: Makatini

Number: 0411323 2

Geographical reference:

Units	Degree	Minute	Dec degree
Latitude (S)	27	23	27.383333333333
Longitude (E):	32	11	32.183333333333

Height above sea level (m) [H]: 73

Period: 1966 - 1990

Observation duration in years (°C - mm): 24 - 23

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	17.1	12							
August	19	15							
September	21.3	43							
October	22.6	59							
November	23.9	77							
December	25.7	83							
January	26.7	102							
February	26	112							
March	25.3	78							
April	22.8	42							
May	20	24							
June	16.9	14							
Mean annual temperature (°C)	22.3								
Mean annual precipitation (mm) [maP]		661							

Mean daily minimum, coldest month (°C)	8.7
Lowest temperature recorded (°C)	0.1
Mean daily maximum, warmest month (°C)	32.2
Highest temperature recorded (°C)	44.2
Mean daily temperature variations	12.7
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [Ab]	267.3
Mean annual potenial evapotranspiration (mm) [maEp]	
Mean annual biotemperature (°C) [maB]	22.275
Standard of humidity (maEp/maP)	
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	22.713
Latitudinal region	Subtropical
maB at sea level	18-24
Altitudinal belt	Premontane
Mean annual biotemperature range	18-24
Humidity province	
Standard of humidity range	
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	
Associated vegetation	
Genetic climate classification based on	Air masses and frontal zones
Climate group	Low-latitude
Dominant air masses	maritime tropical or continental tropical
Climate type	Wet-dry tropical
Latitude range	5-20° N and S
Applied climate classification based on (Macro climate)	Soil-water balance
Climate type	
Water shortage (D) >=	
Mean annual evapotranspiration [maEp] >=	
Climate sub-type	
Water storage [S=+G] in any months >	

Weather station:	Belfast			
Number:	0517039 X			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	25	39	25.65
	Longitude (E):	30	2	30.0333333333333
Height above sea level (m) [H]:	1950			
Period:	1961 - 1990			
Observation duration in years (°C - mm):	29 - 25			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	8.6	5							
August	10.8	9							
September	14	33							
October	14.9	93							
November	15.7	156							
December	16.8	152							
January	17.3	170							
February	17	101							
March	16.1	83							
April	13.7	53							
May	11.1	16							
June	8.3	7							
Mean annual temperature (°C)	13.7								
Mean annual precipitation (mm) [maP]		878							

Mean daily minimum, coldest month (°C)	1.2
Lowest temperature recorded (°C)	-6
Mean daily maximum, warmest month (°C)	22.9
Highest temperature recorded (°C)	32.2
Mean daily temperature variations	12.9
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [Ab]	164.3
Mean annual potenial evapotranspiration (mm) [maEp]	
Mean annual biotemperature (°C) [maB]	13.6916666666667
Standard of humidity (maEp/maP)	
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	25.3916666666667
Latitudinal region	Tropical
maB at sea level	24-30
Altitudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	
Standard of humidity range	
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	**Precipitation**
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	**Precipitation & Temperature**
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	
Associated vegetation	
Genetic climate classification based on	**Air masses and frontal zones**
Climate group	Low-latitude
Dominant air masses	maritime tropical or continental tropical
Climate type	Wet-dry tropical
Latitude range	5-20° N and S
Applied climate classification based on (Macro climate)	**Soil-water balance**
Climate type	
Water shortage (D) >=	
Mean annual evapotranspiration [maEp] >=	
Climate sub-type	
Water storage [S=+G] in any months >	

Weather station:	Barberton			
Number:	0519017 4			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	25	47	25.7833333333
	Longitude (E):	31	1	31.01666666667
Height above sea level (m) [H]:	772			
Period:	1961-73 & 1986 - 88			
Observation duration in years (°C - mm):	13 - 13			

Months	Mean monthly temperature (°C)		Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	14.3		7							
August	16.6		15							
September	19.3		28							
October	20.6		83							
November	21.5		109							
December	23.2		133							
January	23.9		104							
February	23.7		96							
March	22.6		89							
April	20.2		51							
May	16.9		14							
June	13.9		9							
Mean annual temperature (°C)	19.7									
Mean annual precipitation (mm) [maP]			738							
Mean daily minimum, coldest month (°C)		5.2								
Lowest temperature recorded (°C)		-2.7								
Mean daily maximum, warmest month (°C)		29.3								
Highest temperature recorded (°C)		39.2								
Mean daily temperature variations		13.7								

CLIMATE CLASSIFICATION		
Annual biotemperature (°C) [Ab]		236.7
Mean annual potenial evapotranspiration (mm) [maEp]		
Mean annual biotemperature (°C) [maB]		19.725
Standard of humidity (maEp/maP)		
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]		24.357
Latitudinal region	Tropical	
maB at sea level	24-30	
Altitudinal belt	Premontane	
Mean annual biotemperature range	18-24	
Humidity province		
Standard of humidity range		
World life zone or plant formation	Dry forest	
World latitude zone	Subtropical	
Latitude range	25-45° N and S	
Empirical climate classification based on	**Precipitation**	
World precipitation region	Moist subtropical regions	
Latitude range	25-45° N and S	
Empirical climate classification based on	**Precipitation & Temperature**	
Köppen main climate type	Warm, humid (Temperate)	
Köppen climate province	Winter dry	
Associated vegetation	Forest	
Thornthwaite humidity province		
Associated vegetation		
Genetic climate classification based on	**Air masses and frontal zones**	
Climate group	Low-latitude	
Dominant air masses	maritime tropical or continental tropical	
Climate type	Wet-dry tropical	
Latitude range	5-20° N and S	
Applied climate classification based on (Macro climate)	**Soil-water balance**	
Climate type		
Water shortage (D) >=		
Mean annual evapotranspiration [maEp] >=		
Climate sub-type		
Water storage [S=+G] in any months >		

Weather station:	Figtree			
Number:	0520589A6			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	25	49	25.8166666666667
	Longitude (E):	31	50	31.8333333333333
Height above sea level (m) [H]:	247			
Period:	1984 - 1990			
Observation duration in years (°C - mm):	5 - 6			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	16.9	19							
August	18.7	15							
September	21	33							
October	22.7	58							
November	23.8	73							
December	25.1	85							
January	25.7	93							
February	26.1	94							
March	25.5	44							
April	23.1	61							
May	20.5	11							
June	17.1	19							
Mean annual temperature (°C)	22.2								
Mean annual precipitation (mm) [maP]		605							

Mean daily minimum, coldest month (°C)	8.6
Lowest temperature recorded (°C)	1.5
Mean daily maximum, warmest month (°C)	31.1
Highest temperature recorded (°C)	40
Mean daily temperature variations	13

CLIMATE CLASSIFICATION

Annual biotemperature (°C) [Ab]	266.2
Mean annual potenial evapotranspiration (mm) [maEp]	
Mean annual biotemperature (°C) [maB]	22.183333333333
Standard of humidity (maEp/maP)	
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	23.665333333333
Latitudinal region	Subtropical
maB at sea level	18-24
Altitudinal belt	Premontane
Mean annual biotemperature range	18-24
Humidity province	
Standard of humidity range	
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	**Precipitation**
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	**Precipitation & Temperature**
Köppen main climate type	Tropical rain
Köppen climate province	Savanna
Associated vegetation	Open grasslands, scattered trees
Thornthwaite humidity province	
Associated vegetation	
Genetic climate classification based on	**Air masses and frontal zones**
Climate group	Low-latitude
Dominant air masses	maritime tropical or continental tropical
Climate type	Wet-dry tropical
Latitude range	5-20° N and S
Applied climate classification based on (Macro climate)	**Soil-water balance**
Climate type	
Water shortage (D) >=	
Mean annual evapotranspiration [maEp] >=	
Climate sub-type	
Water storage [S=+G] in any months >	

Weather station:	Carolina			
Number:	0480184 9			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	26	4	26.0666666666667
	Longitude (E):	30	7	30.1166666666667
Height above sea level (m) [H]:	1689			
Period:	1964 - 1990			
Observation duration in years (°C - mm):	20 - 19			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E Index
July	9.7	4	53.3	(49.3)	0.0		94.2	40.9	0.42444821731749
August	11.9	11	72.3	(61.3)	0.0		117.5	45.2	0.93624989360797
September	14.8	30	89.8	(59.8)	0.0		141.3	51.5	2.1231422505308
October	16.3	80	95.2	(15.2)	0.0		156.6	61.3	5.1101684381987
November	17.3	140	87.4		52.6		144.0	56.6	9.7222222222222
December	18.4	119	97.6		21.5		160.9	63.3	7.3963577599602
January	18.9	153	94.0		59.0		160.0	66.0	9.5648912228057
February	18.4	86	80.3		5.8		143.1	62.8	6.0106234274532
March	17.6	64	77.6	(13.5)	0.0		145.1	67.5	4.4113592500689
April	15	51	61.4	(10.4)	0.0		110.1	48.7	4.6321525885559
May	12.1	12	56.5	(44.5)	0.0		106.0	49.5	1.1318619128466
June	9	6	47.8	(41.8)	0.0		84.9	37.2	0.70671378091873
Mean annual temperature (°C)	15		913.0	(295.8)	138.8		1,563.6	650.7	52.170210964486
Mean annual precipitation (mm) [maP]		756							

Mean daily minimum, coldest month (°C)	1.8
Lowest temperature recorded (°C)	-6
Mean daily maximum, warmest month (°C)	24.5
Highest temperature recorded (°C)	32.5
Mean daily temperature variations	12.8
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [aB]	179.4
Mean annual potenial evapotranspiration (mm) [maEp]	1563.61
Mean annual biotemperature (°C) [maB]	14.95
Standard of humidity (maEp/maP)	2.0682671957672
Basal belt (lapse rate 6°C/1000m; [maB+(H/1000)(6)]	25.084
Lattudinal region	Tropical
maB at sea level	24-30
Altudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	Subhumid
Standard of humidity range	1-2
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	Subhumid
Associated vegetation	Grassland
Genetic climate classification based on	Air masses and frontal zones
Climate group	Midlatitude
Dominant air masses	tropical or polar
Climate type	Dry subtropical
Latitude range	25-35° N and S
Applied climate classification based on (Macro climate)	Soil-water balance
Climate type	Dry tropical
Water shortage (D) >=	150 mm
Mean annual evapotranspiration [maEp] >=	1300 mm
Climate sub-type	Semidesert
Water storage [S=+G] for one month >	20 mm

	Sun latitude	Sun altitude - noon
June	23.5	40.4
September	0	63.9
December	-23.5	87.4
March	0	63.9

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Weather station:	Piet Retief			
Number:	0444570 6			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	27	2	27.0333333333333
	Longitude (E):	30	48	30.8
Height above sea level (m) [H]:	1253			
Period:	1961 - 1990			
Observation duration in years (°C - mm):	29 - 25			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E Index
July	11.8	14	85.6	(71.8)	0.0		102.9	17.2	1.36028
August	13.7	20	107.3	(87.3)	0.0		124.6	17.4	1.604879
September	16.3	44	122.3	(78.3)	0.0		137.4	15.1	3.202329
October	17.4	104	133.7	(29.7)	0.0		143.8	10.1	7.230258
November	18.6	135	131.3		3.7		142.5	11.2	9.473684
December	20.1	149	148.7		0.3		153.5	4.8	9.710003
January	20.6	160	139.5		20.5		160.0	20.4	10.0025
February	20.2	97	122.3	(25.3)	0.0		137.8	15.5	7.041231
March	19.5	77	124.0	(47.0)	0.0		142.0	18.0	5.423299
April	16.8	60	95.8	(35.6)	0.0		123.0	27.2	4.878049
May	14.2	19	85.9	(66.9)	0.0		113.8	27.8	1.670038
June	11.3	13	73.2	(60.2)	0.0		97.2	24.0	1.337449
Mean annual temperature (°C)	16.7		1,369.9	(502.4)	24.5		1,578.4	208.5	62.934
Mean annual precipitation (mm) [maP]		892							

Mean daily minimum, coldest month (°C)	3.7
Lowest temperature recorded (°C)	-4.9
Mean daily maximum, warmest month (°C)	26.1
Highest temperature recorded (°C)	36.5
Mean daily temperature variations	12.9
CLIMATE CLASSIFICATION	
Annual biotemperature (°C) [Ab]	200.5
Mean annual potenial evapotranspiration (mm) [maEp]	1578.4
Mean annual biotemperature (°C) [maB]	16.7083333333333
Standard of humidity (maEp/maP)	1.7695067264574
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	24.2263333333333
Latitudinal region	Tropical
maB at sea level	24-30
Altitudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	Subhumid
Standard of humidity range	1-2
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	Subhumid
Associated vegetation	Grassland
Genetic climate classification based on	Air masses and frontal zones
Climate group	Midlatitude
Dominant air masses	tropical or polar
Climate type	Dry subtropical
Latitude range	25-35° N and S
Applied climate classification based on (Local climate)	Soil-water balance
Climate type	Dry tropical
Water shortage (D) >=	150 mm
Mean annual evapotranspiration [maEp] >=	1300 mm
Climate sub-type	Desert
Water storage [S=+G] in any months >	20 mm

	Sun latitude	Sun altitude - noon
June	23.5	39.5
September	0	62.9
December	-23.5	86.5
March	0	62.9

Weather station:	Carolina			
Number:	0480184 9			
Geographical reference:	Units	Degree	Minute	Dec degree
	Latitude (S)	26	4	26.0666666666667
	Longitude (E):	30	7	30.1166666666667
Height above sea level (m) [H]:	1689			
Period:	1964 - 1990			
Observation duration in years (°C - mm):	20 - 19			

Months	Mean monthly temperature (°C)	Mean monthly rainfall (mm)	In mm actual (Ea) evapotranspiration	Storage (G) withdrawal (-)	Storage (G) recharge (+)	Water surplus (+R)	In mm potenial (Ep) evapotranspiration	(Ep-Ea=D) Soil-water shortage (D)	P-E index
July	9.7	4	89.5	(85.5)			94.2	4.7	0.4244482
August	11.9	11	121.4	(110.4)			117.5	(3.9)	0.9362499
September	14.8	30	150.9	(120.9)			141.3	(9.6)	2.1231423
October	16.3	80	159.9	(79.9)			156.6	(3.4)	5.1101884
November	17.3	140	146.8	(6.8)			144.0	(2.8)	9.7222222
December	18.4	119	163.9	(44.9)			160.9	(3.0)	7.3963578
January	18.9	153	157.9	(4.9)			160.0	2.0	9.5648912
February	18.4	86	134.8	(48.8)			143.1	8.3	6.0106234
March	17.6	64	130.3	(66.3)			145.1	14.8	4.4113593
April	15	51	103.2	(52.2)			110.1	6.9	4.6321526
May	12.1	12	94.9	(82.9)			106.0	11.1	1.1318619
June	9	6	80.2	(74.2)			84.9	4.7	0.7067138
Mean annual temperature (°C)	15		1,533.8	(672.3)			1,563.6	29.9	52.170211
Mean annual precipitation (mm) [maP]		756							

Mean daily minimum, coldest month (°C)	1.8
Lowest temperature recorded (°C)	-6
Mean daily maximum, warmest month (°C)	24.5
Highest temperature recorded (°C)	32.5
Mean daily temperature variations	12.8

CLIMATE CLASSIFICATION

Annual biotemperature (°C) [aB]	179.4
Mean annual potenial evapotranspiration (mm) [maEp]	1563.61
Mean annual biotemperature (°C) [maB]	14.95
Standard of humidity (maEp/maP)	2.0682671957672
Basal belt (lapse rate 6°C/1000m) [maB+(H/1000)(6)]	25.084
Latitudinal region	Tropical
maB at sea level	24-30
Altitudinal belt	Lower Montane
Mean annual biotemperature range	12-18
Humidity province	Subhumid
Standard of humidity range	1-2
World life zone or plant formation	Dry forest
World latitude zone	Subtropical
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation
World precipitation region	Moist subtropical regions
Latitude range	25-45° N and S
Empirical climate classification based on	Precipitation & Temperature
Köppen main climate type	Warm, humid (Temperate)
Köppen climate province	Winter dry
Associated vegetation	Forest
Thornthwaite humidity province	Subhumid
Associated vegetation	Grassland
Genetic climate classification based on	Air masses and frontal zones
Climate group	Midlatitude
Dominant air masses	tropical or polar
Climate type	Dry subtropical
Latitude range	25-35° N and S
Applied climate classification based on (Local climate)	Soil-water balance
Climate type	Moist subtropical
Water shortage (D) <	150 mm
Every month mean annual evapotranspiration [maEp] >=	8 mm
Climate sub-type	Subhumid
150 mm > D > 0, water recharge (R) =	0 mm

	Sun latitude	Sun altitude - noon
June	23.5	40.4
September	0	63.9
December	-23.5	87.4
March	0	63.9

APPENDIX B

Crests

Class	% slope interval	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	000-001	1	0.0084	1	0.0084
2	000-003	5	0.04202	6	0.05042
3	000-004	5	0.04202	11	0.09244
4	000-005	2	0.01681	13	0.10924
5	000-006	1	0.0084	14	0.11765
6	000-008	5	0.04202	19	0.15966
7	000-012	1	0.0084	20	0.16807
8	000-015	2	0.01681	22	0.18487
9	000-020	1	0.0084	23	0.19328
10	001-004	4	0.03361	27	0.22689
11	001-006	1	0.0084	28	0.23529
12	001-008	1	0.0084	29	0.2437
13	001-012	5	0.04202	34	0.28571
14	001-015	1	0.0084	35	0.29412
15	002-004	5	0.04202	40	0.33613
16	002-005	2	0.01681	42	0.35294
17	002-006	3	0.02521	45	0.37815
18	002-008	7	0.05882	52	0.43697
19	002-010	1	0.0084	53	0.44538
20	003-005	2	0.01681	55	0.46218
21	003-006	3	0.02521	58	0.48739
22	003-008	10	0.08403	68	0.57143
23	003-012	5	0.04202	73	0.61345
24	003-015	1	0.0084	74	0.62185
25	004-008	2	0.01681	76	0.63866
26	004-012	3	0.02521	79	0.66387
27	004-015	3	0.02521	82	0.68908
28	004-020	1	0.0084	83	0.69748
29	005-008	1	0.0084	84	0.70588
30	005-012	2	0.01681	86	0.72269
31	005-015	3	0.02521	89	0.7479
32	005-020	1	0.0084	90	0.7563
33	006-012	1	0.0084	91	0.76471
34	006-015	5	0.04202	96	0.80672
35	008-015	3	0.02521	99	0.83193
36	008-020	10	0.08403	109	0.91597
37	012-020	6	0.05042	115	0.96639
38	012-025	3	0.02521	118	0.9916
39	012-070	1	0.0084	119	1

Scarp

Class	% slope interval	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	005-012	2	0.1333	2	0.133

2	015-090	1	0.[illegible]	[illegible]	0.2
3	050-100+	2	0.1333	5	0.333
4	090+	8	0.5333	13	0.867
5	100+	2	0.1333	15	1

Midslope

Class	% slope interval	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	000-003	1	0.00794	1	0.00794
2	002-005	2	0.01587	3	0.02381
3	003-006	2	0.01587	5	0.03968
4	003-008	7	0.05556	12	0.09524
5	003-012	7	0.05556	19	0.15079
6	003-014	1	0.00794	20	0.15873
7	003-015	3	0.02381	23	0.18254
8	003-016	1	0.00794	24	0.19048
9	003-030	1	0.00794	25	0.19841
10	004-006	1	0.00794	26	0.20635
11	004-008	1	0.00794	27	0.21429
12	004-010	2	0.01587	29	0.23016
13	004-012	6	0.04762	35	0.27778
14	004-015	5	0.03968	40	0.31746
15	004-020	4	0.03175	44	0.34921
16	004-060+	1	0.00794	45	0.35714
17	005-006	2	0.01587	47	0.37302
18	005-012	2	0.01587	49	0.38889
19	005-015	5	0.03968	54	0.42857
20	005-020	1	0.00794	55	0.43651
21	006-012	6	0.04762	61	0.48413
22	006-015	6	0.04762	67	0.53175
23	006-020	4	0.03175	71	0.56349
24	006-045	1	0.00794	72	0.57143
25	008-015	2	0.01587	74	0.5873
26	008-020	4	0.03175	78	0.61905
27	008-030	4	0.03175	82	0.65079
28	008-045	2	0.01587	84	0.66667
29	008-050	6	0.04762	90	0.71429
30	008-060	1	0.00794	91	0.72222
31	010-050	1	0.00794	92	0.73016
32	012-030	2	0.01587	94	0.74603
33	012-040	2	0.01587	96	0.7619
34	012-050	1	0.00794	97	0.76984
35	012-060	2	0.01587	99	0.78571
36	012-070	1	0.00794	100	0.79365
37	012-100	10	0.07937	110	0.87302
38	015-050	2	0.01587	112	0.88889
39	015-100	10	0.07937	122	0.96825
40	020-100	1	0.00794	123	0.97619
41	030-090	1	0.00794	124	0.98413

4.	030-100	2			1

Footslope

Class	% slope interval	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	000-001	1	0.0159	1	0.0159
2	001-003	3	0.0476	4	0.0635
3	001-004	8	0.127	12	0.1905
4	001-005	1	0.0159	13	0.2063
5	001-008	1	0.0159	14	0.2222
6	002-003	1	0.0159	15	0.2381
7	002-004	4	0.0635	19	0.3016
8	002-006	3	0.0476	22	0.3492
9	002-008	2	0.0317	24	0.381
10	003-005	3	0.0476	27	0.4286
11	003-006	6	0.0952	33	0.5238
12	003-008	1	0.0159	34	0.5397
13	003-015	2	0.0317	36	0.5714
14	004-005	2	0.0317	38	0.6032
15	004-008	1	0.0159	39	0.619
16	004-012	8	0.127	47	0.746
17	006-012	6	0.0952	53	0.8413
18	006-015	3	0.0476	56	0.8889
19	008-015	2	0.0317	58	0.9206
20	008-020	5	0.0794	63	1

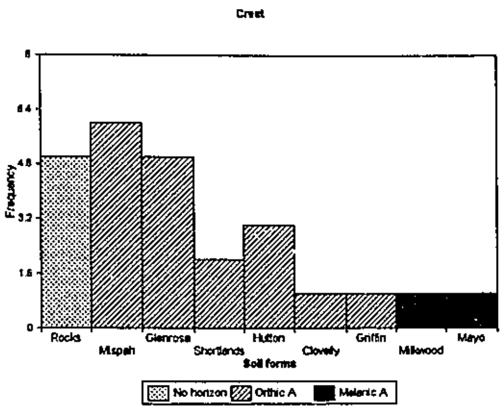
Valley bottom

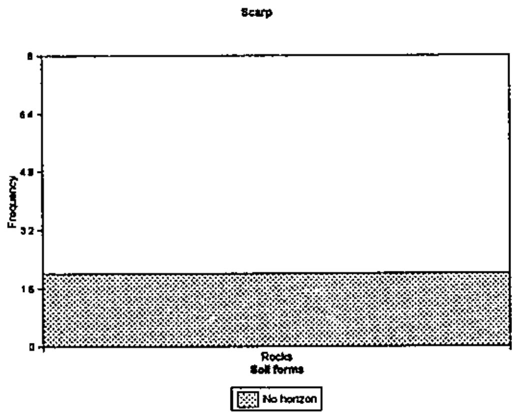
Class	% slope interval	Frequency	Relative Frequency	Cumulative Frequency	Cum. Rel. Frequency
1	000-001	21	0.16535	21	0.165
2	000-002	13	0.10236	34	0.268
3	000-003	7	0.05512	41	0.323
4	000-004	2	0.01575	43	0.339
5	000-012	1	0.00787	44	0.346
6	001-002	5	0.03937	49	0.386
7	001-004	3	0.02362	52	0.409
8	001-006	1	0.00787	53	0.417
9	001-008	3	0.02362	56	0.441
10	001-012	5	0.03937	61	0.48
11	001-014	1	0.00787	62	0.488
12	001-020	4	0.0315	66	0.52
13	001-050	5	0.03937	71	0.559
14	002-012	1	0.00787	72	0.567
15	002-015	2	0.01575	74	0.583
16	002-020	2	0.01575	76	0.598
17	003-006	1	0.00787	77	0.606
18	003-008	2	0.01575	79	0.622
19	003-015	1	0.00787	80	0.63

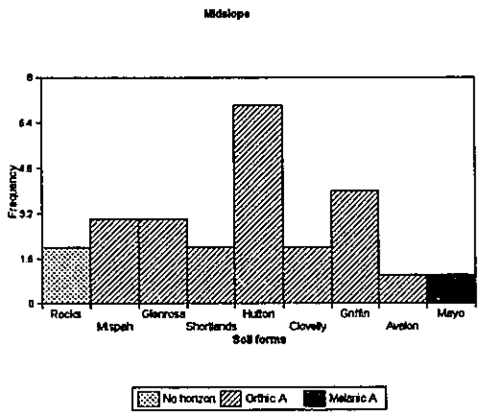
20	003-016	1	0.00787	81	0.638
21	003-020	2	0.01575	83	0.654
22	003-030	2	0.01575	85	0.669
23	003-050	5	0.03937	90	0.709
24	004-008	1	0.00787	91	0.717
25	004-010	1	0.00787	92	0.724
26	004-012	4	0.0315	96	0.756
27	004-015	1	0.00787	97	0.764
28	004-025	1	0.00787	98	0.772
29	004-030	2	0.01575	100	0.787
30	004-060	1	0.00787	101	0.795
31	005-020	1	0.00787	102	0.803
32	005-050	1	0.00787	103	0.811
33	006-012	3	0.02362	106	0.835
34	006-015	4	0.0315	110	0.866
35	006-025	1	0.00787	111	0.874
36	006-045	1	0.00787	112	0.882
37	008-015	1	0.00787	113	0.89
38	008-020	1	0.00787	114	0.898
39	008-030	1	0.00787	115	0.906
40	008-045	2	0.01575	117	0.921
41	008-050	3	0.02362	120	0.945
42	008-100	1	0.00787	121	0.953
43	012-060	2	0.01575	123	0.969
44	012-070	1	0.00787	124	0.976
45	020-100	2	0.01575	126	0.992
46	030-090	1	0.00787	127	1

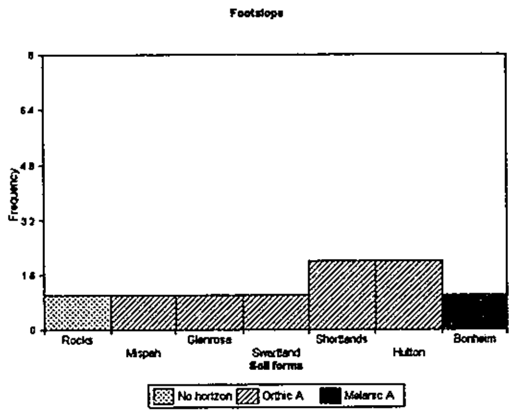
APPENDIX C

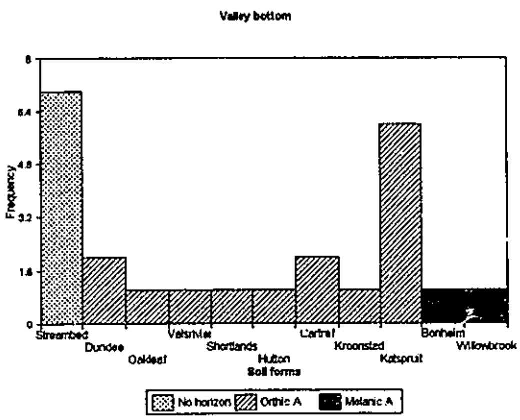
Soil forms of the Ab soil pattern per terrain unit



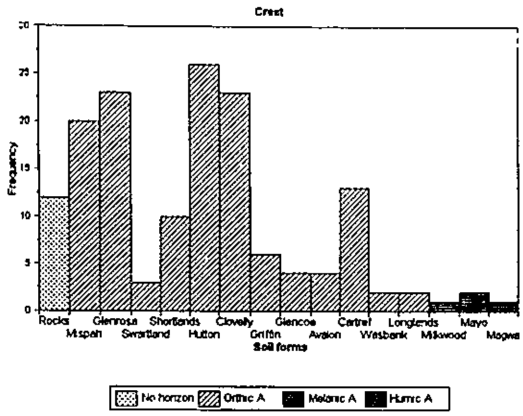


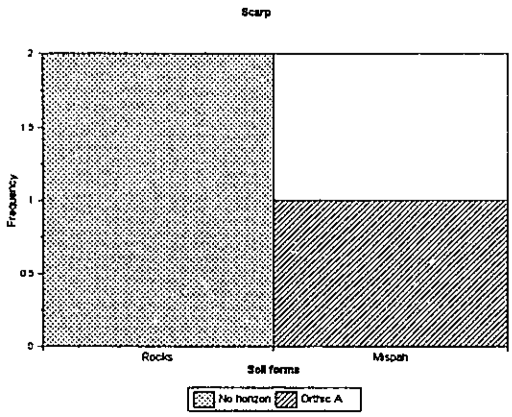


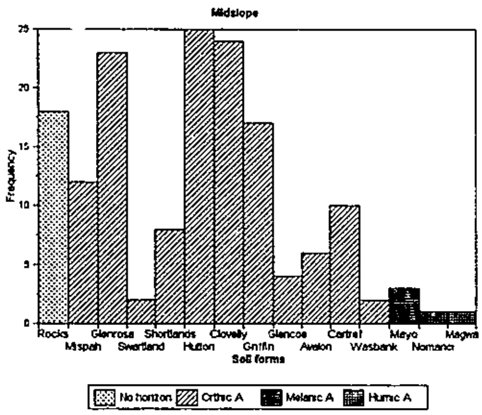


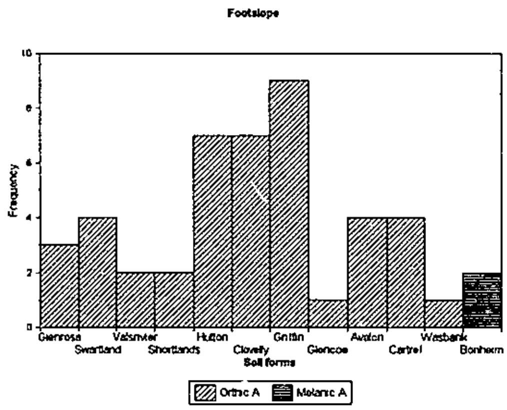


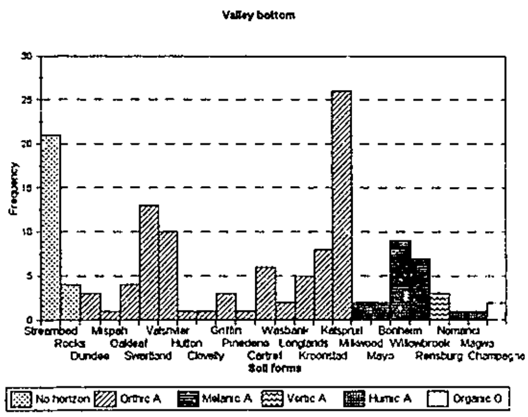
Soil forms of the Ac soil pattern per terrain unit



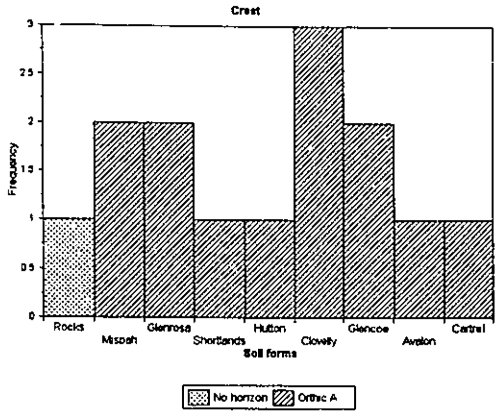


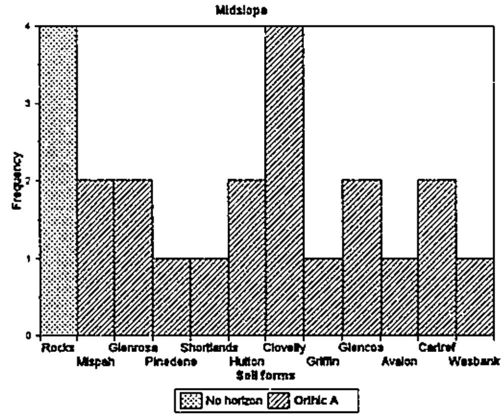


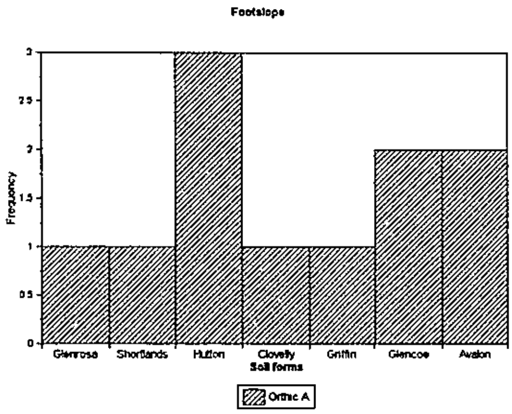


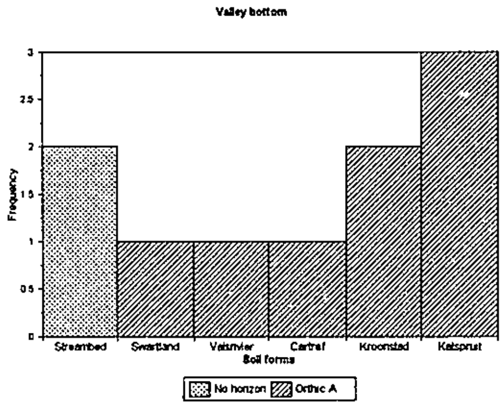


Soil forms of the Ad soil pattern per terrain unit

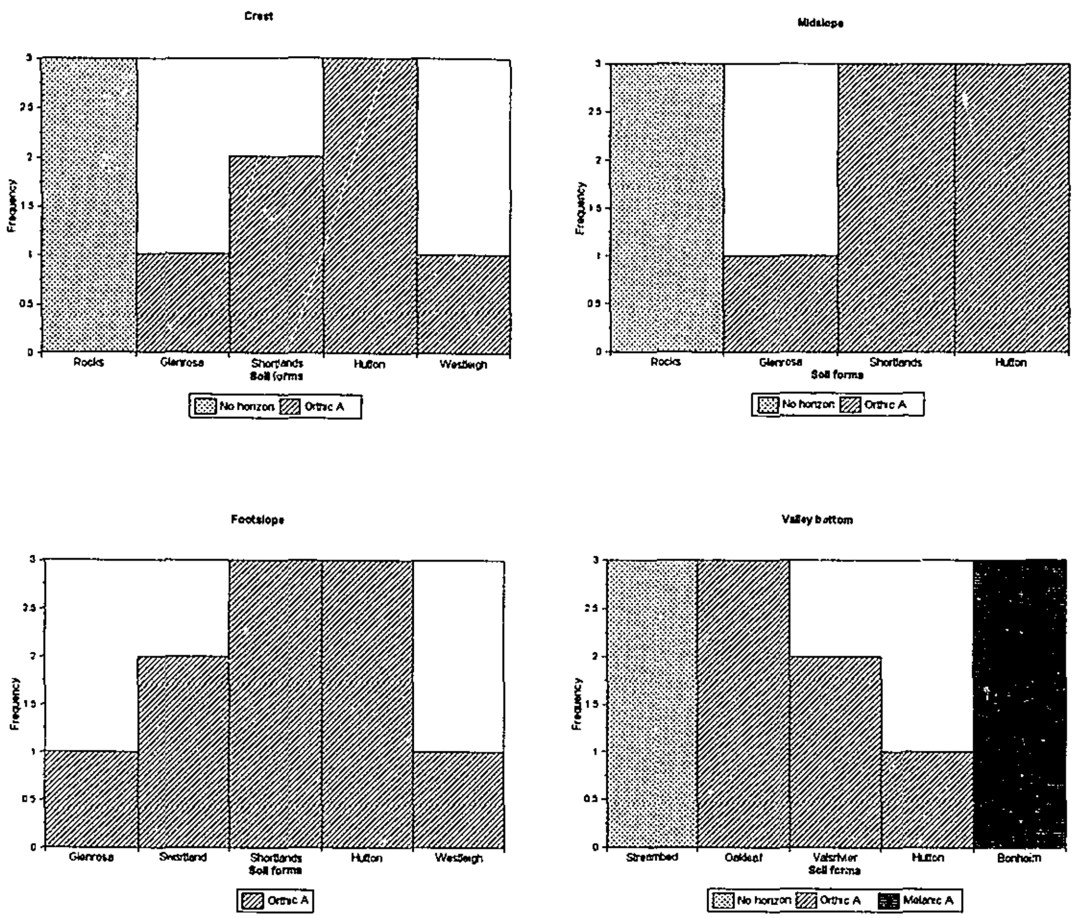




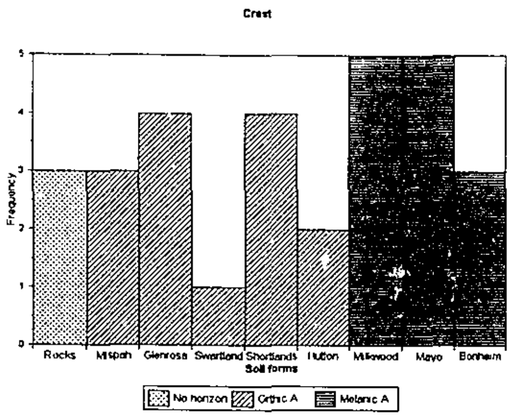


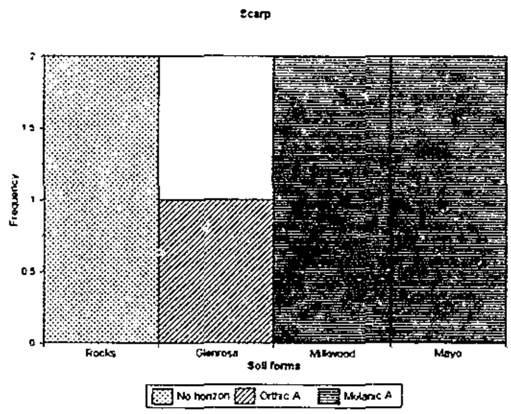


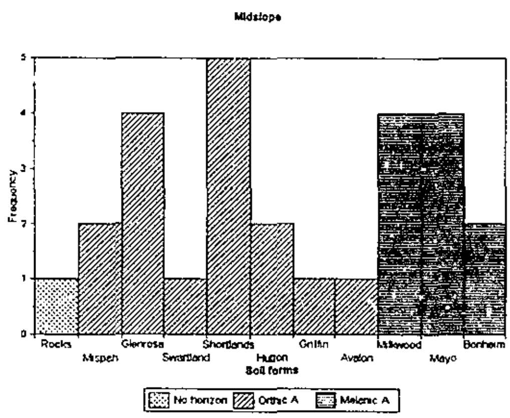
Soil forms of the Ae soil pattern per terrain unit

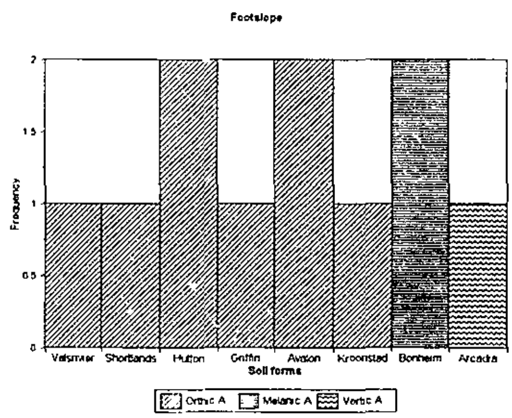


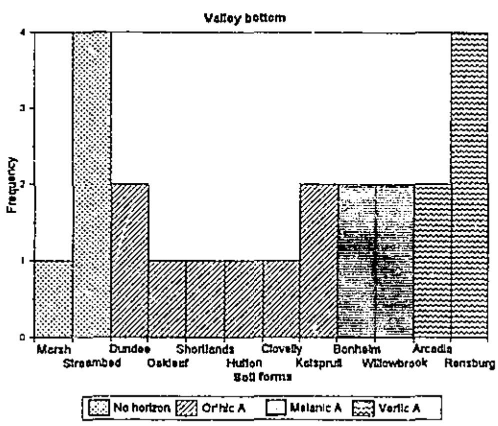
Soil forms of the Ea soil pattern per terrain unit



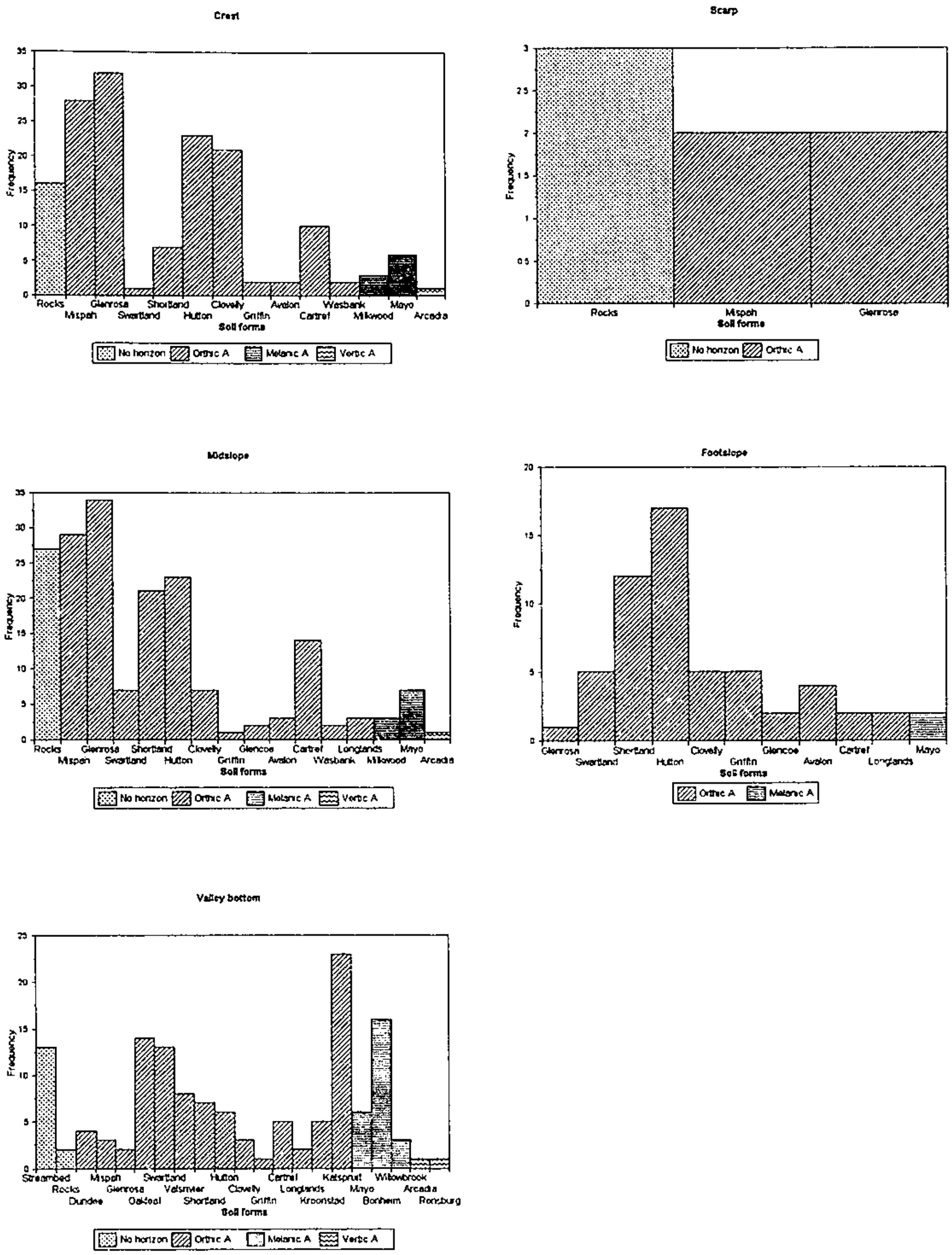




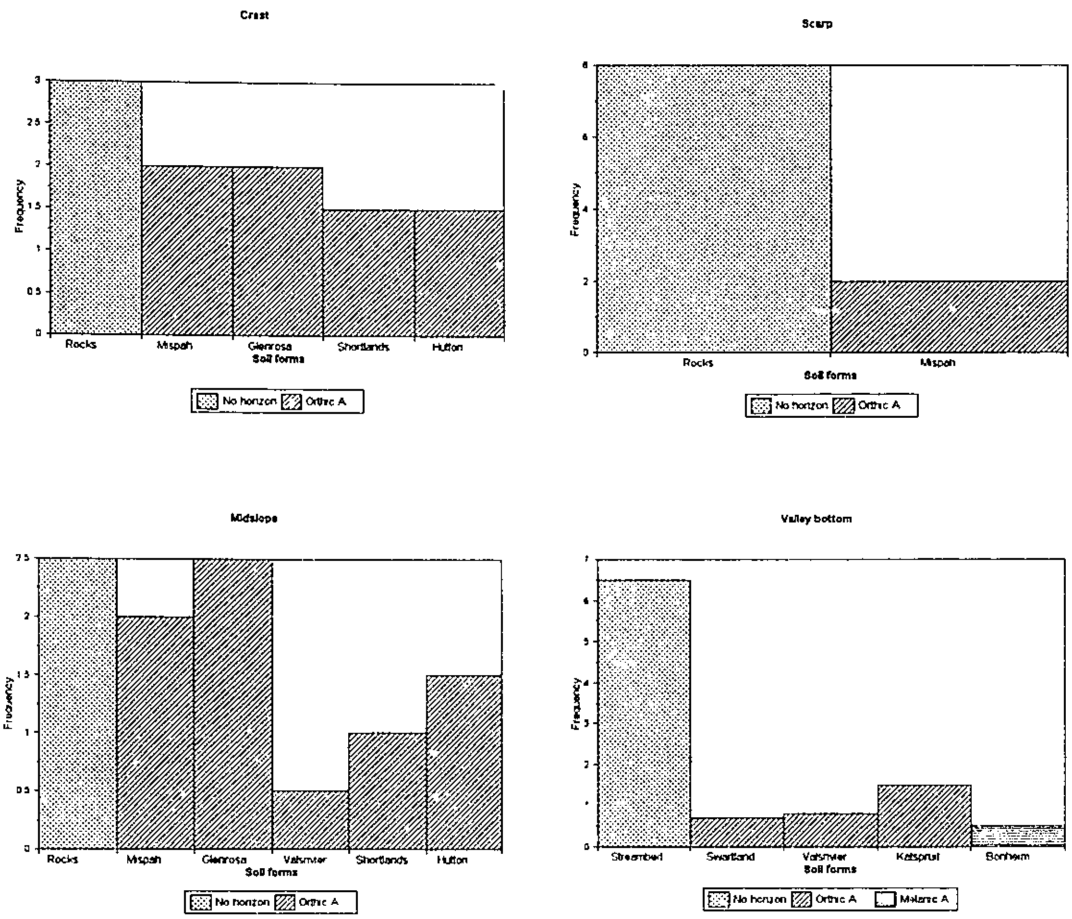




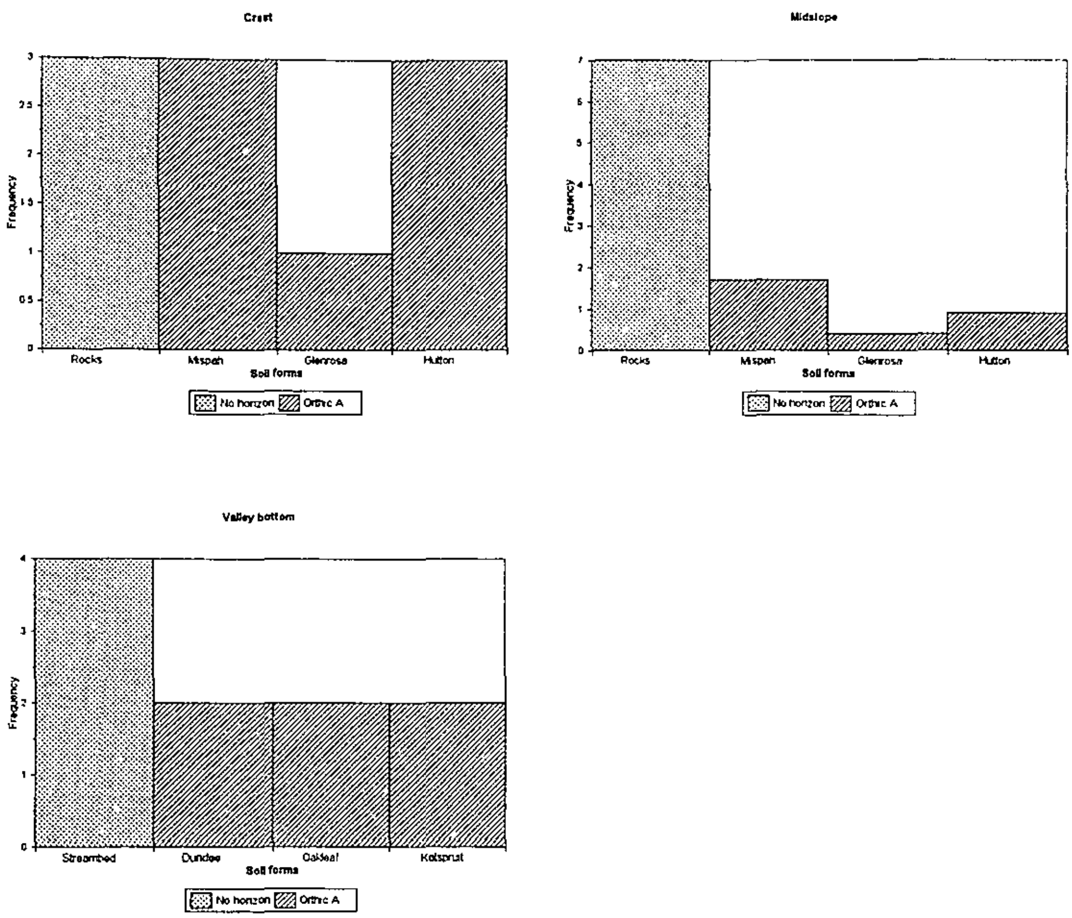
Soil forms of the Fa soil pattern per terrain unit



Soil forms of the Fb soil pattern per terrain unit



Soil forms of the Ib soil pattern per terrain unit



APPENDIX D

Plant families associated with certain life forms and physiognomic categories

Anatomy/ Cytology	Life forms (Raunkiaer In Mueller-Dombois,1974)			Physiognomy (Edwards, 1983)		Taxonomy - Plant families of southern Africa (Arnold & de Wet, 1993)	
	Main Groups	Subdivisions					
		Substrate					
		Soil	Water/ other plants	Single trunk	Multi-stemmed	Monocotyledonae	Dicotyledonae
Woody (Perennials with much sclerenchiem)	Phanerophytes >50cm	Mega- 50m+		Trees:	branching conspicuous above ground	AREC	CELA,LORA,BIGN,MYRT,LOGA,COMB, **CASU**,RHAM,ARAL,MORA,OCHN, ANAC,MELI,**BOMB**,LAUR,**MYRI**, ANNO,SAPO,**HAMA**,PROT,**MYRO**, SALI,EBEN,ULMA,FLAC,**FAGA**,TAMA
		Meso- 5-50m					
		Micro- 2-5m			branching inconspicuous above ground		
		Nano- <2m		Shrubs:			
Herbaceous (Annuals/ bi-annuals with little sclerenchiem)	Chamaephytes < 50cm			Herbs: limited signs of woodiness			
	Hemicryptophytes			Grasses & graminiods		POAC,CYPE,REST	
	Cryptophytes	Geophytes	Hydrophytes	Herbs: with no signs of woodiness		**LILI**,ORCH,IRID,AMAR, CANN,PONT,ALIS,**APON**, **POTA**	OXAL,ASCL,CONV
			Parasites				SCRO,**VISC**,**HYDN**
			Epiphytes				
			Lianas				
	Therophytes						

Note: Not all 224 Angiospermae families are included because they do not fit into a single category, the abbreviated family name in bold and underlined indicate that the family consists of a single species, those in bold only indicate the family consists of a single genus.

APPENDIX E

		Relevo no	9	50	217
TWINSPAN results based on total floristic composition of 405 releves		atwnseq	3	2	1
		atwnlev1	0	0	0
		atwnlev2	0	0	0
		atwnlev3	1	1	1
		atwnlev4	1	1	1
		atwnlev5	0	0	0
		atwnlev6	1	1	1
DECORANA results based on total floristic composition of 405 releves		adecax1	316	318	302
		adecax2	335	332	261
		adecax3	159	181	191
		adecax4	221	222	328
		tercde	1	1	1
		Comseq	11	11	11
TWINSPAN results based on the floristic composition of each landform		twinseq	1	2	3
		twnlev1	0	0	0
		twnlev2	0	0	0
		twnlev3	0	0	0
		twnlev4	0	0	0
		twnlev5			
		twnlev6			
		Longitude (dd)	30.735	30.74	30.743
		Latitude (dd)	-26.067	-26.067	-26.069
ABIOTIC COMPONENT					
GEOLOGICAL ENVIRONMENT		**Attributes**			
Internasional - Chronostratigraphical units		Eon	Cryptozoic	Cryptozoic	Cryptozoic
		Erathem	Archaean	Archaean	Archaean
		System	Precambrian	Precambrian	Precambrian
Nasional - Chronostratigraphical unit		Erathem	Swazian	Swazian	Swazian
		Petrological types	Metamorphic	Metamorphic	Metamorphic
		Lithological units	Gneiss	Gneiss	Gneiss
Stratigraphical units		Sequence/ Complex/ Supergroup/ Group	-	-	-
		Formation/ Suite	-	-	-
GEOMORPHOLOGICAL ENVIRONMENT		Terrain group	Closed hills and mountains with moderate and high relief	Closed hills and mountains with moderate and high relief	Closed hills and mountains with moderate and high relief
Researched data	ATLAS_P	Terrain type	High mountains	High mountains	High mountains
	topo	Terrain type nature	50 - 80% of area, slope < 8%, local relief 150 - 300 m	50 - 80% of area, slope < 8%, local relief 150 - 300 m	50 - 80% of area, slope < 8%, local relief 150 - 300 m
	rteanh	Estimated terrain morphological unit	Midslope	Midslope	Midslope
Modeled data	hter100	Terrain unit interval (%)	Footslope or valley bottom (0 - 12)	Footslope or valley bottom (0 - 12)	Footslope or valley bottom (0 - 12)
		Slope angle (°)	2.262070417	5.263206482	0.537950277
		Slope angle (%)	3.950110435	9.211954117	0.938928127
	hasp100	Aspect in azimuths	342.848999	320.4451599	331.9460754
	htm100	Altitude extracted from the digital terrain model	1172.116455	1176.2052	1200
CLIMATIC ENVIRONMENT		Date (myy)	594	594	594
	hall100	Altitudinal class based on the digital terrain model	120	120	120
Local climate	klsone	Climate zone of land type survey staff	0118s	0118s	0118s
	jgreen	Average yearly rainfall within climate zone	894.1	894.1	894.1
	hins100	Slope angle & perpendicular insolation period	Slopes of 2 - 25°, summer only	Slopes of 2 - 25°, summer only	Slopes of 0 - 2°, never
	hbl100	Insolation exposure period & aspect	All seasons, NE - NW	All seasons, NE - NW	All seasons, NE - NW
	hmcim100	Insolation attitudes	Gentle, north facing	Gentle, north facing	Flat, north facing
PEDOLOGICAL ENVIRONMENT	rtpe	Soil pattern	fa166	fa166	fa166
	rhgte	Altitude of soil pattern	900	900	900
	vgrdv	Modal soil form of soil pattern	Glenrosa	Glenrosa	Glenrosa
	tekstuur	Modal soil texture class of soil pattern	AcoSa-SaLm	AcoSa-SaLm	AcoSa-SaLm
	Diepte	Modal soil depth of soil pattern	0300-0400	0300-0400	0300-0400
	prts	Estimated percentage rock cover	0	15	0
		Prominent estimated categorial rock size	None	Stones	None
BIOTIC COMPONENT					
FLORISTIC DATA	fisionomie	Physiognomic classification (Edwards, 1983)	Pure short closed grassland	Pure short closed grassland	Pure short closed grassland
	Spp/rel	Number of species per relevé	29	30	33
	ACOCKS	Veld types (Acocks, 1988)	Piet Retief Sourveld	Piet Retief Sourveld	Piet Retief Sourveld
	ROBLW	Vegetation types (Low & Rebelo, 1996)	North-eastern Mountain Grassland	North-eastern Mountain Grassland	North-eastern Mountain Grassland
		Specific plant community			
WILDLIFE MANAGEMENT CATEGORIES	hpas100	Pasture landscape class	Flat (0-8%)	Medium (9-15%)	Flat (0-8%)
	heros100	Slope limitation class	Crop growth (0-15%)	Crop growth (0-15%)	Crop growth (0-15%)
	hlnd100	Land use suitability class	Annual cropping (0-3%)	Rotation of ley and crops (8-12%)	Annual cropping (0-3%)

The complete set of environmental attributes, except for the TWINSPAN and DECORANA sequence, were exported to the TURBOVEG database

APPENDIX F

Section of a BBNEW table FTPed from the mainframe
and imported into a spreadsheet

RYE: 1 TOT 269

1

NOMMER	SPESIE	TOTAAL	052	053	055	045	042	043	115	086	087	093	104	109
1321	SP51 006	5	1	1	+									
743	LOUD FLA	70	A	A	1									
1304	SP48 011	5	1	1										
1332	SP53 004	2	1	1										
1174	SCHI CRA	62				+	+			+	+	+	+	+
608	GNID CAF	16				+		+		+	+	+	+	+
168	CYMB PLU	89				+		+		+	1			
750	MAYT ANG	2					+	+						
915	RAPH GAL	7					+	+						
1197	SENE OXY	19					+		+					
1067	SAAM 045	2				+			+					
1482	SUTE CAE	5					1	+						
746	MALV RNK	3					1	1						
371	ENKE 170	11					+		'					
585	FAUR SPE	14					+		1					
662	HELI DAS	34								+	+	+	+	+
921	RHUS DIS	69								+		+		+
44	ANDR SCH	16						+		+	+			+
768	NIDO ANO	16								+	+	+		
667	HELI NUD	55									+			+
659	HELI CEP	72								+	+	+		
553	ERAG CHL	83											+	
1520	VERN OLI	40								+	+	+		
692	HYPE DIS	62	B	B	1									
598	GEIG BUR	51		+		+	+	1					+	
60	ARIS DIF	17			+								+	
1494	THEM TRI	262				+	1	+	+	3	A	3	+	1
1207	SETA SPH	212				+	+	+			+		+	
1519	VERN NAT	124				+		+		1	1	A	A	
11	ACAL ANG	148			1		1			+	+		+	+
1505	TRIS LEU	152	1	1	+		+		+	1	+		+	
677	HETE CON	173	1	1	+	+	+							
786	PANI NAT	121	1	1		+	A	1	+		+	+	+	+
559	ERAG RAC	167	1	1	+						+		+	+
1199	SENE VEN	114	+		1	+	1	1	+					

Cover abundance estimates replaced with an one (1)

RYE: 1 TOT 269

1

NOMMER	SPESIE	TOTAAL	052	053	055	045	042	043	115	086	087	093	104	109
1321	SP51 006	5	1	1	1									
743	LOUD FLA	70	1	1	1									
1304	SP48 011	5	1	1										
1332	SP53 004	2	1	1										
1174	SCHI CRA	62				1	1			1	1	1	1	1
608	GNID CAF	16				1		1		1	1	1	1	1
168	CYMB PLU	89				1		1		1	1			
750	MAYT ANG	2					1	1						
915	RAPH GAL	7					1	1						
1197	SENE OXY	19					1		1					
1067	SAAM 045	2				1			1					
1482	SUTE CAE	5					1	1						
746	MALV RNK	3					1	1						
371	ENKE 170	11					1		1					
585	FAUR SPE	14					1		1					
662	HELI DAS	34								1	1	1	1	1
921	RHUS DIS	69								1		1		1
44	ANDR SCH	16						1		1	1			1
768	NIDO ANO	16								1	1	1		
667	HELI NUD	55									1			1
659	HELI CEP	72								1	1	1		
553	ERAG CHL	83											1	
1520	VERN OLI	40								1	1	1		
692	HYPE DIS	62	1	1	1									
598	GEIG BUR	51		1		1	1	1					1	
60	ARIS DIF	17			1								1	
1494	THEM TRI	262				1	1	1	1	1	1	1	1	1
1207	SETA SPH	212				1	1	1			1		1	
1519	VERN NAT	124				1		1		1	1	1	1	
11	ACAL ANG	148			1		1			1	1		1	1
1505	TRIS LEU	152	1	1	1		1		1	1	1		1	
677	HETE CON	173	1	1	1	1	1							
786	PANI NAT	121	1	1		1	1	1	1		1	1	1	1
559	ERAG RAC	167	1	1	1						1		1	1
1199	SENE VEN	114	1		1	1	1	1	1					

	A	B	C	D	E	F	G	H	I	K	L	M	O	P	Q	R	S	U	V	W	X
1	Formules used to calculate the %constancy and %fidelity								Cluster		1			2					3		
2																					
3																					
4				%Constancy																	
5										0	0	0	0	0	0	1	0	0	0	1	1
6			Cluster	Cluster	Cluster	Cluster	Cluster	Cluster	%Fidelity	5	5	5	4	4	4	1	8	8	9	0	0
7	SPESIE	TOTAAL	1	2	3	1	2	3		2	3	5	5	2	3	5	6	7	3	4	9
8																					
9	SP51 006	5	100	0	0	1	0	0	33.33333	1	1	1									
10	LOUD FLA	70	@SUM(K10..M10)/C$44*100			0	0	0	0	1	1	1									
11	SP48 011	5	66.66667	@SUM(O11..R11)/D$44*100			0	0	0	1	1										
12	SP53 004	2	66.66667	0	@SUM(T12..X12)/E$44*100			0	0	1	1										
13	SCHI CRA	62	0	50	100	@IF(C13>0,1,0)		1	33.33333				1	1			1	1	1	1	1
14	GNID CAF	16	0	50	100	0	@IF(D14>0,1,0)		0				1		1		1	1	1	1	1
15	CYMB PLU	89	0	50	40	0	1	@IF(E15>0,1,0)					1		1		1	1			
16	MAYT ANG	2	0	50	0	0	1	0	@SUM(F16..H16)/I$44*100					1	1						
17	RAPH GAL	7	0	50	0	0	1	0	33.33333					1	1						
18	SENE OXY	19	0	50	0	0	1	0	33.33333					1		1					
19	SAAM 045	2	0	50	0	0	1	0	33.33333				1			1					
20	SUTE CAE	5	0	50	0	0	1	0	33.33333					1	1						
21	MALV RNK	3	0	50	0	0	1	0	33.33333					1	1						
22	ENKE 170	11	0	50	0	0	1	0	33.33333					1		1					
23	FAUR SPE	14	0	50	0	0	1	0	33.33333					1		1					
24	HELI DAS	34	0	0	100	0	0	1	33.33333								1	1	1	1	1
25	RHUS DIS	69	0	0	60	0	0	1	33.33333								1		1		1
26	ANDR SCH	16	0	25	60	0	1	1	66.66667						1		1	1			1
27	NIDO ANO	16	0	0	60	0	0	1	33.33333								1	1	1		
28	HELI NUD	55	0	0	40	0	0	1	33.33333									1			1
29	HELI CEP	72	0	0	60	0	0	1	33.33333								1	1	1		
30	ERAG CHL	63	0	0	20	0	0	1	33.33333											1	
31	VERN OLI	40	0	0	60	0	0	1	33.33333								1	1	1		
32	HYPE DIS	62	100	0	0	1	0	0	33.33333	1	1	1									
33	GEIG BUR	51	33.33333	75	20	1	1	1	100		1		1	1	1					1	
34	ARIS DIF	17	33.33333	0	20	1	0	1	66.66667			1								1	
35	THEM TRI	262	0	100	100	0	1	1	66.66667				1	1	1	1	1	1	1	1	1
36	SETA SPH	212	0	75	40	0	1	1	66.66667				1	1	1			1		1	
37	VERN NAT	124	0	50	60	0	1	1	66.66667				1		1		1	1	1	1	
38	ACAL ANG	148	33.33333	25	80	1	1	1	100			1		1			1	1		1	1
39	TRIS LEU	152	100	50	60	1	1	1	100	1	1	1		1		1	1	1		1	
40	HETE CON	173	100	50	0	1	1	0	66.66667	1	1	1	1	1							
41	PANI NAT	121	66.66667	100	80	1	1	1	100	1	1		1	1	1	1		1	1	1	1
42	ERAG RAC	167	100	0	60	1	0	1	66.66667	1	1	1						1		1	1
43	SENE VEN	114	66.66667	100	0	1	1	0	66.66667	1		1	1	1	1	1					
44	Total		3	4	5	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1
			@SUM(K44..M44)						@SUM(F44..H44)												
				@SUM(O44..R44)																	
					@SUM(T44..X44)																

Table sequence sorted from the highest fidelity (33%) to the lowest fidelity (100%)

		%Constancy							Cluster 1			Cluster 2				Cluster 3				
SPESIE	TOTAAL	Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	052	053	055	045	042	043	115	086	087	093	104	109
HELI DAS	34	0	0	100	0	0	1	33.3333								1	1	1	1	1
RHUS DIS	69	0	0	60	0	0	1	33.3333								1		1		1
FAUR SPE	14	0	50	0	0	1	0	33.3333					1		1					
MALV RNK	3	0	50	0	0	1	0	33.3333					1	1						
ENKE 170	11	0	50	0	0	1	0	33.3333					1		1					
NIDO ANO	16	0	0	60	0	0	1	33.3333								1	1	1		
VERN OLI	40	0	0	60	0	0	1	33.3333								1	1	1		
HYPE DIS	62	100	0	0	1	0	0	33.3333	1	1	1									
ERAG CHL	63	0	0	20	0	0	1	33.3333											1	
HELI NUD	55	0	0	40	0	0	1	33.3333									1			1
HELI CEP	72	0	0	60	0	0	1	33.3333								1	1	1		
SUTE CAE	5	0	50	0	0	1	0	33.3333					1	1						
SP53 004	2	66.6667	0	0	1	0	0	33.3333	1	1										
SP46 011	5	66.6667	0	0	1	0	0	33.3333	1	1										
LOUD FLA	70	100	0	0	1	0	0	33.3333	1	1	1									
SP51 006	5	100	0	0	1	0	0	33.3333	1	1	1									
SENE OXY	19	0	50	0	0	1	0	33.3333					1		1					
SAAM 045	2	0	50	0	0	1	0	33.3333				1			1					
MAYT ANG	2	0	50	0	0	1	0	33.3333					1	1						
RAPH GAL	7	0	50	0	0	1	0	33.3333					1	1						
THEM TRI	262	0	100	100	0	1	1	66.6667				1	1	1	1	1	1	1	1	1
SETA SPH	212	0	75	40	0	1	1	66.6667				1	1	1			1		1	
VERN NAT	124	0	50	60	0	1	1	66.6667				1		1		1	1	1	1	
HETE CON	173	100	50	0	1	1	0	66.6667	1	1	1	1	1							
SENE VEN	114	66.6667	100	0	1	1	0	66.6667	1		1	1	1	1	1					
ERAG RAC	167	100	0	60	1	0	1	66.6667	1	1	1						1		1	1
GNID CAF	16	0	50	100	0	1	1	66.6667				1		1		1	1	1	1	1
CYMB PLU	89	0	50	40	0	1	1	66.6667				1		1		1	1			
ANDR SCH	16	0	25	60	0	1	1	66.6667						1		1	1			1
ARIS DIF	17	33.3333	0	20	1	0	1	66.6667			1								1	
SCHI CRA	62	0	50	100	0	1	1	66.6667				1	1			1	1	1	1	1
PANI NAT	121	66.6667	100	80	1	1	1	100	1	1		1	1	1	1		1	1	1	1
GEIG BUR	51	33.3333	75	20	1	1	1	100		1		1	1	1					1	
ACAL ANG	148	33.3333	25	80	1	1	1	100			1		1			1	1		1	1
TRIS LEU	152	100	50	60	1	1	1	100	1	1	1		1		1	1	1		1	
Total		3	4	5	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1

A community number is assigned to each species using the @If formula

SPESIE	TOTAAL	%Constancy Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	Community 1	Community 2	Community 3	Cluster 1: 052	053	055	Cluster 2: 045	042	043	115	Cluster 3: 086	087	093	104	109
HELI DAS	34	0	0	100	0	0	1	33.33333	0	0	3								1	1	1	1	1
RHUS DIS	69	0	0	60	0	0	1	33.33333	0	0	@IF(H10>0,H$7,0)								1		1		1
FAUR SPE	14	0	50	0	0	1	0	33.33333	0	2	0					1		1					
MALV RNK	3	0	50	0	0	1	0	33.33333	0	2	0					1	1						
ENKE 170	11	0	50	0	0	1	0	33.33333	0	2	0					1		1					
NIDO ANO	16	0	0	60	0	0	1	33.33333	0	0	3								1	1	1		
VERN OLI	40	0	0	60	0	0	1	33.33333	0	0	3								1	1	1		
HYPE DIS	62	100	0	0	1	0	0	33.33333	1	0	0	1	1	1									
ERAG CHL	83	0	0	20	0	0	1	33.33333	0	0	3											1	
HELI NUD	55	0	0	40	0	0	1	33.33333	0	0	3									1			1
HELI CEP	72	0	0	60	0	0	1	33.33333	0	0	3								1	1	1		
SUTE CAE	5	0	50	0	0	1	0	33.33333	0	2	0					1	1						
SP53 004	2	66.6667	0	0	1	0	0	33.33333	1	0	0	1	1										
SP48 011	5	66.6667	0	0	1	0	0	33.33333	1	0	0	1	1										
LOUD FLA	70	100	0	0	1	0	0	33.33333	1	0	0	1	1	1									
SP51 006	5	100	0	0	1	0	0	33.33333	1	0	0	1	1	1									
SENE OXY	19	0	50	0	0	1	0	33.33333	0	2	0					1		1					
SAAM 045	2	0	50	0	0	1	0	33.33333	0	2	0				1			1					
MAYT ANG	2	0	50	0	0	1	0	33.33333	0	2	0					1	1						
RAPH GAL	7	0	50	0	0	1	0	33.33333	0	2	0					1	1						
THEM TRI	202	0	100	100	0	1	1	66.66667	0	2	3				1	1	1	1	1	1	1	1	1
SETA SPH	212	0	75	40	0	1	1	66.66667	0	2	3				1	1	1			1		1	
VERN NAT	124	0	50	80	0	1	1	66.66667	0	2	3				1		1		1	1	1	1	
HETE CON	173	100	50	0	1	1	0	66.66667	1	2	0	1	1	1	1	1							
SENE VEN	114	66.6667	100	0	1	1	0	66.66667	1	2	0	1		1	1	1	1	1					
ERAG RAC	167	100	0	60	1	0	1	66.66667	1	0	3	1	1	1						1		1	1
GNID CAF	16	0	50	100	0	1	1	66.66667	0	2	3				1		1		1	1	1	1	1
CYMB PLU	89	0	50	40	0	1	1	66.66667	0	2	3				1		1		1	1			
ANDR SCH	16	0	25	60	0	1	1	66.66667	0	2	3						1		1	1			1
ARIS DIF	17	33.3333	0	20	1	0	1	66.66667	1	0	3			1								1	
SCHI CRA	62	0	50	100	0	1	1	66.66667	0	2	3				1	1			1	1	1	1	1
PANI NAT	121	66.6667	100	80	1	1	1	100	1	2	3	1	1		1	1	1	1		1	1	1	1
GEIG BUR	51	33.3333	75	20	1	1	1	100	1	2	3		1		1	1	1					1	
ACAL ANG	148	33.3333	25	80	1	1	1	100	1	2	3			1		1			1	1		1	1
TRIS LEU	152	100	50	60	1	1	1	100	1	2	3	1	1	1		1		1	1	1		1	
Total		3	4	5	1	1	1	3				1	1	1	1	1	1	1	1	1	1	1	1

Species sorted according to its community number within each fidelity class

SPESIE	TOTAAL	%Constancy Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	Community 1	Community 2	Community 3
SP53 004	2	66.6667	0	0	1	0	0	33.3333333	1	0	0
SP51 006	5	100	0	0	1	0	0	33.3333333	1	0	0
HYPE DIS	62	100	0	0	1	0	0	33.3333333	1	0	0
LOUD FLA	70	100	0	0	1	0	0	33.3333333	1	0	0
SP48 011	5	66.6667	0	0	1	0	0	33.3333333	1	0	0
RAPH GAL	7	0	50	0	0	1	0	33.3333333	0	2	0
ENKE 170	11	0	50	0	0	1	0	33.3333333	0	2	0
SUTE CAE	5	0	50	0	0	1	0	33.3333333	0	2	0
SENE OXY	19	0	50	0	0	1	0	33.3333333	0	2	0
MAYT ANG	2	0	50	0	0	1	0	33.3333333	0	2	0
MALV RNK	3	0	50	0	0	1	0	33.3333333	0	2	0
SAAM 045	2	0	50	0	0	1	0	33.3333333	0	2	0
FAUR SPE	14	0	60	0	0	1	0	33.3333333	0	2	0
ERAG CHL	83	0	0	20	0	0	1	33.3333333	0	0	3
HELI NUD	55	0	0	40	0	0	1	33.3333333	0	0	3
RHUS DIS	69	0	0	60	0	0	1	33.3333333	0	0	3
NIDO ANO	16	0	0	60	0	0	1	33.3333333	0	0	3
HELI CEP	72	0	0	60	0	0	1	33.3333333	0	0	3
VERN OLI	40	0	0	60	0	0	1	33.3333333	0	0	3
HELI DAS	34	0	0	100	0	0	1	33.3333333	0	0	3
HETE CON	173	100	50	0	1	1	0	66.6666667	1	2	0
SENE VEN	114	66.6667	100	0	1	1	0	66.6666667	1	2	0
ARIS DIF	17	33.3333	0	20	1	0	1	66.6666667	1	0	3
ERAG RAC	167	100	0	60	1	0	1	66.6666667	1	0	3
CYMB PLU	89	0	50	40	0	1	1	66.6666667	0	2	3
GNID CAF	16	0	50	100	0	1	1	66.6666667	0	2	3
SCHI CRA	62	0	50	100	0	1	1	66.6666667	0	2	3
THEM TRI	262	0	100	100	0	1	1	66.6666667	0	2	3
SETA SPH	212	0	75	40	0	1	1	66.6666667	0	2	3
VERN NAT	124	0	50	60	0	1	1	66.6666667	0	2	3
ANDR SCH	16	0	25	60	0	1	1	66.6666667	0	2	3
ACAL ANG	148	33.3333	25	80	1	1	1	100	1	2	3
TRIS LEU	152	100	50	60	1	1	1	100	1	2	3
PANI NAT	121	66.6667	100	80	1	1	1	100	1	2	3
GEIG BUR	51	33.3333	75	20	1	1	1	100	1	2	3
Total		3	4	5	1	1	1	3			

Hierarchical structure created using species groups based on fidelity and constancy values and subjective assessments

SPESIE	TOTAAL	%Constancy Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	Community 1	Community 2	Community 3	Species groups
SP53 004	2	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
SP51 008	5	100	0	0	1	0	0	33.3333333	1	0	0	B
HYPE DIS	62	100	0	0	1	0	0	33.3333333	1	0	0	B
LOUD FLA	70	100	0	0	1	0	0	33.3333333	1	0	0	B
SP48 011	5	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
RAPH GAL	7	0	50	0	0	1	0	33.3333333	0	2	0	B
ENKE 170	11	0	50	0	0	1	0	33.3333333	0	2	0	C
SUTE CAE	5	0	50	0	0	1	0	33.3333333	0	2	0	C
SENE OXY	19	0	50	0	0	1	0	33.3333333	0	2	0	C
MAYT ANG	2	0	50	0	0	1	0	33.3333333	0	2	0	C
MALV RNK	3	0	50	0	0	1	0	33.3333333	0	2	0	C
SAAM 045	2	0	50	0	0	1	0	33.3333333	0	2	0	C
FAUR SPE	14	0	50	0	0	1	0	33.3333333	0	2	0	C
ERAG CHL	83	0	0	20	0	0	1	33.3333333	0	0	3	D
HELI NUD	55	0	0	40	0	0	1	33.3333333	0	0	3	D
RHUS DIS	69	0	0	60	0	0	1	33.3333333	0	0	3	D
NIDO ANO	18	0	0	60	0	0	1	33.3333333	0	0	3	D
HELI CEP	72	0	0	60	0	0	1	33.3333333	0	0	3	D
VERN OLI	40	0	0	60	0	0	1	33.3333333	0	0	3	D
HELI DAS	34	0	0	100	0	0	1	33.3333333	0	0	3	D
HETE CON	173	100	50	0	1	1	0	66.6666667	1	2	0	A
SENE VEN	114	66.6667	100	0	1	1	0	66.6666667	1	2	0	A
ARIS DIF	17	33.3333	0	20	1	0	1	66.6666667	1	0	3	G
ERAG RAC	167	100	0	60	1	0	1	66.6666667	1	0	3	G
CYMB PLU	69	0	50	40	0	1	1	66.6666667	0	2	3	E
GNID CAF	10	0	50	100	0	1	1	66.6666667	0	2	3	E
SCHI CRA	62	0	50	100	0	1	1	66.6666667	0	2	3	E
THEM TRI	262	0	100	100	0	1	1	66.6666667	0	2	3	E
SETA SPH	212	0	75	40	0	1	1	66.6666667	0	2	3	E
VERN NAT	124	0	50	80	0	1	1	66.6666667	0	2	3	E
ANDR SCH	18	0	25	60	0	1	1	66.6666667	0	2	3	E
ACAL ANG	148	33.3333	25	80	1	1	1	100	1	2	3	F
TRIS LEU	152	100	50	60	1	1	1	100	1	2	3	F
PANI NAT	121	66.6667	100	80	1	1	1	100	1	2	3	F
GEIG BUR	51	33.3333	75	20	1	1	1	100	1	2	3	F

Species sequence created using the species group order, each species group was sorted in a decending order based on constancy

SPESIE	Spp sequence	TOTAAL	%Constancy Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	Community 1	Community 2	Community 3	Species groups
HETE CON	1	173	100	50	0	1	1	0	66.6666667	1	2	0	A
SENE VEN	2	114	66.6667	100	0	1	1	0	66.6666667	1	2	0	A
HYPE DIS	3	62	100	0	0	1	0	0	33.3333333	1	0	0	B
SP51 008	4	5	100	0	0	1	0	0	33.3333333	1	0	0	B
LOUD FLA	5	70	100	0	0	1	0	0	33.3333333	1	0	0	B
SP53 004	6	2	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
SP48 011	7	5	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
ENKE 170	8	11	0	50	0	0	1	0	33.3333333	0	2	0	C
SUTE CAE	9	5	0	50	0	0	1	0	33.3333333	0	2	0	C
SENE OXY	10	19	0	50	0	0	1	0	33.3333333	0	2	0	C
MAYT ANG	11	2	0	50	0	0	1	0	33.3333333	0	2	0	C
SAAM 045	12	2	0	50	0	0	1	0	33.3333333	0	2	0	C
RAPH GAL	13	7	0	50	0	0	1	0	33.3333333	0	2	0	C
MALV RNK	14	3	0	50	0	0	1	0	33.3333333	0	2	0	C
FAUR SPE	15	14	0	50	0	0	1	0	33.3333333	0	2	0	C
HELI DAS	16	34	0	0	100	0	0	1	33.3333333	0	0	3	D
VERN OLI	17	40	0	0	60	0	0	1	33.3333333	0	0	3	D
RHUS DIS	18	69	0	0	60	0	0	1	33.3333333	0	0	3	D
HELI CEP	19	72	0	0	60	0	0	1	33.3333333	0	0	3	D
NIDO ANO	20	18	0	0	60	0	0	1	33.3333333	0	0	3	D
HELI NUD	21	55	0	0	40	0	0	1	33.3333333	0	0	3	D
ERAG CHL	22	83	0	0	20	0	0	1	33.3333333	0	0	3	D
SCHI CRA	23	62	0	50	100	0	1	1	66.6666667	0	2	3	E
CYMB PLU	24	69	0	50	40	0	1	1	66.6666667	0	2	3	E
GNID CAF	25	10	0	50	100	0	1	1	66.6666667	0	2	3	E
VERN NAT	26	124	0	50	60	0	1	1	66.6666667	0	2	3	E
SETA SPH	27	212	0	75	40	0	1	1	66.6666667	0	2	3	E
THEM TRI	28	262	0	100	100	0	1	1	66.6666667	0	2	3	E
ANDR SCH	29	18	0	25	60	0	1	1	66.6666667	0	2	3	E
GEIG BUR	30	51	33.3333	75	20	1	1	1	100	1	2	3	F
PANI NAT	31	121	66.6667	100	80	1	1	1	100	1	2	3	F
ACAL ANG	32	148	33.3333	25	80	1	1	1	100	1	2	3	F
TRIS LEU	33	152	100	50	60	1	1	1	100	1	2	3	F
ARIS DIF	34	17	33.3333	0	20	1	0	1	66.6666667	1	0	3	G
ERAG RAC	35	167	100	0	60	1	0	1	66.6666667	1	0	3	G

Table sorted in alphabetical ordering using the species list

SPESIE	Spp sequence	TOTAAL	%Constancy Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3	%Fidelity	Community 1	Community 2	Community 3	Species groups
ACAL ANG	32	148	33,3333	25	80	1	1	1	100	1	2	3	F
ANDR SCH	29	16	0	25	60	0	1	1	66.6666667	0	2	3	E
ARIS DIF	34	17	33,3333	0	20	1	0	1	66.6666667	1	0	3	G
CYMB PLU	24	89	0	50	40	0	1	1	66.6666667	0	2	3	E
ENKE 170	8	11	0	50	0	0	1	0	33.3333333	0	2	0	C
ERAG CHL	22	83	0	0	20	0	0	1	33.3333333	0	0	3	D
ERAG RAC	35	187	100	0	60	1	0	1	66.6666667	1	0	3	G
FAUR SPE	15	14	0	50	0	0	1	0	33.3333333	0	2	0	C
GEIG BUR	30	51	33,3333	75	20	1	1	1	100	1	2	3	F
GNID CAF	25	16	0	50	100	0	1	1	66.6666667	0	2	3	E
HELI CEP	19	72	0	0	60	0	0	1	33.3333333	0	0	3	D
HELI DAS	16	34	0	0	100	0	0	1	33.3333333	0	0	3	D
HELI NUD	21	55	0	0	40	0	0	1	33.3333333	0	0	3	D
HETE CON	1	173	100	50	0	1	1	0	66.6666667	1	2	0	A
HYPE DIS	3	62	100	0	0	1	0	0	33.3333333	1	0	0	B
LOUD FLA	5	70	100	0	0	1	0	0	33.3333333	1	0	0	B
MALV RNK	14	3	0	50	0	0	1	0	33.3333333	0	2	0	C
MAYT ANG	11	2	0	50	0	0	1	0	33.3333333	0	2	0	C
NIDO ANO	20	18	0	0	60	0	0	1	33.3333333	0	0	3	D
PANI NAT	31	121	66.6667	100	80	1	1	1	100	1	2	3	F
RAPH GAL	13	7	0	50	0	0	1	0	33.3333333	0	2	0	C
RHUS DIS	18	69	0	0	60	0	0	1	33.3333333	0	0	3	D
SAAM 045	12	2	0	50	0	0	1	0	33.3333333	0	2	0	C
SCHI CRA	23	62	0	50	100	0	1	1	66.6666667	0	2	3	E
SENE OXY	10	19	0	50	0	0	1	0	33.3333333	0	2	0	C
SENE VEN	2	114	66.6667	100	0	1	1	0	66.6666667	1	2	0	A
SETA SPH	27	212	0	75	40	0	1	1	66.6666667	0	2	3	E
SP48 011	7	5	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
SP51 006	4	5	100	0	0	1	0	0	33.3333333	1	0	0	B
SP53 004	6	2	66.6667	0	0	1	0	0	33.3333333	1	0	0	B
SUTE CAE	9	5	0	50	0	0	1	0	33.3333333	0	2	0	C
THEM TRI	28	262	0	100	100	0	1	1	66.6666667	0	2	3	E
TRIS LEU	33	152	100	50	60	1	1	1	100	1	2	3	F
VERN NAT	26	124	0	50	80	0	1	1	66.6666667	0	2	3	E
VERN OLI	17	40	0	0	60	0	0	1	33.3333333	0	0	3	D
Total			3	4	5	1	1	1	3				

Alphabetical species list, species sequence and cover abundance values combined

```
                           0   0   0     0   0   0   1     0   0   0   1   1
                           5   5   5     4   4   4   1     8   8   9   0   0
SPESIE    Spp sequence     2   3   5     5   2   3   5     6   7   3   4   9
**********
ACAL ANG            32 |           1 |       1         | +   +       +   +   |
ANDR SCH            29 |             |         +       | +   +           +   |
ARIS DIF            34 |         +   |                 |             +       |
CYMB PLU            24 |             | +       +       | +     1             |
ENKE 170             8 |             |     +       +   |                     |
ERAG CHL            22 |             |                 |             +       |
ERAG RAC            35 |   1   1 +   |                 |     +       +   +   |
FAUR SPE            15 |             |     +         1 |                     |
GEIG BUR            30 |     +       | +   +     1     |             +       |
GNID CAF            25 |             | +       +       | +   +   +   +   +   |
HELI CEP            19 |             |                 | +   +   +           |
HELI DAS            16 |             |                 | +   +   +   +   +   |
HELI NUD            21 |             |                 |     +           +   |
HETE CON             1 |   1   1 +   | +   +           |                     |
HYPE DIS             3 | B   B     1 |                 |                     |
LOUD FLA             5 | A   A     1 |                 |                     |
MALV RNK            14 |             |       1   1     |                     |
MAYT ANG            11 |             |     +   +       |                     |
NIDO ANO            20 |             |                 | +   +   +           |
PANI NAT            31 |   1   1     | +   A     1 +   |     +   +   +   +   |
RAPH GAL            13 |             |     +   +       |                     |
RHUS DIS            18 |             |                 | +       +       +   |
SAAM 045            12 |             | +           +   |                     |
SCHI CRA            23 |             | +   +           | +   +   +   +   +   |
SENE OXY            10 |             |     +       +   |                     |
SENE VEN             2 | +         1 | +     1   1 +   |                     |
SETA SPH            27 |             | +   +   +       |     +       +       |
SP48 011             7 |   1   1     |                 |                     |
SP51 006             4 |   1   1 +   |                 |                     |
SP53 004             6 |   1   1     |                 |                     |
SUTE CAE             9 |             |       1 +       |                     |
THEM TRI            28 |             | +     1 +   +   |   3 A     3 +     1 |
TRIS LEU            33 |   1   1 +   |     +       +   |   1 +       +       |
VERN NAT            26 |             | +       +       |   1   1 A   A       |
VERN OLI            17 |             |                 | +   +   +           |
```

Cover abundance values sorted according to species sequence

SPESIE	Spp sequence	052	053	055	045	042	043	115	086	087	093	104	109
HETE CON	1	1	1	+	+	+							
SENE VEN	2	+		1	+	1	1	+					
HYPE DIS	3	B	B	1									
SP51 006	4	1	1	+									
LOUD FLA	5	A	A	1									
SP53 004	6	1	1										
SP48 011	7	1	1										
ENKE 170	8					+		+					
SUTE CAE	9					1	+						
SENE OXY	10					+		+					
MAYT ANG	11					+	+						
SAAM 045	12				+			+					
RAPH GAL	13					+	+						
MALV RNK	14					1	1						
FAUR SPE	15					+		1					
HELI DAS	16								+	+	+	+	+
VERN OLI	17								+	+	+		
RHUS DIS	18								+		+		+
HELI CEP	19								+	+	+		
NIDO ANO	20								+	+	+		
HELI NUD	21									+			+
ERAG CHL	22											+	
SCHI CRA	23				+	+			+	+	+	+	+
CYMB PLU	24				+		+		+	1			
GNID CAF	25				+		+		+	+	+	+	+
VERN NAT	26				+		+		1	1	A	A	
SETA SPH	27				+	+	+			+		+	
THEM TRI	28				+	1	+	+	3	A	3	+	1
ANDR SCH	29						+		+	+			+
GEIG BUR	30		+		+	+	1					+	
PANI NAT	31	1	1		+	A	1	+		+	+	+	+
ACAL ANG	32			1		1			+	+		+	+
TRIS LEU	33	1	1	+		+		+	1	+		+	
ARIS DIF	34			+								+	
ERAG RAC	35	1	1	+						+		+	+

al phytosociological table

SPESIE	052	053	055	045	042	043	115	086	087	093	104	109
Community	1			1				2				
Sub-community	1.1			1.2								
Diagnostic species group A												
HETE CON	1	1	+	+	+							
SENE VEN	+		1	+	1	1	+					
Diagnostic species group B												
HYPE DIS	B	B	1									
SP51 006	1	1	+									
LOUD FLA	A	A	1									
SP53 004	1	1										
SP48 011	1	1										
ENKE 170					+		+					
SUTE CAE					1	+						
SENE OXY					+		+					
MAYT ANG					+	+						
SAAM 045				+			+					
RAPH GAL					+	+						
MALV RNK					1	1						
FAUR SPE					+		1					
Diagnostic species group C												
HELI DAS								+	+	+	+	+
VERN OLI								+	+	+		
RHUS DIS								+		+		+
HELI CEP								+	+	+		
NIDO ANO								+	+	+		
HELI NUD									+			+
ERAG CHL											+	
Diagnostic species group D												
SCHI CRA				+	+			+	+	+	+	+
CYMB PLU				+		+		+	1			
GNID CAF				+		+		+	+	+	+	+
VERN NAT				+		+		1	1	A	A	
SETA SPH				+	+	+			+		+	
THEM TRI				+	1	+	+	3	A	3	+	1
ANDR SCH						+		+	+			+
Constant species group E												
GEIG BUR		+		+	+	1					+	
PANI NAT	1	1		+	A	1	+		+	+	+	+
ACAL ANG			1		1			+	+		+	+
TRIS LEU	1	1	+		+		+	1	+		+	
ARIS DIF			+								+	
ERAG RAC	1	1	+						+		+	+

APPENDIX G

Insasp	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
All seasons, NE - NW	52	3	2	[illegible]				8	2	2	2	4	4	2		5	1	3	2
Autumn & spring afternoons, NW - W	6														1				
Autumn & spring mornings, E - NE	6		1					1					1		1	1			
Summer afternoons, W - SW	14								1	1						1		2	
Summer mornings, E - SE	28							1			1		2		2	1	1	2	1
Seldom, SE - SW	20		1					2					2		1				2
Always, no aspect	10			1		1	1	5						1			1	4	
Inslit	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Flat, east facing	2					1	1												
Flat, south west facing	2				1		1												
Flat, west facing	2			2															
Flat, south east facing	8			1		2					1						1	2	1
Flat, south facing	9			2	1	3									1				2
Flat, north facing	13	1		1			3		1				1			3		1	2
Flat, no aspect	16			1		1	1	5						1			1	6	
Gentle, west facing	6			1		1	3								1				
Gentle, east facing	7		1	1		1		1					1		1	1			
Gentle, south facing	11		1	7				2					1						
Gentle, south west facing	12			4		1	2		1	1						1		2	
Gentle, south east facing	17			7	3	3		1					2		2	1			
Gentle, north facing	38	2	2		2	2	6	6	1	2	2	4	3	1		2	1	2	
Steep, north facing	1													1					
Steep, south east facing	1					1													
Soilset	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
ab030	3							2						1					
ac104	2														1	1			
ac106	2						1	1											
ac079	3		1			1		1											
ac102	3						2	1											
ac107	3							2								1			
ac039	4				1		3												
ac073	4				1	2	1												
ac037	5						2	2							1				
ac072	6																	6	
ac043	7					3												4	
ac077	8			6	1	1													
ad009	1						1												
ad011	5						3	1								1			
ad010	10					5	2											3	
ae094	4															2	2		
ae105	4					1				1	2								
be045	2														2				
ca017	2						2												
fa104	1				1														
fa195	1												1						
fa336	1				1														
fa002	3																		2
fa362	2								1							1			
fa310	3			1		1		1											
fa198	4												2	2					
fa366	8							1	2		1					1	1		
fa189	10		1	1		1		3		2			2						
fa188	15	3		1								4	2		1	1			3
fa337	22		2	18		1							1						
Soilalt	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
630	4					1				1	2								
650	10		1	1		1		3		2			2						
750	4															2	2		
900	21	3		1				1	2		1	4	2		1	2	1		3
1060	3							2								1			
1100	3							2						1					
1150	3		1			1		1											
1200	7												3	2	1	1			
1280	22		2	19		1							1						
1300	2														2				
1350	5			1		1	1	2											
1450	17			6	3	1	2	2	1						1	1			
1480	6																	6	
1500	17					8	2											7	
1550	1						1												
1560	8						5	2								1			
1650	8				2	2	4												
1700	4						2												2
Soilform	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Streambed/ [illegible]	1																1		
Katspruit	21		1							1					3	6	1	6	2
Avalon	2						1								1				
Griffin	7						1	1							1			4	
Clovelly/ Wesbank	1						1												
Clovelly	5					2	1	1										1	
Hutton	35		1	6		6	9	4	1		1	1	3					1	2
Hutton/ Shortlands	3															2	1		
Glenrosa	45	3	2	21	2	4		4		1		3	3	2					
Mispah	1							1											
Hutton/ Rock	2					1					1								
Rock/ Clovelly	5					2	3												
Rock/ Hutton/ Shortlands	1										1								
Rock/ Mispah	8				3	1	1	3										1	
Rock	7							1	2	1			2	1					
Soiltex	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
A:fi/meSaLm-SaCl	1															1			
A:meSaLm-SaClLm	1															1			
A:SaCl,ClLm,Cl	1																	1	
A:SaClLm	1															1			
A:co/meSaClLm	2													2					
A:me/coSa-SaClLm	2															1	1		
A:me/fiSaClLm	2																	2	
A:meSaClLm-SaCl	2					2													
A:SaClLm-SaCl	2														1	1			
A:fiSaCl-Cl	3																	3	
A:me/coSaClLm	3						2	1											
A:me/coSaLm-SaClLm	3							1	2										
A:coSa-LmSa	4														1	1			2
A:fi/meSaLm-SaClLm	4			1		1		1					1						
A:fiSaClLm	8			1		1		3		1			2						
A:coSa-SaLm	11	3		1								4	2						1
A:fiSaClLm-SaCl	37		3	18	1	7	1	1					1				1	2	2
B:me/coSaClLm-SaCl	1							1											
B:co/meSaClLm-SaCl	2												2						
B:me/fiSaClLm-SaCl	3					1												2	
B:me/coSaLm-SaCl	4					1				1	2								
B:fi/meSaClLm-SaCl	5				2		3												
B:fi/meSaLm-SaClLm	5						4	1											
B:fiSaClLm-SaCl	5		1							1						2	1		
B:fiSaCl-Cl	6				1	2	1											2	
B:SaCl	6						1	3	1		1								
B:SaCl-Cl	7						3	1							2			1	
B:SaCl,ClLm,Cl	11			6	1	1		2						1					
E:fiSaLm-SaCl	1						1												
E:Lm/me/coSa-SaLm	1						1												
E:me/coSaLm-SaClLm	1														1				
Soildepth	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
0100-0350	3												1	2					
0100-0400	1																	1	
0100-0800	3						2	1											
0150-0350	8			1		1		3		1			2						
0200-0400	4			1	1	1		1											
0200-0450	4					2							2						
0200-0500	1						1												
0200-0600	30		2	18	1	6	1						1					1	
0200-0700	5							1	2							1	1		
0300-0400	11	3		1								4	2						1
0300-0500	4														1	1			2
0300-0600	14		1			2		1		1	2				1	4		2	
0300-0700	2																		2
0300-0800	1										1								
0400-0750	1														1				
0400-0800	2							1							1				
0400-0900	5					1	1											3	
0400-1000	1								1										
0400-1200+	2		1							1									
0450-1200	4				1		3												
0450-1200+	3															2	1		
0500-0700	3																	3	
0500-1200+	15			6	2	3	1										1	2	
0600-0900	1						1												
0600-1200	8						4	1							1				
0900-1200	1																	1	
0900-1200+	8						3	4						1					
1200+	2							2											
Terrain	Total Of Perrock	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Closed hills and mountains with moderate and high relief	21.6066665517241	6	37.5	5.425926	33	30.9375	8.5294118	24.66667	33.333333	10	18.666667	62.5	65.625	73.333333	1	15	0	17.461538	0
Rocksize	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
None	69	2	2	6	3	6	13	8	1	1	2				4	6	3	7	5
Gravel	3					3													
Pebble	1						1												
Pebbles	6					1		1		2								2	
Stones	38	1		20		2	1	4	1			1	3		1	1		3	
Stones/Rocks	1					1													
Rocks	28		2	1	2	3	3	3	1		1	3	8	3		3		1	
Physclas	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Pure low closed grassland	44			8		10	8	4								2		8	5
Low closed grassland	5			3		1													
Pure short closed grassland	8	3					1						1		1			2	
Short closed grassland	5						1	2							2				
Low/ short sparse shrubland	41		3	17	2	5	5	5		1		2	5	1					
Low/ short bushland	16		1				1		1	1	1				2	5	2	2	
Low/ short thicket	19			4	3			4	1	1		2	2	1					
Low/ short sparse woodland	6								1		2			1		1	1		
Terrain	Total Of Numbspp	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Closed hills and mountains with moderate and high relief	36.2758620689655	30.666667	30.75	38.96296	50.6	37.5	33.058824	44.73333	50.333333	37.666667	35.666667	40.25	40.75	20.333333	29.8	28.75	37.333333	28	14.6
Acocks	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
North-eastern Mountain Sourveld	17		3	9	2	1				1			1						
Lowveld Sour Bushveld	18		1			6	1	1		1				2		2	1	3	
Lowveld	7										2								
North-eastern Sandy Highveld	24				2	8	7								1			6	2
Piet Retief Sourveld	71	3		18	1	3	7	11	1	1		4	7	1	3	3	1	4	3
Northern Tall Grassveld (transition between Piet Retief Sourveld and Southern Tall Grassveld	13						2	3	2		1				1	3			
VegLow	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Afromontane Forest	3						2	1											
Sour Lowveld Bushveld	42		4	28	1	5		1		3	2		1						
Wet Sandy Highveld Grassland	8				1		3		1						2	1			
North-eastern Mountain Grassland	92	3		1	3	11	12	13	2	1	1	4	7	3	3	7	3	13	5
Pastclas	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Flat (0-8%)	87	2		8	3	10	10	10	2	2	3	3	2	1	5	7	3	11	5
Medium (8-15%)	28	1	1	4	1	4	8	4	1			1	2			1		2	
Steep (16-25%)	15		3	6	1	1	1	1		1			1						
Very steep >25%	15			9		1							3	2					
Broaclas	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Crop growth (0-15%)	114	3	1	11	4	14	10	14	3	2	3	4	4	1	5	6	3	13	5
Grazing (15-30%)	22		3	1	1	1	1	1		1			2						
Wildlife & Afforestation >30%	8			4									2	2					
Landuse	Total Of ID	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14	I15	I16	I17	I18
Annual cropping (0-3%)	55	2		1		2	6	5	1		3		1	1	2	3	3	9	5
Ley or special (age 4-7%)	28				1	2	4	5	1	2		2	1		2	4	1	2	
Rotation of ley and crops (8-12%)	25	1		3		4	4	3	1			3	1		1	1		2	
Permanent cover crop (13-20%)	11			1	1	2	3	2		1			1						
Natural veld or afforestation (21-30%)	15		3	10	1								2						
Wildlife or afforestation >31%	7			2		1							2	2					

Southeastern Mpumalanga Mountains Vegetation Type

	Veld type	South-eastern																		
	Ecosystem		1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
	Cutlevel 2		1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.1	2.1	2.1	2.2	2.2
	Cutlevel 3		1.1.1	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2	1.2.1	1.2.1	1.2.1	1.2.1	1.2.2	1.2.2	1.2.2	2.1.1	2.1.2	2.1.2	2.2.a	2.2.b
	Cutlevel 4		1.1.1.1	1.1.1.2	1.1.1.2	1.1.2.1	1.1.2.1	1.1.2.2	1.2.1.1	1.2.1.2	1.2.1.2	1.2.1.2	1.2.2.1	1.2.2.1	1.2.2.2		2.1.2.a	2.1.2.b		
	Cutlevel 5			1.1.1.2.a	1.1.1.2.b	1.1.2.1.a	1.1.2.1.b			1.2.1.2.1	1.2.1.2.1	1.2.1.2.2	1.2.2.1.a	1.2.2.1.b						
	Cutlevel 6									1.2.1.2.1.a	1.2.1.2.1.b									
	Community		1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.10	1.11	2.1	2.2	2.3	2.4	2.5
	Sub-community			1.2.a	1.2.b								1.10.a	1.10.b						
Eon	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Phanerozoic		20				1		9	4	1						2	3			
Cryptozoic		125	3	4	27	4	16	8	11	2	3	3	4	8	3	3	5	3	13	5
Erathem	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Mesozoic		7						4	3											
Paleozoic		13				1		5	1	1						2	3			
Proterozoic		35				2	11	3	3						1				13	2
Archaeozoic		8		3	2						1			2						
Archaean		82	3	1	25	2	5	5	8	2	2	3	4	6	2	3	5	3		3
System	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
		20				1		9	4	1						2	3			
Precambrian		125	3	4	27	4	16	8	11	2	3	3	4	8	3	3	5	3	13	5
NeoEra	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Phanerozoic		20				1		9	4	1						2	3			
Vaalian		35				2	11	3	3						1				13	2
Swazian		82	3	1	25	2	5	5	8	2	2	3	4	6	2	3	5	3		3
Archaean		8		3	2						1			2						
Petro	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Sedimentary		50		1		4	12	8	5	1					1	2	3		11	2
Metamorphic		19	3		1								4	6		1	1			3
Igneous		76		3	26	1	4	9	10	2	3	3		2	2	2	4	3	2	
Litho	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Arenite		12		1		2	1	2	1	1						2	2			
Shale		38				2	11	6	4						1		1		11	2
Gneiss		19	3		1								4	6		1	1			3
Andesite		2																	2	
Syenite		2													2					
Dolerite		7						4	3											
Ultramafic rocks		8		3	2						1			2						
Granite		19						5	4	2		3				2	2	1		
Lava		38			24	1	4		3		2						2	2		
Strat	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Ecca		13				1		5	1	1						2	3			
Pretoria		34				1	11	3	3						1				13	2
Transvaal		1				1														
Barberton		42		1	24	2	5		4		2						2	2		
Unnamed		55	3	3	3			9	7	2	1	3	4	8	2	3	3	1		3
Grpform	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Karoo dolerite		7						4	3											
Vryheid		7						2		1						2	2			
Pietermaritzburg		2							1								1			
Volksrust		4				1		3												
Hekpoort		2																	2	
Silverton		27				1	10	3											11	2
Timeball Hill		5					1		3						1					
Pretoria		1				1														
Bosmanskop Syenite		2													2					
Kaap Valley Granite		2										2								
Moodies		4		1		1	1		1											
Onverwacht		38			24	1	4		3		2						2	2		
Unnamed		44	3	3	3			5	4	2	1	1	4	8		3	3	1		3
Terrgrp	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Closed hills and mountains with moderate and high relief		145	3	4	27	5	16	17	15	3	3	3	4	8	3	5	8	3	13	5
Terrtype	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Low mountains		37				1	2	11	6	3		3				3	5	1	2	
High mountains		108	3	4	27	4	14	6	9		3		4	8	3	2	3	2	11	5
Tlymat	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
50 - 80% of area, slope < 8%, local relief 30 - 90 m		8						3	3						1		1			
80%> of area, slope < 8%, local relief 30 - 90 m		7						3	3								1			
50 - 80% of area, slope < 8%, local relief 90 - 150 m		18				1	3	5	3		1	2				3				
80%> of area, slope < 8%, local relief 90 - 150 m		18				1	1	4									2	2	8	
<20% of area, slope < 8%, local relief 150 - 300 m		12			6	1	1			1						1	2			
20 - 50% of area, slope < 8%, local relief 150 -300 m		48		3	20	2	3		5	2	2	1		6	2		1	1		
50 - 80% of area, slope < 8%, local relief 150 - 300 m		31	3		1		7	2					4	2		1	1		5	5
<20% of area, slope < 8%, local relief 300 - 900 m		3		1			1		1											
Terunit	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Crest		28		1	1	2	9	4	4			1	2	2	1				1	
Scarp		18				3	2	1	5	2	1			2	1				1	
Midslope		55	3	2	26		5	8	6		1	1	1	1	1					
Footslope		22						3	1	1		1	1	3		2	2	1	5	2
Valley bottom		22		1							1					3	6	2	6	3
Unitper	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Footslope or valley bottom (0 - 12)		103	3	1	10	3	13	13	12	3	2	3	4	3	1	5	8	3	11	5
Midslope or crest (12 - 100)		42		3	17	2	3	4	3		1			5	2				2	
Terrgrp	Total Of Slpdeg		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Closed hills and mountains with moderate and high relief		5.46303650942342	2.6877424	10.865165	9.773813	5.2158769	5.3852551	3.9808484	3.392399	2.9001732	6.0911356	1.3943857	4.3441446	10.820316	157[illegible]088	3.3748306	2.4121799	1.0932354	1.655079	0.9763989
Terrgrp	Total Of Slpper		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Closed hills and mountains with moderate and high relief		9.74168611292182	4.7003309	19.259043	17.34877	9.1975508	9.8000035	6.9824829	5.950006	5.0723859	10.700905	2.4346512	7.6006909	19.341194	28.577263	5.898733	4.2164858	1.909916	2.8998597	1.7044166
Terrgrp	Total Of Aspdeg		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Closed hills and mountains with moderate and high relief		165.835698660017	331.74674	242.95807	173.4418	173.24169	131.48535	255.93498	106.5113	78.809105	305.67832	43.311375	260.49376	107.63106	225.66901	137.93378	182.44017	149.38278	110.07064	106.06089
Terrgrp	Total Of Posheight		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
Closed hills and mountains with moderate and high relief		1352.92806817418	1183.4406	1250.5969	1420.714	1591.0777	1482.6211	1537.0561	1285.793	1101.0589	982.08311	789.17729	1010.9356	1153.5484	1284.5679	1365.912	1190.3974	950.3831	1589.3394	1348.6771
Date	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
195		53		1		4	14	4	8		2	2			1	1	3		13	
294		3						1						1		1				
295		17						5	2	2		1					2	3		2
394		7							1				4		2					
395		10						3	4							1	2			
494		32		3	26			1			1			1						
495		8				1		3		1						2	1			
594		13	3		1									6						3
595		2					2													
Alticles	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
80		2										2								
90		11					2			1	2	1					3	2		
100		6						2	3	1										
110		9											4	2				1		2
120		14	3		1		1		3					4			1			1
130		17		4	2		1		3		1			2	2	1	1			
140		14			7			1	3						1	1	1			
150		32			17	2	1	3		1						3	1		4	
160		8					2	1											5	
170		28				2	8	8	3								1		4	2
180		4				1	1	2												
Cimzone	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
0051a		4				1	2	1												
0052a		21			1	1	9	2	1										7	
0054a		1						1												
0056a		4				1		3												
0057a		2						2												
0111a		2														2				
0112a		6							1	2		1					1	1		
0118a		10						2	2					3	2	1				
0119a		15	3		1								4	2		1	1			3
0120a		10		1	1		1		3		2			2						
0121a		4															2	2		
0247a		2								1							1			
0249a		3						2	1											
0250a		5						3	1								1			
0252a		2														1	1			
0253a		2						1	1											
0256a		3							2								1			
0949a		8			6	1	1													
1068a		2																		2
1078a		3							2						1					
1090a		1				1														
1089a		22		2	18		1							1						
1093a		3		1			1		1											
1095a		4					1				1	2								
1105a		6																	6	
Avgrain	Total Of ID		11	12	13	14	15	16	17	18	19	110	111	112	113	114	115	116	117	118
656.4		4															2	2		
719.0		4					1				1	2								
720.3		4				1	2	1												
724.7		2						2												
733.4		4				1		3												
737.6		10		1	1		1		3		2			2						
758.5		6																	6	
775		2								1							1			
794.3		7					3												4	
794.6		14			1	1	6	2	1										3	
821.9		2														2				
838.8		6							1	2		1					1	1		
850		3							2						1					
856.9		10						2	2					3	2	1				
861		2																		2
872		1						1												
869.3		8			6	1	1													
891.6		2														1	1			
894.1		15	3		1								4	2		1	1			3
913.5		3		1			1		1											

[illegible]	11		2			1	2	3	1			1		1
Autumn & spring afternoons, NW - W	4	1					2					1		
Autumn & spring mornings, E - NE	20				5	2	5	2				1		1
Summer afternoons, W - SW	9						3		1		2		2	
Summer morings, E - SE	8				2	2	1			2				
Seldom, SE - SW	41					4	13	2	4	5		2	4	
Always, no aspect	16		1	1	1		4	5			1	1		2
Invsart	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Flat, south east facing	2			1			1							
Flat, north facing	6		2			1	1	1				1		
Flat, east facing	7			1	2		3	1						
Flat, south facing	[illegible]		1	1		3	3	2	2	1		1	1	
Flat, no aspect	18		1	1	1		4	5			1	1		2
Gentle, west facing	4	1					2					1		
Gentle, north facing	5						1	2	1					1
Gentle, south east facing	6				2	2				2				
Gentle, south west facing	9		1				3		1		2		2	
Gentle, east facing	13	1	2		3	2	2	1				1		1
Gentle, south facing	26	1	2	2		1	10		2	4		1	3	
Soilpat	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
ab027	4			1			1	2						
ab066	4		1			1	1					1		
ab067	9		1	1		4	1					2		
ac043	1												1	
ac040	2													2
ac107	2			1	1									
ac035	3						2	1						
ac037	3		1					1					1	
ac104	3				2							1		
ac109	3						3							
ac041	4	1								2				1
ac042	6	1								4			1	
ac034	7			2	1		2		1		1			
ac038	14	1	2					5	1	1			3	1
ac106	14		1		3		7				2	1		
ad009	2		1		1									
ea096	10		1	1		3	5							
fa164	1							1						
fa166	1								1					
fa366	6					1	3	2						
fa163	10		1				5		3			1		
Soilalt	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
900	17		1	1		4	8	2	1					
940	9		1	1		4	1					2		
1050	4			1			1	2						
1060	2			1	1									
1150	7		1			1	4					1		
1170	7			2	1		2		1		1			
1200	16		1		2		7	1	3			2		
1270	14	1	2					5	1	1			3	1
1350	14		1		3		7				2	1		
1450	4		1					2					1	
1500	1												1	
1550	6	1	1		1					2				1
1700	8	1								4			1	2
Soilform	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Streambed	3		2	1										
Streambed/ Rensburg	2		1	1										
Katspruit	14	2	8	3	3									
Mayo/ Milkwood	3					2	1							
Rock/ Mayo/ Milkwood	1					1								
Hutton/ Shortlands	3			1			2							
Bonheim/ Avalon/ Hutton	1						1							
Griffin	10				4		4	2						
Hutton	34	1			1	1	14	6	2	5		1	2	1
Shortlands	3						3							
Glenrosa	13					1	5	3	4					
Mispah	4					3		1						
Rock/ Mispah	14									2	3	2	4	3
Rock	4					1						3		
Soiltex	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
A:coSa-SaLm	1								1					
A:coSaLm-SaClLm	1											1		
A:fi/meSaClLm-SaCl	1	1												
A:fiSaCl-Cl	1		1											
A:me/coSa-SaLm	1											1		
A:fiSaClLm-SaCl	2			2										
A:meSaLm-SaClLm	2		1		1									
A:SaCl-Cl	3		1	2										
A:fi/coSaClLm	4						3					1		
A:me/coSa-Lmme/coSa	4					3						1		
A:me/coSaClLm	5	1	3					1						
A:SaClLm-SaCl	5		2	1	2									
A:fi/meSaLm-SaClLm	7							1		4			1	1
A:me/coSaLm-SaClLm	18					1	3	7	1	1			3	2
B:Cl	1						1							
B:me/coSaCl-Cl	1						1							
B:me/fiSaClLm-SaCl	1												1	
E:me/coSaLm-SaClLm	1		1											
B:SaClLm-SaCl	2						2							
B:coSaCl-Cl	3						1	2						
B:fi/meSaClLm-SaCl	3	1								2				
B:me/coSaClLm-SaCl	3				1								1	1
B:fiSaCl-Cl	5						2		3					
B:fi/meSaCl-Cl	7				1		3	1	1		1			
B:SaCl-Cl	12				1	3	8							
B:SaCl	15			1	2	2	6				2	2		
Soildepth	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
0100-0200	1											1		
0100-0300	4									3			1	
0100-0350	1							1						
0100-0400	4						3					1		
0100-0600	12							6	1	1			3	1
0200-0300	2									1				1
0200-0400	5					3						2		
0200-0600	1													1
0200-0700	6					1	3	2						
0300-0400	1								1					
0300-0450	4						1		3					
0300-0600	12	2	6	1	3									
0400-0600	4		1	3										
0400-0750	1		1											
0400-0800	1												1	
0400-0900	5			1		1	1					1	1	
0450-0600	2						1	1						
0450-0900	1									1				
0450-1200+	3						1	2						
0500-0800	3		1	1										1
0500-0900	2	1								1				
0500-1200+	2						2							
0600-1200	2				2									
0750-1200+	6				1		2		1		1			
0800-1200	3						3							
0900-1200+	21				1	4	13				2	1		
1200+	1				1									
Terrgrp	Total Of Perrock	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	20.954128440367	38.6666667	10	5.83333333	0	23.3333333	11.9	30.5833333	37.5	18.5714286	53.3333333	48.3333333	9.16666667	63.75
Rcksize	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
None	60	1	7	5	8	4	19	3	3	4	1	1	4	
Gravel	1						1							
Pebbles	4						2	1					1	
Stones	16	1	1				4	5	3	2			1	1
Rocks	26	1	1	1		5	4	3		1	2	5		3
Physcles	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Pure low closed grassland	30	3	5	1	3		5	5	1	5			1	1
Low closed grassland	4				1		2			1				
Pure short closed grassland	11			2	1		7	1						
Short closed grassland	13				2	2	7	2						
Low// short sparse shrubland	28				1	5	7	4	3	1			5	2
Low// short bushland	8		4	3			1							
Low// short thicket	14					2			2		3	6		1
Low// short sparse woodland	1						1							
Terrgrp	Total Of Numbspp	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	39.2644036697248	22.6666667	30.1111111	30.3333333	21.825	48.7777778	36.2666667	44.25	47.6666667	31.1428571	50.6666667	72.3333333	47	39.6
Acocks	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
North-eastern Sandy Highveld	17	2	1					2	1	6			1	4
Bankenveld to Sour Sandveld Transition	2								1		1			
Piet Retief Sourveld	54	1	5	3	5		18	8	4	1	2	2	5	
Northern Tall Grassveld (transition between Piet Retief Sourveld and Southern Tall Grassveld	36		3	3	3	9	12	2				4		
VegLow	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
North-eastern Mountain Grassland	100	3	9	6	8	9	30	12	6	7	3	6	6	4
Pastcles	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Flat (0-8%)	96	2	9	5	8	9	26	11	4	5	2	5	6	4
Medium (9-15%)	12	1		1			4		2	2	1	1		
Steep (16-25%)	1							1						
Eroscles	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Crop growth (0-15%)	106	3	9	6	8	9	30	11	6	5	3	6	6	4
Grazing (15-30%)	3							1		2				
Lnduse	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Annual cropping (0-3%)	46		4	4	3	4	12	9	2	1	1	3	3	2
Ley or special tige (4-7%)	40	1	4	1	3	6	13	2	1	4		2	3	1
Rotation of ley and crops (8-12%)	15	1	1	1	2		6		3		1			1
Permanent cover crop (13-20%)	6	1								2	1	1		
Natural veld or afforestation (21-30%)	1							1						

Southeastern Mpumalanga Hills and Lowlands Vegetation Type

	Veld type	Sou												
	Ecosystem	1	1	1	1	2	2	2	2	2	2	2	2	2
	Cutlevel 2	1.1	1.2	1.2	1.2	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
	Cutlevel 3		1.2.1	1.2.1	1.2.2	2.1.1	2.1.1	2.1.2	2.1.2	2.1.2	2.2.1	2.2.1	2.2.2	2.2.2
	Cutlevel 4		1.2.1.a	1.2.1.b		2.1.1.a	2.1.1.b	2.1.2.1	2.1.2.1	2.1.2.2	2.2.1.a	2.2.1.b	2.2.2.a	2.2.2.b
	Cutlevel 5							2.1.2.1.a	2.1.2.1.b					
	Cutlevel 6													
	Community	1.1	1.2	1.2	1.3	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.7
	Sub-community		1.2.a	1.2.b		2.1.a	2.1.b	2.2.a	2.2.b					
Eon	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Phanerozoic	20		1		5		9	1			2	2		
Cryptozoic	89	3	8	6	3	9	21	11	6	7	1	4	6	4
Erathem	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Mesozoic	7				1		4				1	1		
Palaeozoic	13		1		4		5	1			1	1		
Proterozoic	16	2		1			1	3		6		1	1	1
Archaean	73	1	8	5	3	9	20	8	6	1	1	3	5	3
System	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
	20		1		5		9	1			2	2		
Precambrian	89	3	8	6	3	9	21	11	6	7	1	4	6	4
NasEra	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Phanerozoic	20		1		5		9	1			2	2		
Vaalian	16	2		1			1	3		6		1	1	1
Randian	46	1	5	3	2	3	14	5	5	1	1	1	5	
Swazian	27		3	2	1	6	6	3	1			2		3
Petro	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Sedimentary	21	1	1	1	5		6	2		2	1	1		1
Metamorphic	2		1					1						
Igneous	86	2	7	5	3	9	24	9	6	5	2	5	6	3
Litho	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Arenite	3		1				2							
Quartzite	3			1	1		1							
Tillite	3						2	1						
Shale	12	1			4		1	1		2	1	1		1
Gneiss	2		1					1						
Gabbro	1						1							
Andesite	6	1								4			1	
Dolerite	7				1		4				1	1		
Tuff	10		1	1			4		3		1			
Basalt	12		1	1		3	7							
Quartz monzonite	18	1	3		1			5	2	1			5	
Granite	32		2	3	1	6	8	4	1			4		3
Strat	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Ecca	10		1		4		3				1	1		
Karoo	3						2	1						
Pretoria	11	2						1		6			1	1
Pongola	15		1	2	1	3	8							
Unnamed	70	1	7	4	3	6	17	10	6	1	2	5	5	3
Glgform	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Karoo dolerite	7				1		4				1	1		
Vryheid	3		1				2							
Dwyka	3						2	1						
Pietermaritzburg	7				4		1				1	1		
Timeball Hill	5	1						1		2				1
Hekpoort	6	1								4			1	
Usushwana	1						1							
Mozaan	3			1	1		1							
Amsterdam	10		1	1			4		3		1			
Nauze	12		1	1		3	7							
Mpluze Granite	18	1	3		1			5	2	1			5	
Unnamed	34		3	3	1	6	8	5	1			4		3
Terrgrp	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	109	3	9	6	8	9	30	12	6	7	3	6	6	4
Terrtype	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Undulating hills and lowlands	109	3	9	6	8	9	30	12	6	7	3	6	6	4
Tlpnat	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
80%> of area, slope < 8%, local relief 30 - 90 m	23		1	3	5		9		1		3	1		
50 - 80% of area, slope < 8%, local relief 90 - 150 m	46	2	6	2		8	7	6	1	5		3	5	1
80%> of area, slope < 8%, local relief 90 - 150 m	15		1	1	1		6	3					1	2
<20% of area, slope < 8%, local relief 150 - 300 m	3				2							1		
20 - 50% of area, slope < 8%, local relief 150 - 300 m	21	1	1			1	8	3	3	2		1		1
50 - 80% of area, slope < 8%, local relief 150 - 300 m	1								1					
Terunit	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Crest	31	1				5	9	5	5	3			2	1
Scarp	19					2				2	3	5	4	3
Midslope	25					2	14	5	1	2		1		
Footslope	15			1	5		7	2						
Valley bottom	19	2	9	5	3									
Unitper	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
Footslope or valley bottom (0 - 12)	103	2	9	6	8	9	30	11	6	5	2	5	6	4
Midslope or crest (12 - 100)	6	1						1		2	1	1		
Terrgrp	Total Of Slpdeg	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	2.88318267984128	5.31551727	2.40046518	1.9190978	2.86634442	2.5784037	2.78106875	2.01542999	4.1248338	4.43917962	4.45553573	2.97361306	2.51648185	2.32936978
Terrgrp	Total Of Slpper	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	5.04849857146587	9.31413873	4.19594307	3.35487771	5.01041329	4.50501799	4.65347274	3.55724909	7.2237095	7.78676748	7.61931973	5.20845893	4.39572938	4.07470405
Terrgrp	Total Of Aspdeg	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	130.727132394773	184.347636	135.401716	133.942975	65.1524754	119.155009	138.407184	74.2140935	194.736992	156.205202	152.819667	110.224833	205.428218	105.825508
Terrgrp	Total Of Ftmhgte	21	22	23	24	25	26	27	28	29	210	211	212	213
Open hills, lowlands and mountains with moderate to high relief	1337.23341131648	1656.86104	1333.22365	1173.25051	1280.68193	1092.61572	1234.18359	1387.42188	1382.70107	1721.2443	1345.44702	1229.77445	1598.00655	1561.50793
Date	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
195	37	3	4		1			7	4	7	1		6	4
295	52		4	5	1	9	22	5	2			4		
395	20		1	1	6		8				2	2		
Alticlas	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
110	14		1	2	1	3	4	2				1		
120	23		2	2		6	8	2				3		
130	18		1	2	3		9	1	1		1			
140	19		2		3		8	1	2		2	1		
150	6		1		1		1		2			1		
160	16	1	2					5	1	1			5	1
170	7	1						1		2				3
180	6	1								4			1	
Cimzone	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
0052s	6	1						1		2			1	1
0054s	16	1	3		1			5	1	1			3	1
0111s	3						2	1						
0112s	6					1	3	2						
0113s	3						3							
0114s	10		1				5		3			1		
0115s	11			3	1		3	2	1		1			
0116s	3		1					1					1	
0117s	2													2
0118s	1								1					
0119s	6	1								4			1	
0252s	3				2							1		
0253s	14		1		3		7				2	1		
0256s	2			1	1									
0259s	9		1	1		4	1					2		
0260s	10		1	1		3	5							
1078s	4		1			1	1					1		
Avgrain	Total Of ID	21	22	23	24	25	26	27	28	29	210	211	212	213
794.3	5	1								2			1	1
794.6	1							1						
803.4	11			3	1		3	2	1		1			
804.8	10		1	1		3	5							
821.9	3						2	1						
835.4	9		1	1		4	1					2		
838.8	6					1	3	2						
840.1	10		1				5		3			1		
842.9	3						3							
850	4		1			1	1					1		
856.9	3		1					1					1	
871.7	6	1								4			1	
872	16	1	3		1			5	1	1			3	1
891.6	3				2							1		
894.1	1								1					
905.7	2													2
1021.8	2			1	1									

Summer afternoons, W - SW	8					1		2	3	1					1				
Summer mornings, E - SE	19	2	3						3	1		3		1	3			1	2
Seldom, SE - SW	26		1	1	1							2			2	3	2	1	1
Always, no aspect	40	1	2	1	3								2	1	3	3			1
Insett	Total Of ID	31	32	33	34	35						311	312	313	314	315	316	317	318
Flat, west facing	1															1			
Flat, south west facing	4					1			3										
Flat, south facing	7			1	1				2	2					1				
Flat, south east facing	9	1							3			2			1				2
Flat, east facing	10								4						2	1		2	1
Flat, north facing	16			2		1	2	2	6							3			
Flat, no aspect	40	1	2	1	3		1	6	13	3			2	1	3	3			1
Gentle, south west facing	4							2		1					1				
Gentle, east facing	6								2						3		1		
Gentle, west facing	6				2	1			1									2	
Gentle, south east facing	10	1	3							1		1		1	2			1	
Gentle, north facing	19	1						2	3	2	2		2	2	1			1	3
Gentle, south facing	19		1					1		4	3	2			1	3	2	1	1
Soilpat	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
ab039	2											2							
ac002	2								2										
ac035	2	1							1										
ac036	2									2									
ac040	2								2										
ac043	2								2										
ac033	7		1	1						5									
ac039	29		1		5	2	1	5	15										
ad009	7	1					2		4										
ba051	3										3								
bb037	2			1	1														
ea025	5					1		4											
fa165	1											1							
fa366	1								1										
fa163	2								1	1									
fa393	7			2					5										
fa162	10							3	3	4									
fa166	65	2	4					1	1	1	2	2	4	4	15	11	3	7	8
Soilalt	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
900	66	2	4					1	2	1	2	2	4	4	15	11	3	7	8
1100	2											2							
1150	7		1	1						5									
1200	5	1							2	1		1							
1370	2									2									
1450	10							3	3	4									
1500	4			1	1				2										
1550	7	1					2		4										
1600	5					1		4											
1630	3										3								
1650	36		1	2	5	2	1	5	20										
1700	2								2										
1850	2								2										
Soilform	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Streambed/ Rensburg	1					1													
Katspruit	21	4	5	2	1	2	2		1				1	2					1
Bonheim/ Avalon/ Hutton	1							1											
Mayo/ Milkwood	1							1											
Rock/ Mayo/ Milkwood	1							1											
Avalon	1				1														
Avalon/ Glenrosa	1										1								
Griffin	6			1	4			1	2										
Clovelly	1								1										
Hutton	41		1	1			1	1	20	4	1	1		1	3	3	1	1	2
Hutton/ Shortlands	1											1							
Shortlands	1							1											
Mispah	1											1							
Glenrosa	47							3	7		1	2	2	1	12	6	2	6	5
Rock/ Clovelly	2								2										
Rock/ Mispah	9							4	1	4									
Rock/ Mispah/ Glenrosa/ Hutton	1										1								
Rock	12								3	5	1		1			2			
Soiltex	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
A:fi/coSaClLm	1									1									
A:fi/meSaCl-Cl	1	1																	
A:fiSaCl-Cl	1					1													
A:fi/meSaClLm	2								2										
A:me/coSaClLm	2	1					1												
A:me/coSaLm-SaClLm	2								2										
A:meSaClLm-SaCl	2			1					1										
A:SaClLm	2			1					1										
A:fi SaClLm-SaCl	4							4											
A:coSa-LmSa	10	2	3						1				1	2					1
A:me/fiSaLm-SaClLm	10							3	3	4									
A:coSa-SaLm	55		1					1		1	2	2	3	2	15	11	3	7	7
B:me/coSaCl-Cl	1								1										
B:meSaClLm-SaCl	1				1														
B:fi/meSaCl-Cl	2									2									
B:SaCl,ClLm,Cl	2											2							
B:me/coSaClLm-SaCl	4						1		3										
B:me/fiSaClLm-SaCl	4								1		3								
B:SaClLm-SaCl	5			1					4										
B:fi/coSaClLm-SaCl	6			1						5									
B:fiSaCl-Cl	6		1		1	2	1		1										
B:fi/meSaClLm-SaCl	25				4			5	15			1							
E:fi/coSaLm-SaClLm	1		1																
E:Lm/me/coSa-SaLm	2								2										
Soildepth	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
0100-0400	3								2	1									
0200-0400	5							4				1							
0200-0450	11							3	4	4									
0200-0500	2								2										
0200-0600	1								1										
0200-0700	1								1										
0300-0400	55		1					1		1	2	2	3	2	15	11	3	7	7
0300-0450	1								1										
0300-0500	12	2	3	1					2				1	2					1
0300-0600	2	1					1												
0400-0600	1					1													
0400-0900	1								1										
0450-0600	2		1	1															
0450-1200	24				4			5	15										
0500-0800	2								2										
0500-1200+	9			1					1	7									
0600-1200	2						1		1										
0600-1200+	1	1																	
0750-1200	1				1														
0800-1200	5			1					4										
0900-1200+	5										3	2							
1200+	5		1		1	2	1												
Terrgrp	Total Of Perrock	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	13.75								13.75										
Plains with moderate relief	28.3061224489796	15	0	22.5	5.16667	0	0	29.6154	19.0909	57.6923	32	10	33.75	25	4.33333	24.0909	70	85.7143	78.75
Rcksize	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
None	66	2	6	2	4	3	3	6	18	1	2	3	1	2	10	3			
Gravel	3								1						1	1			
Pebbles	2				1				1										
Stones	22	1		1	1			2	5	1	1	1			3	4		2	
Stones/Rocks	3							1	2										
Rocks/Stones	3								2	1									
Rocks	52	1		1				4	8	10	2	1	3	2	1	3	3	5	8
Phyacles	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Pure low closed grassland	30	1	1	2	6		2	3	15	7		1				5			
Low closed grassland	14			1			1		12										
Pure short closed grassland	16							1	1					2	9	3			
Short closed grassland	4							1	1	1						1			
Low/ short sparse shrubland	38		1					6	7	6	5	1	1	1	4	2		1	3
Low/ short bushland	18	3	4	1		3			1	1		1	1	1					2
Low/ short thicket	15							2		2							2	6	3
Low/ short sparse woodland	8									1		2	2		2		1		
Terrgrp	Total Of Numbspp	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	32.75								32.75										
Plains with moderate relief	38.0612244897959	26	36	26	29.5	26.6667	22.3333	41.3077	35.6061	55.6154	50.2	31	39.75	28.75	32.1333	32.7273	34.3333	48.2857	56.125
Acocks	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Lowveld Sour Bushveld	6												3	1	2				
Themeda Veld to Highland Sourveld Transition	2								2										
North-eastern Sandy Highveld	63	1	1	3	6	3	3	9	28	3	3	2				1			
Piet Retief Sourveld	80	3	5	1				4	7	10	2	3	1	3	13	10	3	7	8
VegLow	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Moist Clay Highveld Grassland	27				1	2		6	11	4	3								
Moist Sandy Highveld Grassland	28		1	2	4	1	1	6	13										
North-eastern Mountain Grassland	96	4	5	2	1		2	1	13	9	2	5	4	4	15	11	3	7	8
Pastcles	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Flat (0-8%)	123	4	5	4	4	2	3	8	36	12	5	3	4	2	11	10	3	4	8
Medium (9-15%)	22		1		2	1		5	1	1		2		2	4	1		2	
Steep (16-25%)	1																	1	
Eroscles	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Crop growth (0-15%)	149	4	6	4	6	3	3	13	37	13	5	5	4	4	15	10	3	6	8
Grazing (15-30%)	2															1		1	
Lnduse	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Annual cropping (0-3%)	93	2	2	4	4	2	3	8	33	7		2	2	2	7	9		2	4
Ley or special tige (4-7%)	33	2	3						3	5	5	1			4	1	3	2	4
Rotation of ley and crops (8-12%)	18		1		2	1		3	1	1		1	2	1	4			1	
Permanent cover crop (13-20%)	7							2				1		1		1		2	

Southeastern Mpumalanga Plains Vegetation Type

	Valid type	Southeastern																	
	Ecosystem	1	1	1	1					1	1	1	2	2	2	2	2	2	2
	Cullevel 2	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	2.1	2.1	2.1	2.1	2.2	2.2	2.2
	Cullevel 3	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2	1.1.2	1.2.1	1.2.1	1.2.1	1.2.1	1.2.2	2.1.1	2.1.2	2.1.2	2.1.2	2.2.1	2.2.1	2.2.2
	Cullevel 4	1.1.1a	1.1.1b	1.1.2.1	1.1.2.1	1.1.2.2	1.1.2.2	1.2.1.1	1.2.1.1	1.2.1.2	1.2.1.2			2.1.2.1	2.1.2.2	2.1.2.2	2.2.1a	2.2.1b	
	Cullevel 5			1.1.2.1a	1.1.2.1b	1.1.2.2a	1.1.2.2b	1.2.1.1a	1.2.1.1b	1.2.1.2a	1.2.1.2b				2.1.2.2a	2.1.2.2b			
	Cullevel 6																		
	Community	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.8	1.9	2.1	2.2	2.3	2.4	2.5	2.5	2.5
	Sub-community							1.7a	1.7b	1.8a	1.8b						2.5a	2.5b	2.5c
Eon	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Phanerozoic	59		1	2	5	3	1	12	28	4	3								
Cryptozoic	92	4	5	2	1		2	1	9	9	2	5	4	4	15	11	3	7	8
Erathem	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
	2								2										
Mesozoic	25					2		8	11	1	3								
Palaeozoic	32		1	2	5	1	1	4	15	3									
Proterozoic	2								2										
Archaean	90	4	5	2	1		2	1	7	9	2	5	4	4	15	11	3	7	8
System	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
	59		1	2	5	3	1	12	28	4	3								
Precambrian	92	4	5	2	1		2	1	9	9	2	5	4	4	15	11	3	7	8
NeoEra	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Phanerozoic	59		1	2	5	3	1	12	28	4	3								
Vaalian	2								2										
Randian	22	2	1	2	1		2		6	8									
Swazian	68	2	4					1	1	1	2	5	4	4	15	11	3	7	8
Petro	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Sedimentary	34		1	2	5	1	1	4	17	3									
Metamorphic	59	2	4					1	1	1		5	4	3	15	11	1	4	7
Igneous	58	2	1	2	1	2	2	8	19	9	6			1			2	3	1
Litho	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Mudstone	2								2										
Shale	9		1	2				2	4										
Arenite	23				5	1	1	2	11	3									
Gneiss	59	2	4					1	1	1		5	4	3	15	11	1	4	7
Gabbro	2									2									
Granite	2										2								
Andesite	2								2										
Basalt	6	1	1	2	1				1										
Lava	7													1			2	3	1
Quartz monzonite	7	1					2		4										
Tuff	7								1	6									
Dolerite	25					2		8	11	1	3								
Strat	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Ecca	32		1	2	5	1	1	4	15	3									
Karoo	2								2										
Pretoria	2								2										
Pongola	6	1	1	2	1				1										
Barberton	7													1			2	3	1
Unnamed	102	3	4			2	2	9	17	10	5	5	4	3	15	11	1	4	7
Gpform	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Karoo dolerite	25					2		8	11	1	3								
Beaufort	2								2										
Vryheid	23				5	1	1	2	11	3									
Volksrust	9		1	2				2	4										
Hekpoort	2								2										
Mpuluzi Granite	7	1					2		4										
Amsterdam	7								1	6									
Usushwana	2									2									
Nsuze	6	1	1	2	1				1										
Onverwacht	7													1			2	3	1
Unnamed	61	2	4					1	1	1	2	5	4	3	15	11	1	4	7
Terrgrp	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	4								4										
Plains with moderate relief	147	4	6	4	6	3	3	13	33	13	5	5	4	4	15	11	3	7	8
Terrtype	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Slightly undulating plains	4								4										
Moderately undulating plains	22	2	1	2	1		2		6	8									
Strongly undulating plains	125	2	5	2	5	3	1	13	27	5	5	5	4	4	15	11	3	7	8
Ttpnat	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
50 - 80% of area, slope < 8%, local relief 30 - 90 m	2											2							
80%> of area, slope < 8%, local relief 30 - 90 m	2								2										
80%> of area, slope < 8%, local relief 90 - 150 m	54	2	2	2	6	2	3	5	24	5	3								
20 - 50% of area, slope < 8%, local relief 150 - 300 m	19					1		7	5	5		1							
50 - 80% of area, slope < 8%, local relief 150 - 300 m	74	2	4	2				1	6	3	2	2	4	4	15	11	3	7	8
Terunit	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Crest	34							3	13	2	2	2	1		2	2	1	3	3
Scarp	23							5	4	9	2		1			2			
Midslope	43							2	16	1	1	1	1	1	10	4	1	3	2
Footslope	29		1	2	5		1	3	3	1		2		1	3	3	1	1	2
Valley bottom	22	4	5	2	1	3	2		1				1	2					1
Unitper	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Footslope or valley bottom (0 - 12)	141	4	6	4	6	3	3	9	37	12	5	4	4	3	15	10	3	5	8
Midslope or crest (12 - 100)	10							4		1		1		1		1		2	
Terrgrp	Total Of Slpdeg	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	0.937320053577423								0.93732										
Plains with moderate relief	2.28045171762811	1.71216	2.65386	[illegible]	2.07633	2.68049	0.67565	2.00193	1.11343	2.51628	4.15068	3.39593	2.49008	3.90739	2.47584	1.77223	3.27717	4.9127	1.81831
Terrgrp	Total Of Slpper	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	1.63651609420776								1.63652										
Plains with moderate relief	3.99214626372266	2.93992	4.64461	1.19038	3.63629	4.69088	1.17923	5.26734	1.94525	4.40133	[illegible]	[illegible]	4.75699	6.85019	4.33067	3.10577	5.72608	8.62364	3.17666
Terrgrp	Total Of Aspdeg	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	31.7204742431641								31.7205										
Plains with moderate relief	94.7303485205384	61.3863	85.7195	67.4992	127.891	182.468	112.969	60.182	82.2521	114.924	228.97	158.124	15.6497	113.744	90.212	77.4344	122.581	146.096	99.2645
Terrgrp	Total Of Ftmhgte	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Plains with low relief	1723.33331298828								1723.33										
Plains with moderate relief	1355.657670832	1284.17	1214.02	1620	1669.74	1704.27	1654.31	1633.76	1671.68	1406.51	1444.99	1225.3	1031.52	1025.6	1006.61	1060.33	922.596	953.761	978.376
Date	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
18	1								1										
194	1											1							
195	36	1		1	1	1		4	19	3	5	1							
294	4											2				2			
295	45	2	5	1	6	2	3	7	9	10		1							
394	26								1					2	4	2	2	7	8
495	12		1	2				2	7										
594	26	1											4	2	11	7	1		
Alticlss	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
90	2												1		1				
100	34	1											1	2	7	5	3	7	8
110	14		2						1					1	6	4			
120	17	1	3	1				1		4		3	2	1	1				
130	9								1	3	2	1				2			
140	3	1							1			1							
160	12			1	1			1	4	2	3								
170	42	1	1		5	2	3	10	16	4									
180	10					1		1	8										
190	8			2					6										
Climzone	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
0050s	2								2										
0052s	2								2										
0054s	9	1		1	1		2		4										
0055s	3										3								
0056s	34		1		5	3	1	9	15										
0057s	7			2					5										
0109s	10							3	3	4									
0110s	2									2									
0111s	2	1							1										
0112s	1								1										
0113s	7		1	1						5									
0114s	2								1	1									
0116s	1											1							
0117s	2								2										
0118s	65	2	4					1	1	1	2	2	4	4	15	11	3	7	8
1078s	2											2							
Avgrain	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
644	3										3								
724.7	7			2					5										
733.4	34		1		5	3	1	9	15										
779.4	2								2										
794.3	2								2										
821.9	7	1							3										
838.6	1								1										
840.1	2								1	1									
842.9	7		1	1						5									
850	2											2							
856.9	1											1							
866.6	10							3	3	4									
872	9	1		1	1		2		4										
873.4	2									2									
894.1	65	2	4					1	1	1	2	2	4	4	15	11	3	7	8
905.7	2								2										
Perislp	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
Slopes of 0 - 2°, never	66	2	2	4	4	2	3	8	31	5		2	2	1	7	6		2	3
Slopes of 0 - 2°, never	1																		1
Slopes of 2 - 25°, summer only	64	2	4		2	1		5	6	8	5	3	2	3	8	3	3	6	4
Inssrp	Total Of ID	31	32	33	34	35	36	37	38	39	310	311	312	313	314	315	316	317	318
All seasons, NE - NW	35	1		2	1	1	2	4	9	2	2		2	2	1	3		1	3

APPENDIX H

Table 24.a: Phytosociological table reflecting the percentage constancy of the species

Vegetation type	South-eastern Mpumalanga Mountain Veld Type																					
Ecosystem					1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Cutlevel 2					1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.1	2.1	2.1	2.2	2.2
Cutlevel 3					1.1.1	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2	1.2.1	1.2.1	1.2.1	1.2.1	1.2.2	1.2.2	1.2.2	2.1.1	2.1.2	2.1.2	2.2.a	2.2.b
Cutlevel 4					1.1.1.1	1.1.1.2	1.1.1.2	1.1.2.1	1.1.2.1	1.1.2.2	1.2.1.1	1.2.1.2	1.2.1.2	1.2.1.2	1.2.2.1	1.2.2.1	1.2.2.2		2.1.2.a	2.1.2.b		
Cutlevel 5						1.1.1.2.a	1.1.1.2.b	1.1.2.1.a	1.1.2.1.b			1.2.1.2.1	1.2.1.2.1	1.2.1.2.2	1.2.2.1.a	1.2.2.1.b						
Cutlevel 6												1.2.1.2.1.a	1.2.1.2.1.b									
Community					1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.10	1.11	2.1	2.2	2.3	2.4	2.5
Sub-community						1.2.a	1.2.b								1.10.a	1.10.b						
	Frequency within total data set	Frequency within table data set	% freq. within table data set	% freq. within total data set	% frequency of each species within the TWINSPAN classification clusters: 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Diagnostic Species Group A																						
Loudetia flavida	70	18	12	26	100	0	7	20	19	12	27	0	0	0	0	13	33	20	0	0	0	0
Ipomoea bathycolpos	5	5	3	100	100	0	4	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Indigofera hedyantha	5	3	2	60	67	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Euryops transvaalensis	2	2	1	100	67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waltheria indica	3	3	2	100	67	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Diagnostic Species Group B																						
Schistostephium crataegifolium	62	28	19	45	0	50	44	20	6	18	7	67	33	33	25	25	0	20	0	0	0	0
Gnidia caffra	16	14	10	88	0	50	41	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Cymbopogon plurinodis	89	26	18	29	0	50	41	20	6	16	13	33	0	33	75	13	0	0	0	0	0	0
Diagnostic Species Group C																						
Raphionacme galpinii	7	6	4	86	0	50	11	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Senecio oxyriifolius	19	6	4	32	0	50	4	0	0	0	7	0	0	0	25	13	0	0	0	0	0	0
Sutera caerulea	5	4	3	80	0	50	0	0	0	6	0	0	0	0	0	0	0	20	0	0	0	0
Clutia cordata	11	5	3	45	0	50	0	20	13	0	0	0	0	0	0	0	0	0	0	0	0	0
Faurea speciosa	14	13	9	93	0	50	15	0	13	0	13	0	33	0	0	25	0	0	0	0	0	0
Diagnostic Species Group D																						
Helichrysum dasycephalum	34	29	20	85	0	0	93	0	0	18	7	0	0	0	0	0	0	0	0	0	0	0
Andropogon schirensis	16	15	10	94	0	25	48	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0
Nidorella anomala	16	14	10	88	0	0	44	0	0	6	0	0	0	0	0	0	0	20	0	0	0	0
Tephrosia multijuga	14	11	8	79	0	25	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kalanchoe paniculata	27	13	9	48	0	0	37	0	0	0	0	0	0	0	25	25	0	0	0	0	0	0
Albuca spp.	14	10	7	71	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helichrysum nudifolium	55	17	12	31	0	0	37	0	0	12	20	33	0	0	25	0	0	0	0	0	0	0
Diagnostic Species Group E																						
Tetradenia riparia	27	10	7	37	0	0	0	60	6	12	20	0	33	0	0	0	0	0	0	0	0	0
Cussonia paniculata	15	6	4	40	0	0	4	60	0	0	0	0	33	0	0	13	0	0	0	0	0	0
Scilla nervosa	11	7	5	64	0	0	0	60	13	0	7	0	0	0	0	0	0	0	0	0	8	0
Vernonia sutherlandii	14	8	6	57	0	0	0	40	25	6	7	0	0	0	0	0	0	0	0	0	0	0
Ledebouria ovatifolia	66	18	12	27	0	25	15	40	19	6	13	33	0	0	0	0	0	0	0	0	31	0
Senecio erubescens	21	11	8	52	0	0	0	40	19	6	13	0	33	0	0	0	0	0	0	0	15	0
Aristea woodii	11	4	3	36	0	0	0	40	0	0	7	0	0	0	0	0	0	20	0	0	0	0
Leucosidea sericea	22	8	8	36	0	25	0	40	0	6	7	0	33	0	0	0	0	20	13	0	0	0
Cyanotis speciosa	33	9	6	27	0	0	7	40	19	0	13	0	0	0	0	0	0	0	0	0	0	0
Scabiosa columbaria	75	16	11	21	0	0	0	40	31	18	27	33	0	0	0	0	0	0	0	0	8	0
Aloe davyana	15	5	3	33	0	0	0	40	6	0	7	33	0	0	0	0	0	0	0	0	0	0
Helichrysum pallidum	8	4	3	50	0	0	0	40	13	0	0	0	0	0	0	0	0	0	0	0	0	0
Elionurus muticus	42	11	8	26	0	0	4	40	19	6	13	33	0	0	0	0	0	0	0	0	8	0
Myrsine africana	12	3	2	25	0	0	0	40	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Diagnostic Species Group F																						
Crabbea acaulis	55	19	13	35	0	0	22	0	44	24	7	0	0	0	0	0	0	0	0	0	8	0
Asclepias affinis	38	12	8	32	0	25	0	20	38	0	20	0	0	0	0	0	0	0	0	33	0	0
Brachiaria serrata	46	18	12	39	0	0	15	20	38	12	13	0	0	33	0	0	0	0	0	0	15	0
Diagnostic Species Group G																						
Cyperus obtusiflorus	70	29	20	41	0	25	7	60	69	29	33	0	0	0	25	0	0	0	13	0	0	0
Alloteropsis semialata	44	14	10	32	0	0	4	60	44	18	0	0	0	0	0	0	0	0	0	0	0	0
Diagnostic Species Group H																						
Anthospermum rigidum	65	16	11	25	0	0	0	20	6	53	27	0	0	0	0	13	0	0	0	0	0	0
Helichrysum cephaloideum	72	19	13	26	0	0	26	0	0	47	13	33	0	0	25	0	0	0	0	0	0	0
Eragrostis chloromelas	83	24	17	29	0	0	22	20	19	41	13	0	0	33	25	0	0	0	13	33	8	0
Vernonia oligocephala	40	19	13	48	0	0	30	20	6	35	7	0	33	0	25	0	0	0	0	0	0	0
Crepis hypochoeridea	37	9	6	24	0	0	0	0	6	35	0	33	0	0	0	0	0	20	0	0	0	0
Diagnostic Species Group I																						
Conyza podocephala	97	21	14	22	0	0	22	0	0	29	33	67	0	0	0	0	0	0	13	33	0	20
Zanthoxylum capense	10	3	2	30	0	0	0	0	0	0	7	67	0	0	0	0	0	0	0	0	0	0
Sonchus wilmsii	35	10	7	29	0	0	0	20	6	0	13	67	0	0	0	0	0	0	13	33	15	0
Eriosema burkei	3	3	2	100	0	25	0	0	0	0	0	67	0	0	0	0	0	0	0	0	0	0
Diagnostic Species Group J																						
Acacia karroo	25	11	8	44	0	25	0	0	6	0	0	33	100	0	0	13	33	20	25	0	0	0
Bauhinia galpinii	10	3	2	30	0	0	0	0	6	0	0	0	67	0	0	0	0	0	0	0	0	0
Maytenus heterophylla	40	9	6	23	0	0	0	20	13	0	7	0	67	33	0	13	0	0	13	0	0	0
Cussonia spicata	23	17	12	74	0	0	15	20	13	0	33	33	67	0	0	13	33	0	0	0	0	0
Lantana rugosa	12	5	3	42	0	0	0	20	0	0	0	0	67	33	0	13	0	0	0	0	0	0
Sebaea grandis	32	14	10	44	0	25	4	0	19	12	20	33	67	0	0	0	0	0	13	0	0	0
Raphionacme burkei	13	11	8	85	0	25	0	0	6	6	33	0	67	0	0	13	0	0	0	0	0	0
Diagnostic Species Group K																						
Rhus pentheri	18	8	6	44	0	0	0	20	0	0	7	33	33	100	0	0	0	0	13	0	0	0
Acacia sieberiana	15	7	5	47	0	0	0	0	0	0	0	33	33	67	0	0	33	0	13	33	0	0
Hermannia depressa	10	4	3	40	0	0	0	0	0	0	0	0	0	67	0	0	0	0	13	0	8	0
Diagnostic Species Group L																						
Hyperthelia dissoluta	62	17	12	27	100	0	4	0	0	0	7	0	0	33	100	88	0	0	0	0	0	0
Aristida congesta subsp. congesta	68	16	11	24	0	0	0	0	0	18	13	0	0	33	100	75	0	0	0	0	0	0
Pavetta edentula	42	19	13	45	0	25	0	20	6	0	40	0	0	0	100	75	0	0	0	0	0	0
Geigeria burkei	51	22	15	43	33	75	4	20	25	0	27	0	33	0	100	38	0	0	13	0	0	0
Cucumis zeyheri	42	17	12	40	0	0	4	0	13	18	13	0	33	0	100	38	0	0	0	0	0	0
Ozoroa sphaerocarpa	19	10	7	53	0	0	0	0	6	0	7	0	33	0	100	38	0	0	0	0	0	0
Aristida diffusa	17	11	8	65	33	0	11	0	0	0	0	0	0	0	100	38	0	0	0	0	0	0
Plectranthus madagascariensis	17	11	8	65	0	25	7	0	0	0	7	0	0	0	100	38	0	0	0	0	0	0
Diagnostic Species Group M																						
Annona senegalensis	10	5	3	50	0	0	0	0	0	0	0	0	33	0	100	0	0	0	0	0	0	0
Barleria guenzii	5	4	3	80	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	8	0
Haplocarpha lyrata	11	6	4	55	0	0	0	20	0	0	0	0	0	0	100	0	0	0	0	0	0	0

Table 24 b. Phytosociological table reflecting the percentage fidelity and qualifying clusters of the species

	# of clusters that qualified (%>33)	% fidelity of qualifing cluster	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Vegetation type			South-eastern Mpumalanga Mountain Veld Type																	
Ecosystem			1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Cutlevel 2			1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.2	2.1	2.1	2.1	2.2	2.2
Cutlevel 3			1.1.1	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2	1.2.1	1.2.1	1.2.1	1.2.1	1.2.2	1.2.2	1.2.2	2.1.1	2.1.2	2.1.2	2.2.a	2.2.b
Cutlevel 4			1.1.1.1	1.1.1.2	1.1.1.2	1.1.2.1	1.1.2.1	1.1.2.2	1.2.1.1	1.2.1.2	1.2.1.2	1.2.1.2	1.2.2.1	1.2.2.1	1.2.2.2		2.1.2.a	2.1.2.b		
Cutlevel 5				1.1.1.2.a	1.1.1.2.b	1.1.2.1.a	1.1.2.1.b			1.2.1.2.1	1.2.1.2.1	1.2.1.2.2	1.2.2.1.a	1.2.2.1.b						
Cutlevel 6										1.2.1.2.1.a	1.2.1.2.1.b									
Community			1.1	1.2	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	1.10	1.11	2.1	2.2	2.3	2.4	2.5
Sub-community				1.2.a	1.2.b								1.10.a	1.10.b						
			Qualifing clusters/ vegetation communities reflecting the different diagnositc species groups																	
Diagnostic Species Group A																				
Loudetia flavida	1	6	1																	
Ipomoea bathycolpos	1	6	1																	
Indigofera hedyantha	1	6	1																	
Euryops transvaalensis	1	6	1																	
Waltheria indica	1	6	1																	
Diagnostic Species Group B																				
Schistostephium crataegifolium	3	17		2	3					8										
Gnidia caffra	2	11		2	3															
Cymbopogon plurinodis	3	17		2	3								11							
Diagnostic Species Group C																				
Raphionacme galpinii	1	6		2																
Senecio oxyriifolius	1	6		2																
Sutera caerulea	1	6		2																
Clutia cordata	1	6		2																
Faurea speciosa	1	6		2																
Diagnostic Species Group D																				
Helichrysum dasycephalum	1	6			3															
Andropogon schirensis	1	6			3															
Nidorella anomala	1	6			3															
Tephrosia multijuga	1	6			3															
Kalanchoe paniculata	1	6			3															
Albuca spp	1	6			3															
Helichrysum nudifolium	1	6			3															
Diagnostic Species Group E																				
Tetradenia riparia	1	6				4														
C[illegible]aniculata	1	6				4														
S[illegible]osa	1	6				4														
V[illegible]utherlandii	1	6				4														
L[illegible] ovalifolia	1	6				4														
S[illegible]ubescens	1	6				4														
A[illegible]odii	1	6				4														
L[illegible] sericea	1	6				4														
C[illegible]peciosa	1	6				4														
S[illegible]olumbana	1	6				4														
A[illegible]na	1	6				4														
H[illegible]m pallidum	1	6				4														
Elionurus muticus	1	6				4														
Myrsine africana	1	6				4														
Diagnostic Species Group F																				
Crabbea acaulis	1	6					5													
Asclepias affinis	1	6					5													
Brachiaria serrata	1	6					5													
Diagnostic Species Group G																				
Cyperus obtusiflorus	2	11				4	5													
Alloteropsis semialata	2	11				4	5													
Diagnostic Species Group H																				
Anthospermum rigidum	1	6						6												
Helichrysum cephaloideum	1	6						6												
Eragrostis chloromelas	1	6						6												
Vernonia oligocephala	1	6						6												
Crepis hypochoeridea	1	6						6												
Diagnostic Species Group I																				
Conyza podocephala	1	6								8										
Zanthoxylum capense	1	6								8										
Sonchus wilmsii	1	6								8										
Eriosema burkei	1	6								8										
Diagnostic Species Group J																				
Acacia karroo	1	6									9									
Bauhinia galpinii	1	6									9									
Maytenus heterophylla	1	6									9									
Cussonia spicata	1	6									9									
Lantana rugosa	1	6									9									
Sebaea grandis	1	6									9									
Raphionacme burkei	1	6									9									
Diagnostic Species Group K																				
Rhus pentheri	1	6										10								
Acacia sieberiana	1	6										10								
Hermannia depressa	1	6										10								
Diagnostic Species Group L																				
Hyperthelia dissoluta	3	17	1										11	12						
Aristida congesta subsp. congesta	2	11											11	12						
Pavonia adentula	3	17							7				11	12						
Geigeria burkei	3	17		2									11	12						
Cucumis zeyheri	2	11											11	12						
Ozoroa sphaerocarpa	2	11											11	12						
Aristida diffusa	2	11											11	12						
Plectranthus madagascariensis	2	11											11	12						
Diagnostic Species Group M																				
Annona sengalensis	1	6											11							
Barleria guenzii	1	6											11							
Haplocarpha lyrata	1	6											11							

Eriosema cordatum	65	20	14	31	0	0	0	20	31	6	13	33	0	0	100	25	0	20	25	0	0	0
Helichrysum dasymallum	9	6	4	67	0	0	0	0	0	6	0	0	0	0	100	0	0	0	0	0	8	0
Thunbergia neglecta	12	6	4	50	0	0	0	0	0	6	0	0	0	0	100	0	0	20	0	0	0	0
Felicia muricata	15	6	4	40	0	0	0	0	0	6	0	0	0	0	100	0	0	20	0	0	0	0
Acalypha peduncularis	8	6	4	76	0	25	0	0	0	0	7	0	0	0	100	0	0	0	0	0	0	0
Pavetta gardeniifolia	9	4	3	44	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Mundulea sericea	6	4	3	67	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Oldenlandia herbacea	19	8	6	42	0	0	0	0	0	12	13	0	0	0	100	0	0	0	0	0	0	0
Aristida scabrivalvis	5	4	3	60	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Leonotis dysophylla	4	4	3	100	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Acacia nilotica	17	8	4	35	0	25	0	0	0	0	0	0	0	0	100	13	0	0	0	0	0	0
Euclea divinorum	7	7	5	100	0	25	0	0	0	0	0	0	33	0	100	13	0	0	0	0	0	0
Pachycarpus spp.	13	8	4	48	0	0	0	20	0	6	0	0	0	0	100	0	0	0	0	0	0	0
Clematis brachiata	7	4	3	57	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Dovyalis zeyheri	7	7	5	100	0	0	7	0	0	0	0	0	0	0	100	13	0	0	0	0	0	0
Amaranthus hybridus	10	4	3	40	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Cyphostemma lanigerum	10	6	4	60	0	0	0	0	0	0	7	0	0	0	100	13	0	0	0	0	0	0
Sphedamnocarpus pruriens	5	4	3	60	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Maytenus undata	10	4	3	40	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Helichrysum setosum	8	4	3	50	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Tarchonanthus camphoratus	5	4	3	60	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Xysmalobium undulatum	34	14	10	41	0	0	0	20	0	12	13	33	0	33	100	0	0	0	25	0	8	0
Lannea discolor	8	4	3	50	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Faurea saligna	11	7	5	64	0	0	0	0	6	0	0	33	33	0	100	0	0	0	0	0	0	0
Sansevieria trifasciata	5	4	3	60	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Lippia rehmannii	22	7	5	32	0	0	4	0	0	0	7	33	0	0	100	0	0	0	0	0	0	0
Rhus pondoensis	5	4	3	60	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Lotononis eriantha	25	6	4	24	0	0	0	0	0	12	0	0	0	0	100	0	0	0	0	0	0	0
Vernonia poskeana	7	5	3	71	0	0	0	0	0	6	0	0	0	0	100	0	0	0	0	0	0	0
Dicerocaryum eriocarpum	23	6	4	26	0	0	0	0	0	0	0	0	0	0	100	25	0	0	0	0	0	0
Dianthus mooiensis	9	6	4	67	0	0	0	0	0	0	7	0	0	0	100	0	0	0	0	0	0	0
Melinis nerviglumis	17	13	9	76	0	25	11	20	6	12	0	0	0	0	75	13	33	0	0	0	8	0
Cheilanthes viridis	8	3	2	38	0	0	4	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0
Eragrostis aspera	9	3	2	33	0	0	0	0	0	0	0	0	0	0	50	13	0	0	0	0	0	0
Acacia ataxacantha	7	4	3	57	0	0	0	0	0	0	0	0	33	0	50	13	0	0	0	0	0	0
Diagnostic Species Group H																						
Sutera aurantiaca	5	4	3	60	0	0	0	0	0	0	0	0	0		0	50	0	0	0	0	0	0
Euclea undulata	5	4	3	60	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0
Trichoneura grandiglumis	23	4	3	17	0	0	0	0	0	0	7	0	0	J	0	38	0	0	0	0	0	0
Rhus rehmanniana	8	5	3	63	0	0	4	0	0	0	0	0	33	0	0	38	0	0	0	0	0	0
Pogonarthria squarrosa	32	7	5	22	0	0	0	0	0	0	7	33	0	33	25	38	0	0	0	0	0	0
Xerophyta retinervis	14	8	4	43	0	25	0	0	0	0	7	0	0	0	25	38	0	0	0	0	0	0
Dichrostachys cinerea	11	7	5	64	0	25	0	0	6	0	0	33	0	33	0	38	0	0	0	0	0	0
Pearsonia sessilifolia	5	4	3	60	33	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0
Rhynchosia nitens	3	3	2	100	0	0	0	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0
Diagnostic Species Group O																						
Englerophytum magalismontanum	15	6	4	40	0	0	0	0	0	0	13	0	0	0	25	0	100	0	0	0	0	0
Zantedeschia aethiopica	2	2	1	100	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
Rhus chirindensis	3	2	1	67	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
Euphorbia ingens	6	2	1	33	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
…rrhenia dregeana	48	15	10	31	0	0	0	0	13	0	13	33	33	0	0	0	67	20	25	33	15	20
…obolus pectinatus	3	2	1	67	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
… discolor	2	2	1	100	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
…arborescens	7	5	3	71	0	0	7	0	0	0	7	0	0	0	0	0	67	0	0	0	0	0
…naecrista biensis	3	2	1	67	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
…tacanthus burchellii	2	2	1	100	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
…leja salviifolia	8	4	3	50	0	0	0	0	0	0	13	0	0	0	0	0	67	0	0	0	0	0
…anthos ecklonianus	2	2	1	100	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0
…nostic Species Group P																						
…eme salignum	26	6	4	23	0	0	0	20	0	0	0	0	0	0	0	0	0	60	0	0	15	0
…rrhenia cymbaria	7	5	3	71	0	25	0	0	0	0	0	0	0	0	0	13	0	40	0	0	0	20
…nostic Species Group Q																						
…rostylis coccinea	12	5	3	42	0	0	0	0	0	0	0	0	0	0	0	0	0	20	38	33	0	0
…aecrista comosa	29	7	5	24	0	0	0	0	6	6	13	0	0	0	0	0	0	0	38	0	0	0
Bidens pilosa	28	9	6	32	0	0	0	0	0	6	13	0	0	0	0	0	0	0	38	33	15	0
Senecio affinis	36	12	8	33	0	0	0	20	13	6	13	33	0	0	0	0	0	20	38	0	8	0
Oxalis purpurea	45	10	7	22	0	0	0	0	13	12	7	0	0	0	0	0	0	0	38	0	15	0
Diagnostic Species Group R																						
Kyllinga alba	44	15	10	34	0	0	0	0	0	24	7	0	0	0	0	0	0	60	50	33	8	0
Wahlenbergia undulata	39	9	6	23	0	0	0	0	0	12	0	0	0	0	0	0	0	60	38	33	0	0
Diagnostic Species Group S																						
Bothriochloa insculpta	15	6	4	40	0	0	4	0	0	0	0	0	0	33	25	13	0	0	0	67	0	0
Combretum erythrophyllum	11	3	2	27	0	0	0	0	0	0	0	0	0	33	0	0	0	0	0	67	0	0
Conyza scrabrida	7	2	1	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0
Cynodon dactylon	16	8	4	38	0	0	0	0	0	6	7	0	0	33	0	0	0	20	0	67	0	0
Diagnostic Species Group T																						
Phragmites australis	27	12	8	44	0	0	0	0	0	0	0	0	0	0	0	0	0	20	50	100	31	0
Miscanthus junceus	25	9	6	36	0	0	0	0	0	6	0	0	0	0	0	0	0	20	50	67	0	20
Diagnostic Species Group U																						
Coleochloa setifera	40	14	10	35	0	25	0	20	13	0	0	0	0	33	0	0	0	40	50	67	0	20
Mariscus congestus	35	10	7	29	0	0	0	0	0	0	0	0	0	33	0	0	0	40	38	67	8	20
Diagnostic Species Group V																						
Setaria nigrirostris.	54	19	13	35	0	0	30	0	0	6	0	0	0	0	0	0	33	20	25	0	46	0
Datura stramonium	13	10	7	77	0	0	0	0	0	0	7	0	0	0	0	0	0	0	25	33	46	0
Diagnostic Species Group W																						
Helichrysum harveyana	3	3	2	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Leersia hexandra	19	5	3	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	33	0	40
Andropogon eucomus	23	5	3	22	0	0	0	0	0	12	0	0	0	0	0	0	0	20	0	0	0	40
Agrostis eriantha	23	5	3	22	0	0	0	0	0	12	0	0	0	0	0	0	0	0	13	0	0	40
Mentha aquatica	7	3	2	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	40
Gunnera perpensa	4	3	2	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	40
Constant Species Group X																						
Themeda triandra	262	96	66	37	0	100	96	80	81	88	40	67	33	33	25	63	0	60	50	0	65	0
Setaria sphacelata	212	65	45	31	0	75	37	40	69	41	33	33	33	67	25	25	67	40	25	67	69	60
Hyparrhenia hirta	179	47	32	26	0	0	4	40	6	53	73	67	0	67	25	13	0	100	50	67	46	0
Species Group Y: Species associated wiht terrestrial ecosystems																						
Vernonia natalensis	124	62	43	50	0	50	89	80	63	65	7	33	0	33	100	25	0	0	0	0	15	0
Acalypha angustata	148	61	42	41	33	25	65	40	75	18	20	100	0	0	100	50	0	0	0	0	31	20
Tristachya leucothrix	152	58	40	38	100	50	81	20	75	47	27	33	0	0	25	50	0	0	0	0	0	0
Heteropogon contortus	173	56	39	32	100	50	0	20	63	71	53	67	67	67	100	100	67	0	0	0	0	0
Panicum natalense	121	56	39	46	67	100	63	60	56	35	47	0	33	0	100	25	0	0	0	33	0	0
Eragrostis racemosa	167	55	38	33	100	0	67	40	63	71	47	33	0	33	0	0	0	0	0	0	8	0
Senecio venosus	114	54	37	47	67	100	52	60	56	12	27	33	0	33	100	63	67	0	13	0	15	0
Diheteropogon amplectens	89	45	31	51	33	50	93	60	6	6	20	33	0	0	50	50	0	20	0	0	8	0
Berkheya setifera	145	44	30	30	0	0	74	80	50	59	7	0	33	0	0	0	0	0	0	0	0	0
Bulbostylis burchellii	96	41	28	43	0	100	59	40	19	12	47	0	0	0	100	13	0	0	0	0	8	20
Hypoxis rigidula	114	41	28	36	33	25	26	40	50	41	27	67	0	0	100	25	0	0	0	0	23	0
Loudetia simplex	88	40	28	45	67	75	63	40	19	6	33	0	0	0	50	50	33	0	0	0	0	0
Species Group Z: Species associated with wetland ecosystems																						
Eragrostis plana	155	37	26	24	0	0	7	0	0	71	27	33	0	33	0	0	0	60	88	67	31	20
Cyperus esculentus	89	26	18	29	0	0	0	40	6	0	33	0	0	33	0	0	0	40	63	33	54	40
Verbena brasiliensis	67	26	18	39	0	0	0	0	0	0	7	0	0	0	0	0	0	80	75	33	92	40
Paspalum dilatatum	94	23	16	24	0	0	0	0	13	12	7	33	0	0	0	0	0	0	88	100	46	20
Schkuhria pinnata	50	20	14	40	33	0	0	0	0	0	20	0	0	100	0	0	0	0	38	67	46	40
Arundinella nepalensis	46	19	13	41	0	25	0	0	0	0	0	0	0	0	0	0	0	60	75	33	23	100

Species			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ficus glumosa	1	6											11							
Eriosema cordatum	1	6											11							
Helichrysum dasymallum	1	6											11							
Thunbergia neglecta	1	6											11							
Felicia muricata	1	6											11							
Acalypha peduncularis	1	6											11							
Pavetta gardeniifolia	1	6											11							
Mundulea sericea	1	6											11							
Oldenlandia herbacea	1	6											11							
Aristida scabrivalvis	1	6											11							
Leonotis dysophylla	1	6											11							
Acacia nilotica	1	6											11							
Euclea divinorum	1	6											11							
Pachycarpus spp	1	6											11							
Clematis brachiata	1	6											11							
Dovyalis zeyheri	1	6											11							
Amaranthus hybridus	1	6											11							
Cyphostemma lanigerum	1	6											11							
Sphedamnocarpus pruriens	1	6											11							
Maytenus undata	1	6											11							
Helichrysum setosum	1	6											11							
Tarchonanthus camphoratus	1	6											11							
Xysmalobium undulatum	1	6											11							
Lannea discolor	1	6											11							
Faurea saligna	1	6											11							
Sansevieria trifasciata	1	6											11							
Lippia rehmannii	1	6											11							
Rhus pondoensis	1	6											11							
Lotononis eriantha	1	6											11							
Vernonia poskeana	1	6											11							
Dicerocaryum eriocarpum	1	6											11							
Dianthus mooiensis	1	6											11							
Melinis nerviglumis	1	6											11							
Cheilanthes viridis	1	6											11							
Eragrostis aspera	1	6											11							
Acacia ataxacantha	1	6											11							
Diagnostic Species Group N																				
Sutera aurantiaca	1	6												12						
Euclea undulata	1	6												12						
Trichoneura grandiglumis	1	6												12						
Rhus rehmanniana	1	6												12						
Pogonarthria squarrosa	1	6												12						
Xerophyta retinervis	1	6												12						
Dichrostachys cinerea	1	6												12						
Pearsonia sessilifolia	1	6												12						
Rhynchosia nitens	1	6												12						
Diagnostic Species Group O																				
Englerophytum megalismontanum	1	6													13					
Zantedeschia aethiopica	1	6													13					
Rhus chirindensis	1	6													13					
Euphorbia ingens	1	6													13					
Hyparrhenia dregeana	1	6													13					
...olus pectinatus	1	6													13					
...scolor	1	6													13					
...borescens	1	6													13					
...censis biensis	1	6													13					
...canthus burchellii	1	6													13					
...a salviifolia	1	6													13					
...thes ecklonlana	1	6													13					
...stic Species Group P																				
...e salignum	1	6														14				
...enia cymbaria	1	6														14				
...stic Species Group Q																				
...tylis coccinea	1	6															15			
Chamaecrista comosa	1	6															15			
Bidens pilosa	1	6															15			
Senecio affinis	1	6															15			
Oxalis purpurea	1	6															15			
Diagnostic Species Group R																				
Kyllinga alba	2	11														14	15			
Wahlenbergia undulata	2	11														14	15			
Diagnostic Species Group S																				
Bothriochloa insculpta	1	6																16		
Combretum erythrophyllum	1	6																16		
Conyza scabrida	1	6																16		
Cynodon dactylon	1	6																16		
Diagnostic Species Group T																				
Phragmites australis	2	11															15	16		
Miscanthus junceus	2	11															15	16		
Diagnostic Species Group U																				
Coleochloa setifera	3	17														14	15	16		
Mariscus congestus	3	17														14	15	16		
Diagnostic Species Group V																				
Setaria nigrirostris	1	6																	17	
Datura stramonium	1	6																	17	
Diagnostic Species Group W																				
Helichrysum harveyana	1	6																		18
Leersia hexandra	1	6																		18
Andropogon eucomus	1	6																		18
Agrostis eriantha	1	6																		18
Mentha aquatica	1	6																		18
Gunnera perpensa	1	6																		18
Constant Species Group X																				
Themeda triandra	11	61		2	3	4	5	6	7	8				12		14	15		17	
Setaria sphacelata	11	61		2	3	4	5	6				10			13	14		16	17	18
Hyparrhenia hirta	9	50				4		6	7	8		10				14	15	16	17	
Species Group Y: Species associated witt terrestrial ecosystems																				
Vernonia natalensis	6	33		2	3	4	5	6					11							
Acalypha angustata	6	33			3	4	5			8			11	12						
Tristachya leucothrix	6	33	1	2	3		5	6						12						
Heteropogon contortus	11	61	1	2			5	6	7	8	9	10	11	12	13					
Panicum natalense	8	44	1	2	3	4	5	6	7				11							
Eragrostis racemosa	6	33	1		3	4	5	6	7											
Senecio venosus	8	44	1	2	3	4	5						11	12	13					
Diheteropogon amplectens	5	28		2	3	4							11	12						
Berkheya setifera	4	22			3	4	5	6												
Bulbostylis burchellii	5	28		2	3	4			7				11							
Hypoxis rigidula	5	28				4	5	6		8			11							
Loudetia simplex	6	33	1	2	3	4							11	12						
Species Group Z: Species associated with wetland ecosystems																				
Eragrostis plana	4	22						6								14	15	16		
Cyperus esculentus	5	28				4										14	15		17	18
Verbena brasiliensis	4	22														14	15		17	18
Paspalum dilatatum	3	17															15	16	17	
Schkuhria pinnata	5	28										10					15	16	17	18
Arundinella nepalensis	3	17														14	15			18
Imperata cylindrica	2	11															15		17	

Eulalia villosa	88	49	34	56	0	[illegible]	[illegible]	60	19	35	20	33	0	0	25	0	67	60	13	0	0	0
Trachypogon spicatus	124	48	33	39	100	[illegible]	[illegible]	40	13	35	33	33	0	0	50	50	0	0	0	0	0	0
Gladiolus elliotii	84	36	25	43	67	[illegible]	[illegible]	0	31	12	7	0	33	0	100	50	0	0	0	0	8	0
Bewsia biflora	69	35	24	51	67	100	41	0	6	6	27	33	67	0	0	63	0	60	13	0	0	0
Helichrysum rugulosum	154	35	24	23	0	0	0	40	31	59	47	33	0	100	0	0	0	40	0	0	31	20
Eragrostis capensis	115	32	22	28	0	0	0	40	63	59	20	0	0	33	0	0	0	20	0	0	38	0
Berkheya seminivea	44	30	21	68	0	75	44	40	25	0	7	67	33	0	100	13	0	0	0	0	0	0
Berkheya echinacea	55	30	21	55	67	25	63	20	19	6	20	0	0	0	0	0	67	0	0	0	0	0
Microchloa caffra	76	30	21	39	33	0	44	20	63	29	0	0	0	0	0	13	0	0	0	0	0	0
Commelina africana	108	29	20	27	0	0	0	60	19	29	47	0	33	0	25	0	67	40	25	0	23	0
Monocymbium ceresiiforme	57	27	19	47	67	0	63	0	0	18	0	0	0	0	100	0	0	20	0	0	0	0
Schizachyrium sanguineum	41	25	17	61	67	75	48	0	0	0	7	0	0	0	0	25	67	0	0	33	8	0
Pentanisia angustifolia	64	25	17	39	0	25	11	20	38	35	40	33	0	0	0	0	0	0	0	0	8	0
Indigofera hilaris	28	23	16	88	0	0	67	20	0	0	0	0	0	0	100	0	0	0	0	0	0	0
Digitaria diagonalis	28	23	16	82	0	0	67	20	0	0	0	0	0	0	25	0	67	0	0	33	0	0
Athrixia phylicoides	29	22	15	76	0	0	56	0	13	0	0	0	33	0	100	0	0	0	0	0	0	0
Stachys natalensis	48	21	14	44	0	50	4	0	13	0	33	33	67	0	100	38	0	0	13	0	0	0
Hypoxis iridifolia	75	21	14	28	67	0	0	0	31	18	40	33	0	33	0	0	0	40	0	0	8	0
Chaetacanthus costatus	54	19	13	35	0	0	0	20	38	0	7	33	0	0	100	38	0	40	0	0	8	0
Dicoma zeyheri	49	19	13	39	100	25	19	20	19	12	0	33	0	0	0	38	0	0	0	0	0	0
Cyperus rupestris	30	16	11	53	0	0	0	0	13	0	0	0	0	33	100	0	67	40	25	33	15	0
Chaetacanthus setiger	37	16	11	43	0	0	48	0	0	0	0	0	0	0	0	38	0	0	0	0	0	0
Alepidea longifolia	22	16	11	73	0	0	37	0	0	0	7	33	0	0	100	0	0	0	0	0	0	0
Polygala hottentotta	41	16	11	39	67	0	0	20	19	6	7	0	0	0	100	13	0	0	0	0	23	0
Indigofera comosa	55	15	10	27	0	25	0	20	38	6	40	0	0	0	0	0	0	0	0	0	0	0
Gnidia capitata	20	14	10	70	0	25	0	0	50	0	7	0	0	0	100	0	0	0	0	0	0	0
Dicoma anomala	58	14	10	24	33	0	4	40	0	12	20	0	0	0	0	63	0	0	0	0	0	0
Leonotis microphylla	30	13	9	43	0	0	19	40	6	0	20	67	0	0	0	0	0	0	0	0	0	0
Cheilanthes quadripinnata	20	12	8	60	0	25	11	40	13	0	7	0	67	0	0	0	0	20	0	0	0	0
Ipomoea ommaneyi	9	9	6	100	0	0	11	0	0	6	0	0	0	0	50	0	67	0	13	0	0	0
Berkheya speciosa	8	8	6	100	0	0	0	20	0	6	0	0	0	0	100	0	0	40	0	0	0	0
Lotononis foliosa	20	8	6	40	0	0	0	0	0	0	0	33	33	33	0	0	67	0	13	67	0	0
Xanthium strumarium	19	7	5	37	0	50	0	0	0	6	0	0	0	0	100	0	0	0	0	0	0	0
Species Group AB: Species associated with surface rocks	9	5	3	56	0	0	0	0	0	0	0	0	0	0	0	0	67	0	13	67	0	0
Pellaea calomelanos																						
Diospyros whyteana	86	35	24	41	0	25	7	40	19	16	60	33	0	0	100	88	100	0	0	0	0	0
Aloe marlothii	61	25	17	41	33	25	7	80	0	0	40	33	67	0	75	38	67	0	0	0	0	0
Species Group AC: Species associated with woodland communities	47	22	15	47	0	75	0	0	6	0	20	0	33	0	100	88	100	0	0	0	0	0
Rhoicissus tridentata																						
Diospyros lycioides	78	35	24	45	0	0	15	60	6	0	53	67	67	100	100	50	67	0	25	0	0	0
Euclea natalensis	113	32	22	28	0	0	0	80	6	35	53	100	33	33	0	38	0	20	25	67	0	0
Lippia javanica	43	24	17	58	0	50	19	60	0	6	27	33	33	0	0	50	67	0	13	0	0	0
Asparagus laricinus	45	18	12	40	0	25	7	20	6	12	7	33	33	100	0	38	0	40	0	0	0	0
Acacia caffra	53	18	12	34	0	0	22	60	6	0	7	33	33	0	100	13	0	0	0	0	0	0
Dombeya rotundifolia	24	16	11	67	0	0	0	0	6	0	20	67	67	0	100	13	33	0	13	33	0	0
Combretum molle	26	15	10	58	0	0	0	0	6	0	0	67	100	0	75	25	67	0	0	67	0	0
Athrixia elata	27	15	10	56	0	0	0	0	13	0	7	33	33	0	100	38	100	0	0	0	0	0
Rhus dentata	27	14	10	52	0	25	15	0	0	0	0	67	33	0	100	25	0	0	0	0	0	0
Euclea crispa	50	14	10	28	0	50	4	0	6	6	27	67	0	0	0	13	33	0	0	33	0	0
Ziziphus mucronata	27	12	8	44	0	25	0	0	6	0	13	33	67	0	100	0	33	0	0	0	0	0
Peltophorum africanum	23	11	8	48	0	25	4	0	0	0	7	100	67	67	0	0	0	0	0	33	0	0
Combretum apiculatum	12	8	6	67	0	0	0	0	0	0	7	0	67	33	100	0	0	0	0	0	0	0
Panicum maximum	19	8	6	42	0	0	0	0	6	0	7	0	67	0	50	25	0	0	0	0	0	0
Pappea capensis	15	7	5	47	0	0	0	0	0	0	0	0	0	0	100	0	100	0	0	0	0	0
Senecio barbertonicus	6	6	4	100	0	0	0	0	0	0	0	0	0	0	100	0	67	0	0	0	0	0
Species Group AD: Species associated with over utilization																						
Melinis repens	165	52	36	32	33	0	7	20	38	35	87	100	33	67	50	88	100	0	25	100	0	0
Aristida junciformis	70	35	24	50	33	50	37	0	13	47	33	0	0	0	50	13	67	40	0	0	0	0
Eragrostis curvula	139	35	24	25	0	0	0	20	25	35	47	100	33	67	0	0	33	40	0	33	46	20
Hypochoeris radicata	101	18	12	18	0	0	0	0	6	41	13	0	0	0	0	0	0	20	38	0	31	0
Solanum elaeagnifolium	55	17	12	31	0	0	4	0	13	12	13	0	0	67	100	0	33	0	0	67	6	0
Sporobolus africanus	67	17	12	25	0	0	4	0	0	24	13	33	33	100	0	13	0	20	13	67	0	0
Oenothera tetraptera	60	17	12	28	0	0	0	0	6	0	20	0	0	0	0	0	0	0	38	0	77	0
Phymaspermum athanasioides	59	14	10	24	0	0	0	0	0	18	7	0	0	33	0	0	0	0	13	100	0	100
Hibiscus trionum	23	12	8	52	0	25	0	0	0	0	0	0	0	0	0	0	67	0	0	0	54	40
Richardia brasiliensis	43	11	8	26	0	0	4	0	0	6	13	0	0	67	0	13	0	20	13	67	0	0
Aristida congesta subsp. barbicollis	22	7	5	32	0	0	0	0	0	12	0	0	67	67	0	0	0	0	0	33	0	0
Sida alba	13	7	5	54	0	0	0	0	0	6	0	0	0	67	25	0	0	0	0	100	0	0
Prominent species that do not occur in this veld type																						
Eragrostis gummiflua	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syncolostemon concinnus	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moraea pubiflora	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convolvulus sagittatus sagittatus var. hirtellus	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tephrosia macropoda	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium africanum	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Setaria lindenbergiana	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[illegible]	[illegible]	[illegible]		2	3										13	14				
Cymbopogon [illegible]	6	33		2	3	4									13	14				
Eulalia villosa	7	39	1	2	3	4		6					11	12						
Trachypogon spicatus	5	28	1	2	3								11	12						
Gladiolus elliotii	6	33	1	2	3						9			12		14				
Bewsia biflora	5	28				4		6	7			10				14				
Helichrysum rugulosum	4	22				4	5	6											17	
Eragrostis capensis	5	28		2	3	4				8			11							
Berkheya seminivea	3	17	1		3										13					
Berkheya echinacea	2	11			3		5													
Microchloa caffra	4	22				4			7						13	14				
Commelina africana	3	17	1		3								11							
Monocymbium ceresiiforme	4	22	1	2	3										13					
Schizachyrium sanguineum	3	17					5	6	7											
Pentanisia angustifolia	2	11			3								11							
Indigofera hilaris	2	11			3										13					
Digitaria diagonalis	2	11			3								11							
Athrixia phylicoides	4	22		2							9		11	12						
Stachys natalensis	3	17	1						7							14				
Hypoxis iridifolia	4	22					5						11	12		14				
Chaetacanthus costatus	2	11	1											12						
Dicoma zeyheri	3	17											11		13	14				
Cyperus rupestris	2	11			3									12						
Chaetacanthus setiger	2	11			3								11							
Alepidea longifolia	2	11	1										11							
Polygala hottentotta	2	11					5		7											
Indigofera comosa	2	11					5						11							
Gnidia capitata	2	11				4								12						
Dicoma anomala	2	11				4				8										
Leonotis microphylla	2	11				4					9									
Cheilanthes quadripinnata	2	11											11		13					
Ipomoea ommaneyi	2	11											11			14				
Berkheya speciosa	2	11													13			16		
Lotononis foliosa	2	11		2									11							
Xanthium strumarium	2	11													13			16		
Species Group AB: Species associated with surface rocks																				
Pellaea calomelanos	5	28				4			7				11	12	13					
Diospyros whyteana	6	33				4			7		9		11	12	13					
Aloe marlothii	4	22		2									11	12	13					
Species Group AC: Species associated with woodland communities																				
Rhoicissus tridentata	8	44				4			7	8	9	10	11	12	13					
Diospyros lycioides	6	33				4		6	7	8				12				16		
Euclea natalensis	4	22		2		4								12	13					
Lippia javanica	3	17										10		12		14				
Protasparagus laricinus	2	11				4							11							
Acacia caffra	3	17								8	9		11							
Dombeya rotundifolia	5	28								8	9		11		13			16		
Combretum molle	3	17											11	12	13					
Athrixia elata	2	11								8			11							
Rhus dentata	2	11		2						8										
Euclea crispa	2	11									9		11							
Ziziphus mucronata	3	17								8	9	10								
Peltophorum africanum	2	11									9		11							
Combretum apiculatum	2	11									9		11							
Panicum maximum	2	11											11		13					
Pappea capensis	2	11											11		13					
Senecio barbertonicus																				
Species Group AD: Species associated with over utilization																				
Melinis repens	9	50					5	6	7	8		10	11	12	13			16		
Aristida junciformis	6	33		2	3			6					11		13	14				
Eragrostis curvula	6	33						6	7	8		10				14			17	
Hypochoeris radicata	2	11						6									15			
Solanum elaeagnifolium	3	17										10	11					16		
Sporobolus africanus	2	11										10						16		
Oenothera tetraptera	2	11															15		17	
Phymaspermum athanasioides	2	11																16		18
Hibiscus trionum	3	17													13				17	18
Richardia brasiliensis	2	11										10						16		
Aristida congesta subsp. barbicollis	2	11									9	10								
Sida alba	2	11										10						16		
Prominent species that do not occur in this veld type																				
Eragrostis gummiflua	0	0																		
Syncolostemon concinnus	0	0																		
Moraea pubiflora	0	0																		
Convolvulus sagittatus sagittatus var. hirtellus	0	0																		
Tephrosia macropoda	0	0																		
Trifolium africanum	0	0																		
Setaria lindenbergiana	0	0																		

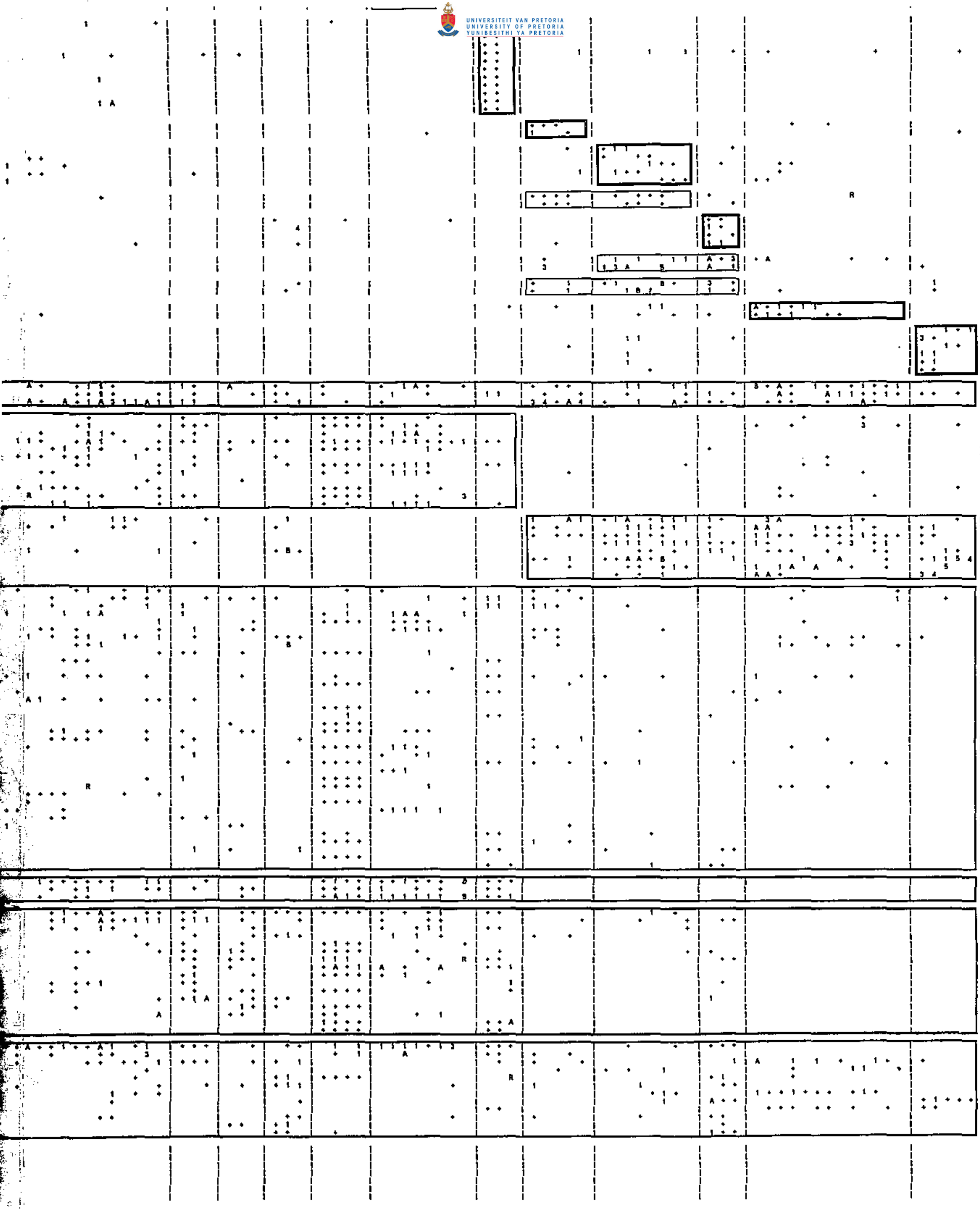
Table 24.c: Phytosociological table reflecting the cover abundance estimates of the species

Veld type	South-eastern Mpumalanga Mountain Veld Type					
Ecosystem	1	1	1	1	1	1
Cutlevel 2	1.1	1.1	1.1	1.1	1.1	1.1
Cutlevel 3	1.1.1	1.1.1	1.1.1	1.1.2	1.1.2	1.1.2
Cutlevel 4	1.1.1.1	1.1.1.2	1.1.1.2	1.1.2.1	1.1.2.1	1.1.2.2
Cutlevel 5		1.1.1.2.a	1.1.1.2.b	1.1.2.1.a	1.1.2.1.b	
Cutlevel 6						
Community	1.1	1.2	1.2	1.3	1.4	1.5
Sub-community		1.2.a	1.2.b			
Cluster	1	2	3	4	5	6
Relevés	052, 053, 055	045, 042, 043, 115	086, 087, 093, 104, 100, 100, 103, 085, 105, … [illegible]	[illegible]	[illegible]	[illegible]

Species	Cover-abundance values
Diagnostic Species Group A	
Loudetia flavida	Cluster 1: A A 1
Ipomoea bathycolpos	Cluster 1: 1 1 +
Indigofera hedyantha	Cluster 1: 1 1
Eriosema transvaalensis	Cluster 1: 1 1
Waltheria indica	Cluster 1: + +
Diagnostic Species Group B	
Schistostephium crataegifolium	[illegible]
Gnidia caffra	[illegible]
Cymbopogon plurinodis	[illegible]
Diagnostic Species Group C	
Raphionacme galpinii	[illegible]
Senecio oxyriifolius	[illegible]
Solanum coeruleum	[illegible]
Chlorophytum [illegible]	[illegible]
Fourea speciosa	[illegible]
Diagnostic Species Group D	
Helichrysum oreophilum	[illegible]
Andropogon schirensis	[illegible]
Nidorella anomala	[illegible]
Tephrosia [illegible]	[illegible]
Koeleria paniculata	[illegible]
Allium spp.	[illegible]
Helichrysum nudifolium	[illegible]
Diagnostic Species Group E	
Trachyandra [illegible]	[illegible]
Commelina [illegible]	[illegible]
Scilla nervosa	[illegible]
Hermannia [illegible]	[illegible]
Ledebouria ovatifolia	[illegible]
Senecio erubescens	[illegible]
Aristea woodii	[illegible]
Leucosidea sericea	[illegible]
Cyanotis speciosa	[illegible]
Scabiosa columbaria	[illegible]
Aloe davyana	[illegible]
Helichrysum pallidum	[illegible]
Bidens [illegible]	[illegible]
Myrsine africana	[illegible]
Diagnostic Species Group F	
[illegible]	[illegible]
Asclepias [illegible]	[illegible]
Bewsia [illegible]	[illegible]
Diagnostic Species Group G	
Cyperus obtusiflorus	[illegible]
Alloteropsis semialata	[illegible]
Diagnostic Species Group H	
Anthospermum rigidum	[illegible]
Helichrysum cephaloideum	[illegible]
Eragrostis chloromelas	[illegible]
Vernonia oligocephala	[illegible]
Crepis hypochaeridea	[illegible]
Diagnostic Species Group I	
Conyza podocephala	[illegible]
Zanthoxylum capense	[illegible]
[illegible]	[illegible]
Eriosema [illegible]	[illegible]
Diagnostic Species Group J	
Acacia karroo	[illegible]
Scabiosa [illegible]	[illegible]
Maytenus heterophylla	[illegible]
Commelina [illegible]	[illegible]
[illegible]	[illegible]
Searsia [illegible]	[illegible]
Raphionacme [illegible]	[illegible]
Diagnostic Species Group K	
Rhus [illegible]	[illegible]
Acacia [illegible]	[illegible]
Hermannia depressa	[illegible]
Diagnostic Species Group L	
Hyparrhenia dregeana	[illegible]
Aristida congesta subsp. *congesta*	[illegible]
Pavetta [illegible]	[illegible]
Gerbera [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Aristida diffusa	[illegible]
Plectranthus madagascariensis	[illegible]
Diagnostic Species Group M	
[illegible]	[illegible]
Berkheya [illegible]	[illegible]
[illegible]	[illegible]
Ficus [illegible]	[illegible]
Eriosema [illegible]	[illegible]
Helichrysum [illegible]	[illegible]
Thunbergia [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Pavetta [illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Aristida [illegible]	[illegible]
[illegible]	[illegible]
Acacia [illegible]	[illegible]
Euclea [illegible]	[illegible]
Podocarpus spp.	[illegible]
Clematis brachiata	[illegible]
Dovyalis zeyheri	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Maytenus [illegible]	[illegible]
Helichrysum [illegible]	[illegible]
Tarchonanthus camphoratus	[illegible]
Xysmalobium undulatum	[illegible]
Lannea discolor	[illegible]
[illegible]	[illegible]
Sansevieria trifasciata	[illegible]
Lippia [illegible]	[illegible]
Rhus [illegible]	[illegible]
[illegible]	[illegible]
Vernonia [illegible]	[illegible]
Dicerocaryum eriocarpum	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Cheilanthes viridis	[illegible]
Eragrostis capensis	[illegible]
Acacia [illegible]	[illegible]
Diagnostic Species Group N	
[illegible]	[illegible]
Euclea [illegible]	[illegible]
Trichoneura grandiglumis	[illegible]
Rhus [illegible]	[illegible]
[illegible]	[illegible]
Xerophyta retinervis	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Diagnostic Species Group
Englerophytum magalismontanum
[illegible]
Rhus [illegible]
Euphorbia ingens
Hyparrhenia dregeana
Sporobolus pectinatus
Rhus discolor
Aloe arborescens
Chamaecrista biensis
Chaetacanthus burchellii
Buddleja salviifolia
Cheilanthes eckloniana
Diagnostic Species Group
Eriosema salignum
Hyperthelia cymbaria
Diagnostic Species Group
Schizostylis coccinea
Chamaecrista comosa
Bidens pilosa
Senecio affinis
Oxalis purpurea
Diagnostic Species Group
Kyllinga alba
Wahlenbergia undulata
Diagnostic Species Group
Bothriochloa insculpta
Combretum erythrophyllum
Conyza scabrida
Cynodon dactylon
Diagnostic Species Group
Phragmites australis
Miscanthus junceus
Diagnostic Species Group
Coleochloa setifera
Mariscus congestus
Diagnostic Species Group
Setaria nigrirostris
Datura stramonium
Diagnostic Species Group
Helichrysum harveyanum
Leersia hexandra
Andropogon eucomus
Agrostis eriantha
Mentha aquatica
[illegible]
Constant Species Group X
Themeda triandra
Setaria sphacelata
Hyparrhenia hirta
Species Group Y: Species
Vernonia natalensis
Acalypha angustata
Tristachya leucothrix
Heteropogon contortus
[illegible] natalensis
Eragrostis racemosa
Senecio venosus
Diheteropogon amplectens
Berkheya setifera
Bulbostylis burchellii
Hypoxis rigidula
Loudetia simplex
Species Group Z: Species
Eragrostis plana
Cyperus esculentus
Verbena brasiliensis
Paspalum dilatatum
Schkuhria pinnata
Arundinella nepalensis
Imperata cylindrica
Polygonum lapathifolium
Species Group AA: Species
Haplocarpha scaposa
Cymbopogon excavatus
Eulalia villosa
Trachypogon spicatus
Gladiolus ecklonii
Bewsia biflora
Helichrysum rugulosum
Eragrostis capensis
Berkheya seminivea
Berkheya echinacea
Microchloa caffra
Commelina africana
Monocymbium ceresiiforme
Schizachyrium sanguineum
Pentanisia angustifolia
Indigofera hilaris
Digitaria diagonalis
Aristida [illegible]
Stachys natalensis
Hypoxis iridifolia
Chaetacanthus costatus
Dicoma zeyheri
Cyperus rupestris
Chaetacanthus setiger
Alepidea longifolia
Polygala hottentotta
Indigofera comosa
Gnidia capitata
Dicoma anomala
Leonotis microphylla
Cheilanthes quadripinnata
Ipomoea ommanneyi
Berkheya speciosa
Lotononis foliosa
Xanthium strumarium
Species Group AB: Species
Pellaea calomelanos
Diospyros whyteana
Aloe marlothii
Species Group AC: Species
Rhoicissus tridentata
Diospyros lycioides
Euclea natalensis
Lippia javanica
Asparagus laricinus
Acacia caffra
Dombeya rotundifolia
Combretum molle
Aristida [illegible]
Rhus dentata
Euclea crispa
Ziziphus mucronata
Peltophorum africanum
Combretum apiculatum
Panicum maximum
Pappea capensis
Senecio barbertonicus
Species Group AD: Species
Melinis repens
Aristida junciformis
Eragrostis curvula
Hypochaeris radicata
Solanum elaeagnifolium
Sporobolus africanus
Oenothera tetraptera
Phymaspermum athanasioides
Hibiscus trionum
Richardia brasiliensis
Aristida congesta subsp. bar
Sida alba
Prominent species that do
Eragrostis gummiflua
[illegible]
Moraea pubiflora
Convolvulus sagittatus
Tephrosia macropoda
Trifolium africanum
Setaria lindenbergiana

Diagnostic Species Group O
Englerophytum magalismontanum
Zantedeschia aethiopica
Rhus [illegible]
Euphorbia ingens
Hyparrhenia dregeana
Sporobolus pectinatus
Rhus discolor
Aloe arborescens
Chamaecrista biensis
Chaetacanthus burchellii
Buddleja salviifolia
Cheilanthes eckloniana
Diagnostic Species Group P
Eriosema salignum
Hyparrhenia cymbaria
Diagnostic Species Group Q
Schizostylis coccinea
Chamaecrista comosa
Bidens pilosa
Senecio affinis
Oxalis purpurea
Diagnostic Species Group R
Kyllinga alba
Wahlenbergia undulata
Diagnostic Species Group S
Sorghastrum incompletum
Combretum erythrophyllum
Conyza scabrida
Cynodon dactylon
Diagnostic Species Group T
Phragmites australis
Miscanthus junceus
Diagnostic Species Group U
Coleochloa setifera
Mariscus congestus
Diagnostic Species Group V
Setaria nigrirostris
Datura stramonium
Diagnostic Species Group W
Helichrysum harveyanum
Leersia hexandra
Andropogon eucomus
Agrostis eriantha
Mentha aquatica
Gamochaeta purpurea
Constant Species Group X
Themeda triandra
Setaria sphacelata
Hyparrhenia hirta
Species Group Y: Species associated with terrestrial ecosystems
Vernonia natalensis
Acalypha angustata
Tristachya leucothrix
Heteropogon contortus
Panicum natalense
Eragrostis racemosa
Senecio venosus
Diheteropogon amplectens
Berkheya setifera
Bulbostylis burchellii
Hypoxis rigidula
Loudetia simplex
Species Group Z: Species associated with wetland ecosystems
Eragrostis plana
Cyperus esculentus
Verbena brasiliensis
Paspalum dilatatum
Schkuhria pinnata
Arundinella nepalensis
Imperata cylindrica
Polygonum lapathifolium
Species Group AA: Species associated with grassland communities
Haplocarpha scaposa
Cymbopogon excavatus
Eulalia villosa
Trachypogon spicatus
Gladiolus ellioti
Bewsia biflora
Helichrysum nudifolium
Eragrostis capensis
Berkheya seminivea
Berkheya echinacea
Microchloa caffra
Commelina africana
Monocymbium ceresiiforme
Schizachyrium sanguineum
Pentanisia angustifolia
Indigofera hilaris
Digitaria diagonalis
Athrixia phylicoides
Stachys natalensis
Hypoxis iridifolia
Chaetacanthus costatus
Lannea zeyheri
Cyperus rupestris
Chaetacanthus setiger
Alepidea longifolia
Polygala hottentotta
Indigofera comosa
Gnidia capitata
Dicoma anomala
Leonotis microphylla
Cheilanthes quadripinnata
Ipomoea ommaneyi
Berkheya speciosa
Lotononis foliosa
Xanthium strumarium
Species Group AB: Species associated with surface rocks
Pellaea calomelanos
Diospyros whyteana
Aloe marlothii
Species Group AC: Species associated with woodland communities
Rhoicissus tridentata
Diospyros lycioides
Euclea natalensis
Lippia javanica
Asparagus laricinus
Acacia caffra
Dombeya rotundifolia
Combretum molle
Athrixia elata
Rhus dentata
Euclea crispa
Ziziphus mucronata
Peltophorum africanum
Combretum apiculatum
Panicum maximum
Pappea capensis
Senecio barbertonicus
Species Group AD: Species associated with over utilization
Melinis repens
Aristida junciformis
Eragrostis curvula
Hypochaeris radicata
Solanum elaeagnifolium
Sporobolus africanus
Oenothera tetraptera
Phymaspermum athanasioides
Hibiscus trionum
Richardia brasiliensis
Aristida congesta subsp. *barbicollis*
Sida alba
Prominent species that do not occur in this veld type
Eragrostis gummiflua
Stenotaphrum secundatum
Moraea pallida
Convolvulus sagittatus sagittatus var. *hirtellus*
Tephrosia macropoda
Trifolium africanum
Setaria lindenbergiana



APPENDIX I

Tabel 25.a: Phytosociological table reflecting the percentage constancy of the species

	Frequency within total data set	Frequency within table data set	% freq. within table data set	% freq. within total data set	1	2	3	4	5	6	7	8	9	10	11	12	13
Veld type					South-eastern Mpumalanga Hills and Lowlands Veld Type												
Ecosystem					1	1	1	1	2	2	2	2	2	2	2	2	2
Cutlevel 2					1.1	1.2	1.2	1.2	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
Cutlevel 3						1.2.1	1.2.1	1.2.2	2.1.1	2.1.1	2.1.2	2.1.2	2.1.2	2.2.1	2.2.1	2.2.2	2.2.2
Cutlevel 4						1.2.1.a	1.2.1.b		2.1.1.a	2.1.1.b	2.1.2.1	2.1.2.1	2.1.2.2	2.2.1.a	2.2.1.b	2.2.2.a	2.2.2.b
Cutlevel 5											2.1.2.1.a	2.1.2.1.b					
Cutlevel 6																	
Community					1.1	1.2	1.2	1.3	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.7
Sub-community						1.2.a	1.2.b		2.1.a	2.1.b	2.2.a	2.2.b					
					% frequency of each species within the TWINSPAN classification clusters												
Diagnostic Species Group A																	
Cliffortia nitidula	6	3	3	50	67	11	0	0	0	0	0	0	0	0	0	0	0
Watsonia densiflora	8	4	4	50	67	11	0	0	0	0	0	0	0	0	0	17	0
Diagnostic Species Group B																	
Polygonum lapathifolium	30	14	13	47	0	78	83	25	0	0	0	0	0	0	0	0	0
Miscanthus junceus	25	10	9	40	33	44	83	0	0	0	0	0	0	0	0	0	0
Diagnostic Species Group C																	
Arundinella nepalensis	46	10	9	22	0	67	33	13	0	3	0	0	0	0	0	0	0
Senecio affinis	36	16	15	44	33	44	33	13	22	10	8	0	0	0	17	17	0
Diagnostic Species Group D																	
Sporobolus africanus	67	24	22	36	33	11	67	25	22	30	17	0	14	33	17	0	0
Schoenoplectus corymbosus	22	6	6	27	0	11	50	25	0	0	0	0	0	0	0	0	0
Mariscus congestus	35	8	7	23	0	33	50	13	0	3	0	0	0	0	0	0	0
Cirsium vulgare	26	6	6	23	0	11	50	0	0	3	0	0	14	0	0	0	0
Agrostis eriantha	23	6	6	26	0	11	50	25	0	0	0	0	0	0	0	0	0
Diagnostic Species Group E																	
Oenothera tetraptera	60	21	19	35	0	22	33	63	0	30	8	0	14	0	17	0	0
Lippia javanica	45	15	14	33	0	0	17	38	11	17	25	0	0	33	17	0	0
Diagnostic Species Group F																	
Anthospermum rigidum	65	24	22	37	0	0	17	13	44	43	25	17	0	33	0	0	0
Helichrysum nudifolium	55	19	17	35	0	0	17	0	56	37	8	17	0	0	0	0	0
Diagnostic Species Group G																	
Paspalum scrobiculatum	33	22	20	67	0	11	17	13	78	33	0	0	0	33	17	0	0
Vernonia oligocephala	40	13	12	33	0	0	0	0	67	10	17	0	0	0	17	0	25
Moraea pubiflora	14	10	9	71	0	11	0	0	56	10	0	17	0	0	0	0	0
Trachyandra spp.	42	17	16	40	0	11	17	0	56	17	0	33	14	0	17	17	0
Solanum elaeagnifolium	55	13	12	24	0	11	0	0	56	13	0	33	14	0	0	0	0
Ruellia patula	26	18	17	69	0	11	33	0	56	23	17	0	0	0	17	0	0
Thunbergia atriplicifolia	23	11	10	48	0	0	17	0	56	7	8	17	14	0	0	0	0
Corchorus confusus	28	17	16	61	0	0	0	0	44	23	25	33	0	0	17	0	0
Sonchus wilmsii	35	17	16	49	0	11	17	25	44	20	8	0	0	0	33	0	0
Aster harveyanus	18	12	11	67	0	11	0	0	44	10	0	0	14	0	17	17	25
Diospyros galpinii	9	7	6	78	0	0	0	0	44	7	0	0	0	0	17	0	0
Striga bilabiata	30	17	16	57	0	0	0	0	44	23	25	17	0	0	17	0	25
Alepidea setifera	13	11	10	85	0	0	0	0	44	13	0	17	0	0	33	0	0
Rhus discolor	69	18	17	26	0	11	0	0	44	10	17	33	14	33	33	17	25
Diagnostic Species Group H																	
Cyperus obtusiflorus	70	17	16	24	0	0	0	13	11	3	50	67	14	0	0	33	25
Dicoma zeyheri	49	16	15	33	0	0	0	0	11	17	42	67	0	0	17	0	0
Pentanisia angustifolia	64	29	27	45	0	0	0	13	33	30	67	50	29	33	17	0	25
Ledebouria ovatifolia	66	18	17	27	0	11	0	0	11	13	50	50	29	33	0	0	0
Diagnostic Species Group I																	
Helichrysum cephaloideum	72	31	28	43	0	11	0	0	33	30	83	33	14	0	33	33	25
Adenanthellum osmitoides	12	7	6	58	0	0	0	0	0	0	50	17	0	0	0	0	0
Gerbera piloselloides	36	14	13	39	0	0	0	25	0	10	42	0	0	33	17	33	0
Brachiaria serrata	46	16	15	35	0	0	0	25	22	13	42	0	14	0	0	33	0
Diagnostic Species Group J																	
Indigofera comosa	55	31	28	56	0	0	0	13	22	53	67	17	0	0	0	33	25
Zornia milneana	50	25	23	50	0	11	0	0	22	37	50	17	29	0	C	33	0
Diagnostic Species Group K																	
Clutia monticola	14	7	6	50	0	0	0	0	0	0	8	67	0	0	17	0	25
Hibiscus aethiopicus	57	23	21	40	0	22	33	0	33	33	8	50	14	0	0	0	25
Aloe davyana	15	9	8	60	0	0	0	0	11	7	0	50	0	33	0	17	0
Cyanotis lapidosa	3	3	3	100	0	0	0	0	0	0	0	50	0	0	0	0	0
Lopholaena segmentata	9	5	5	56	0	0	17	0	0	0	0	50	0	0	17	0	0
Diagnostic Species Group L																	
Oxalis purpurea	45	19	17	42	33	22	0	13	11	10	8	33	71	0	0	33	25
Hermannia transvaalensis	22	8	7	36	0	0	0	0	0	13	0	0	43	33	0	0	0
Walafrida tenuifolia	28	11	10	39	0	11	17	0	0	10	8	17	43	33	0	0	0
Diagnostic Species Group M																	

Tabel 25.b: Phytosociological table reflecting the percentage fidelity and qualifying clusters of the species

Veld type			South-eastern Mpumalanga Hills and Lowlands Veld Type												
Ecosystem			1	1	1	1	2	2	2	2	2	2	2	2	2
Cutlevel 2			1.1	1.2	1.2	1.2	2.1	2.1	2.1	2.1	2.1	2.2	2.2	2.2	2.2
Cutlevel 3				1.2.1	1.2.1	1.2.2	2.1.1	2.1.1	2.1.2	2.1.2	2.1.2	2.2.1	2.2.1	2.2.2	2.2.2
Cutlevel 4				1.2.1.a	1.2.1.b		2.1.1.a	2.1.1.b	2.1.2.1	2.1.2.1	2.1.2.2	2.2.1.a	2.2.1.b	2.2.2.a	2.2.2.b
Cutlevel 5									2.1.2.1.a	2.1.2.1.b					
Cutlevel 6															
Community			1.1	1.2	1.2	1.3	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.7
Sub-community				1.2.a	1.2.b		2.1.a	2.1.b	2.2.a	2.2.b					
	# of clusters that qualified (%>33)	% fidelity of qualifing cluster	Qualifing clusters/ vegetation communities reflecting the different diagnositc species groups												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Diagnostic Species Group A															
[illegible] nitidula	1	8	1												
Watsonia densiflora	1	8	1												
Diagnostic Species Group B															
Polygonum lapathifolium	2	15		2	3										
Miscanthus junceus	2	15		2	3										
Diagnostic Species Group C															
Arundinella nepalensis	1	8		2											
Senecio affinis	1	8		2											
Diagnostic Species Group D															
Sporobolus africanus	1	8			3										
Schoenoplectus corymbosus	1	8			3										
Mariscus congestus	1	8			3										
Cirsium vulgare	1	8			3										
Agrostis eriantha	1	8			3										
Diagnostic Species Group E															
Oenothera tetraptera	1	8				4									
Lippia javanica	1	8				4									
Diagnostic Species Group F															
Anthospermum rigidum	2	15					5	6							
Helichrysum nudifolium	2	15					5	6							
Diagnostic Species Group G															
Paspalum scrobiculatum	1	8					5								
Vernonia oligocephala	1	8					5								
Moraea pubiflora	1	8					5								
Trachyandra spp	1	8					5								
Solanum elaeagnifolium	1	8					5								
Ruellia patula	1	8					5								
Thunbergia atriplicifolia	1	8					5								
Corchorus confusus	1	8					5								
Sonchus wilmsii	1	8					5								
Aster harveyanus	1	8					5								
Diospyros galpinii	1	8					5								
Striga bilabiata	1	8					5								
Alepidea setifera	1	8					5								
Rhus discolor	1	8					5								
Diagnostic Species Group H															
Cyperus obtusiflorus	2	15							7	8					
Dicoma zeyheri	2	15							7	8					
Pentanisia angustifolia	2	15							7	8					
Ledebouria ovatifolia	2	15							7	8					
Diagnostic Species Group I															
Helichrysum cephaloideum	1	8							7						
Adenanthellum osmitoides	1	8							7						
Gerbera piloselloides	1	8							7						
Brachiaria serrata	1	8							7						
Diagnostic Species Group J															
Indigofera comosa	2	15						6	7						
Zornia milneana	2	15						6	7						
Diagnostic Species Group K															
Clutia monticola	1	8								8					
Hibiscus aethiopicus	1	8								8					
Aloe davyana	1	8								8					
Cyanotis lapidosa	1	8								8					
Lopholaena segmentata	1	8								8					
Diagnostic Species Group L															
Oxalis purpurea	1	8									9				
Hermannia transvaalensis	1	8									9				
Walafrida tenuifolia	1	8									9				
Diagnostic Species Group M															

Myrsine africana	12	4	4	[illegible]	[illegible]	0	0	0	0	0	0	0	0	67	33	0	0
Aloe marlothii	47	6	6	13	0	0	0	0	33	0	0	0	0	67	17	0	0
Tetradenia riparia	27	6	6	22	0	0	0	0	11	0	0	0	0	67	33	17	0
Aristida congesta subsp. congesta	68	7	6	10	0	0	0	0	0	17	0	0	0	67	0	0	0
Rhus rigida	3	3	3	100	0	0	0	0	0	3	0	0	0	67	0	0	0
Rhus chirindensis	3	3	3	100	0	0	0	0	0	3	0	0	0	67	0	0	0
Cussonia spicata	23	6	6	26	0	0	0	0	0	0	0	17	0	67	33	0	25
Justicia anagalloides	33	14	13	42	0	0	0	0	22	17	25	33	0	67	0	0	0
Acokanthera rotundata	8	5	5	63	0	0	0	0	0	0	0	17	0	67	17	17	0
Diagnostic Species Group N																	
Diheteropogon amplectens	89	15	14	17	0	0	0	0	22	7	17	33	0	0	83	33	0
Cephalanthus natalensis	27	11	10	41	0	0	17	0	22	0	0	0	14	0	67	33	25
Athrixia elata	27	7	6	26	0	0	0	0	33	0	0	0	0	0	67	0	0
Euclea natalensis	43	8	7	19	0	0	0	0	0	0	8	33	0	33	67	0	0
Dicoma anomala	58	8	7	14	0	0	0	0	11	0	17	0	0	0	50	17	25
Panicum maximum	20	4	4	20	0	0	0	0	0	3	0	0	0	0	50	0	0
Berkheya zeyheri	19	10	9	53	0	0	0	0	22	3	8	33	0	33	50	0	0
Pteridium aquilinum	25	8	7	32	0	0	17	0	0	10	0	0	0	0	50	0	25
Stachys natalensis	48	13	12	27	0	11	17	0	11	3	0	33	0	33	50	33	25
Rubus rigidus	29	12	11	41	33	0	17	25	33	0	0	17	0	0	50	17	0
Cussonia paniculata	15	6	6	40	0	0	0	0	0	0	0	17	0	0	50	33	0
Berkheya seminivea	44	4	4	9	0	0	0	0	11	0	0	0	0	0	50	0	0
Diagnostic Species Group O																	
Zanthoxylum capense	10	7	6	70	0	0	0	0	0	0	0	0	0	100	67	0	0
Eucomis autumnalis	34	10	9	29	0	0	0	13	0	3	17	0	0	67	67	0	0
Maytenus heterophylla	40	12	11	30	0	11	0	0	22	3	0	33	0	67	50	0	25
Diagnostic Species Group P																	
Tetraselago wilmsii	12	7	6	58	0	0	0	0	11	0	0	0	0	0	17	83	0
Pelargonium luridum	37	5	5	14	0	0	0	0	0	0	8	0	0	33	0	50	0
Helichrysum aureonitens	22	9	8	41	33	22	0	13	0	3	8	0	0	0	0	50	0
Pavetta edentula	42	4	4	10	0	0	0	0	0	3	0	0	0	0	0	50	0
Helichrysum coriaceum	11	7	6	64	0	0	0	0	0	0	17	0	0	33	0	50	25
Vernonia sutherlandii	14	5	5	36	0	0	0	0	0	0	0	0	0	0	17	50	25
Cyanotis speciosa	33	13	12	39	33	0	0	0	0	7	33	33	0	0	0	50	25
Diagnostic Species Group Q																	
Pellaea calomelanos	86	19	17	22	0	0	0	0	33	3	8	17	0	100	67	83	25
Rhoicissus tridentata	78	13	12	17	0	0	0	0	0	0	0	0	0	100	100	50	25
Diagnostic Species Group R																	
Sporobolus pectinatus	6	5	5	83	0	0	0	0	0	0	0	17	14	0	0	0	75
Cymbopogon excavatus	90	16	15	18	0	0	0	25	22	10	17	33	0	33	33	0	50
Zantedeschia albomaculata	15	5	5	33	0	0	0	0	0	0	0	0	14	33	0	17	50
Waltheria indica	5	3	3	60	0	0	0	0	0	0	0	0	14	0	0	0	50
Elionurus muticus	42	11	10	26	0	0	0	0	22	13	17	17	0	0	0	0	50
Digitaria monodactyla	8	3	3	38	0	0	0	0	0	0	0	0	0	0	0	17	50
Helichrysum pilosellum	14	7	6	50	0	0	0	0	0	7	17	0	14	0	0	0	50
Agapanthus nutans	13	5	5	38	0	0	0	0	0	0	0	17	0	33	17	0	50
Alloteropsis semialata	44	14	13	32	0	0	0	0	11	7	33	33	14	0	0	33	50
Constant Species Group S																	
Hyparrhenia hirta	179	75	69	42	0	44	50	75	89	97	67	67	14	100	83	50	25
Themeda triandra	262	65	60	25	33	44	33	38	56	63	83	100	71	67	83	33	25
Setaria sphacelata	212	58	53	27	100	11	67	25	78	57	58	100	43	33	83	17	25
Species Group T: Species associated with wetland ecosystems																	
Paspalum dilatatum	94	38	35	40	67	67	67	88	0	33	25	0	43	0	33	17	0
Cyperus esculentus	89	34	31	38	33	78	83	75	0	13	8	0	29	0	33	67	50
Verbena brasiliensis	67	21	19	31	33	56	83	75	0	10	8	0	0	0	0	0	0
Phymaspermum athanasioides	59	31	28	53	67	67	83	13	0	40	17	17	0	0	33	0	0
Wahlenbergia undulata	39	17	16	44	0	44	17	75	22	13	0	0	0	0	0	0	0
Imperata cylindrica	48	16	15	33	67	78	50	13	11	7	0	0	0	0	0	0	0
Kyllinga alba	44	13	12	30	33	56	17	38	0	0	8	0	14	0	17	0	0
Coleochloa setifera	40	11	10	28	0	33	50	38	0	7	0	0	0	0	0	0	0
Species Group U: Species associated with terrestrial ecosystems																	
Tristachya leucothrix	152	40	37	26	0	0	0	0	44	13	83	100	57	67	67	50	75
Cymbopogon plurinodis	89	38	35	43	0	22	33	0	89	43	33	33	0	33	67	17	25
Hypoxis rigidula	114	37	34	32	0	0	0	0	33	43	58	67	43	33	50	33	25
Commelina africana	108	36	33	33	33	44	17	13	33	10	50	0	43	33	83	100	50
Acalypha angustata	148	38	33	24	0	22	0	13	44	30	50	50	29	67	33	83	0
Senecio venosus	114	33	30	29	0	11	0	0	22	17	83	67	14	67	67	33	50
Trachypogon spicatus	124	32	29	28	0	0	0	0	67	23	25	50	43	0	67	83	25
Scabiosa columbaria	75	31	28	41	0	11	0	0	67	33	50	33	29	33	50	0	0
Hypoxis iridifolia	75	29	27	39	0	11	0	13	0	33	50	50	0	33	17	50	75
Loudetia simplex	88	27	25	31	0	0	17	0	33	3	67	67	14	0	50	83	25
Phyllanthus parvulus	43	27	25	63	0	22	0	0	56	30	25	50	0	33	67	0	0
Eriosema cordatum	65	24	22	37	0	11	17	13	44	10	17	0	0	33	83	83	25
Eulalia villosa	88	24	22	27	0	0	0	13	67	30	8	17	0	0	50	17	50
Microchloa caffra	76	22	20	29	0	0	0	0	0	10	58	0	43	33	17	83	50
Gladiolus elliotii	84	22	20	26	0	0	0	0	0	17	67	50	14	33	17	17	50
Bulbostylis burchellii	96	20	18	21	67	0	17	0	0	17	50	0	14	0	0	67	25
Berkheya echinacea	55	18	17	33	0	0	0	0	22	17	8	67	0	0	50	33	25
Schistostephium crataegifolium	62	17	16	27	0	22	17	0	56	7	17	0	14	0	67	0	0
Clutia pulchella	22	15	14	68	0	0	0	0	67	7	17	0	0	0	83	0	0
Sebaea grandis	32	14	13	44	0	11	0	0	22	13	8	50	0	0	50	0	0
Rhus dentata	50	13	12	26	0	0	0	0	33	0	0	67	0	33	50	17	25
Asparagus laricinus	53	11	10	21	0	0	0	0	11	0	0	67	0	33	50	17	25
Species Group V: Species associated with grassland communities																	

Myrsine africana	1	8										10			
Aloe marlothii	1	8										10			
Tetradenia riparia	1	8										10			
Aristida congesta subsp. congesta	1	8										10			
Rhus rigida	1	8										10			
Rhus chirindensis	1	8										10			
Cussonia spicata	1	8										10			
Justicia anagalloides	1	8										10			
Acokanthera rotundata	1	8										10			
Diagnostic Species Group N															
Diheteropogon amplectens	1	8											11		
Cephalanthus natalensis	1	8											11		
Athrixia elata	1	8											11		
Euclea natalensis	1	8											11		
Dicoma anomala	1	8											11		
Panicum maximum	1	8											11		
Berkheya zeyheri	1	8											11		
Pteridium aquilinum	1	8											11		
Stachys natalensis	1	8											11		
Rubus rigidus	1	8											11		
Cussonia paniculata	1	8											11		
Berkheya seminivea	1	8											11		
Diagnostic Species Group O															
Zanthoxylum capense	2	15										10	11		
Eucomis autumnalis	2	15										10	11		
Maytenus heterophylla	2	15										10	11		
Diagnostic Species Group P															
Tetraselago wilmsii	1	8												12	
Pelargonium luridum	1	8												12	
Helichrysum aureonitens	1	8												12	
Pavetta edentula	1	8												12	
Helichrysum coriaceum	1	8												12	
Vernonia sutherlandii	1	8												12	
Cyanotis speciosa	1	8												12	
Diagnostic Species Group Q															
Pellaea calomelanos	3	23										10	11	12	
Rhoicissus tridentata	3	23										10	11	12	
Diagnostic Species Group R															
Sporobolus pectinatus	1	8													13
Cymbopogon excavatus	1	8													13
Zantedeschia albomaculata	1	8													13
Waltheria indica	1	8													13
Elionurus muticus	1	8													13
Digitaria monodactyla	1	8													13
Helichrysum pilosellum	1	8													13
Agapanthus nutans	1	8													13
Alloteropsis semialata	1	8													13
Constant Species Group S															
Hyparrhenia hirta	10	77		2	3	4	5	6	7	8		10	11	12	
Themeda triandra	9	69		2		4	5	6	7	8	9	10	11		
Setaria sphacelata	8	62	1		3		5	6	7	8	9		11		
Species Group T: Species associated with wetland ecosystems															
Paspalum dilatatum	5	38	1	2	3	4					9				
Cyperus esculentus	5	38		2	3	4								12	13
Verbena brasiliensis	3	23		2	3	4									
Phymaspermum athanasioides	4	31	1	2	3			6							
Wahlenbergia undulata	2	15		2		4									
Imperata cylindrica	3	23	1	2	3										
Kyllinga alba	2	15		2		4									
Coleochloa setifera	2	15			3	4									
Species Group U: Species associated with terrestrial ecosystems															
Tristachya leucothrix	8	62					5		7	8	9	10	11	12	13
Cymbopogon plurinodis	3	23					5	6					11		
Hypoxis rigidula	5	38						6	7	8	9		11		
Commelina africana	6	46		2					7		9		11	12	13
Acalypha angustata	5	38					5		7	8		10		12	
Senecio venosus	5	38							7	8		10	11		13
Trachypogon spicatus	5	38					5			8	9		11	12	
Scabiosa columbaria	3	23					5		7				11		
Hypoxis iridifolia	4	31							7	8				12	13
Loudetia simplex	4	31							7	8			11	12	
Phyllanthus parvulus	3	23					5			8			11		
Eriosema cordatum	3	23					5						11	12	
Eulalia villosa	3	23					5						11		13
Microchloa caffra	4	31							7		9			12	13
Gladiolus elliotii	3	23							7	8					13
Bulbostylis burchellii	3	23	1						7					12	
Berkheya echinacea	2	15								8			11		
Schistostephium crataegifolium	2	15					5						11		
Clutia pulchella	2	15					5						11		
Sebaea grandis	2	15								8			11		
Rhus dentata	2	15								8			11		
Protasparagus laricinus	2	15								8			11		
Species Group V: Species associated with grassland communities															

Helichrysum rugulosum	154	56	51	[illegible]	00	0	17	13	56	87	58	50	86	33	17	33	0
Eragrostis racemosa	167	49	45	29	0	0	33	0	22	63	92	50	71	33	33	50	25
Berkheya setifera	145	44	40	30	0	0	17	0	100	57	50	50	29	0	50	33	25
Haplocarpha scaposa	138	40	37	29	0	11	17	0	67	50	33	83	43	33	33	17	25
Eragrostis capensis	115	39	36	34	67	0	0	13	67	40	58	0	86	0	0	50	50
Panicum natalense	121	38	35	31	0	11	50	0	33	23	67	83	29	0	33	83	30
Heteropogon contortus	173	28	26	16	0	11	0	13	22	20	50	50	57	0	33	33	25
Vernonia natalensis	124	26	24	21	0	0	0	13	33	37	17	67	43	0	0	33	0
Setaria nigrirostris.	54	16	15	30	33	44	0	0	11	13	8	17	43	0	17	0	0
Eragrostis chloromelas	83	15	14	18	0	0	0	0	56	10	17	0	43	0	0	33	0
Hyparrhenia dregeana	48	13	12	27	0	0	50	13	11	7	0	0	0	0	67	33	0
Monopsis decipiens	47	12	11	26	67	11	0	25	0	0	8	0	29	0	0	67	0
Species Group W: Species associated with woodland communities																	
Diospyros lycioides	113	38	35	34	0	44	0	25	67	40	25	33	0	100	67	17	25
Diospyros whyteana	61	17	16	28	0	0	0	0	0	0	0	33	14	100	83	67	50
Cheilanthes viridis	16	11	10	69	0	11	17	13	0	3	8	0	0	0	67	0	50
Senecio oxyriifolius	19	9	8	47	0	0	0	0	11	0	8	0	0	33	17	50	50
Vangueria infausta	22	9	8	41	0	0	0	0	11	0	0	0	0	67	33	50	25
Species Group X: Species associated with over utilization																	
Eragrostis plana	155	54	50	35	67	89	50	75	11	80	33	17	0	67	50	0	0
Eragrostis curvula	139	50	46	36	33	11	0	50	44	67	58	33	71	67	50	17	0
Conyza podocephala	97	46	42	47	0	44	50	13	56	70	33	17	0	67	83	0	0
Melinis repens	165	45	41	27	0	22	33	0	89	43	33	33	29	100	50	83	25
Hypochoeris radicata	101	41	38	41	67	22	33	38	11	53	25	17	71	0	17	67	25
Spermacoce natalensis	55	39	36	71	0	22	33	75	89	57	17	0	0	0	33	0	0
Verbena venosa	64	28	26	44	0	44	17	25	22	47	17	33	0	0	17	0	0
Senecio isatideus	36	22	20	61	0	11	33	38	11	30	8	0	0	33	67	0	0
Prominent species which do not occur wihtin this veld type																	
Pogonarthria squarrosa	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kalanchoe paniculata	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aristida sciurus	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indigofera hilaris	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia karroo	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Perotis patens	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia caffra	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dicerocaryum eriocarpum	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoneura grandiglumis	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Combretum apiculatum	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acacia nilotica	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aristida diffusa	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nidorella anomala	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gnidia caffra	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andropogon schirensis	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tephrosia multijuga	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albuca spp.	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faurea speciosa	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sclerocarya birrea	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raphionacme burkei	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peltophorum africanum	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ozoroa paniculosa	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ficus glumosa	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bauhinia galpinii	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyphostemma lanigerum	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maytenus undata	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trifolium africanum	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Annona senegalensis	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

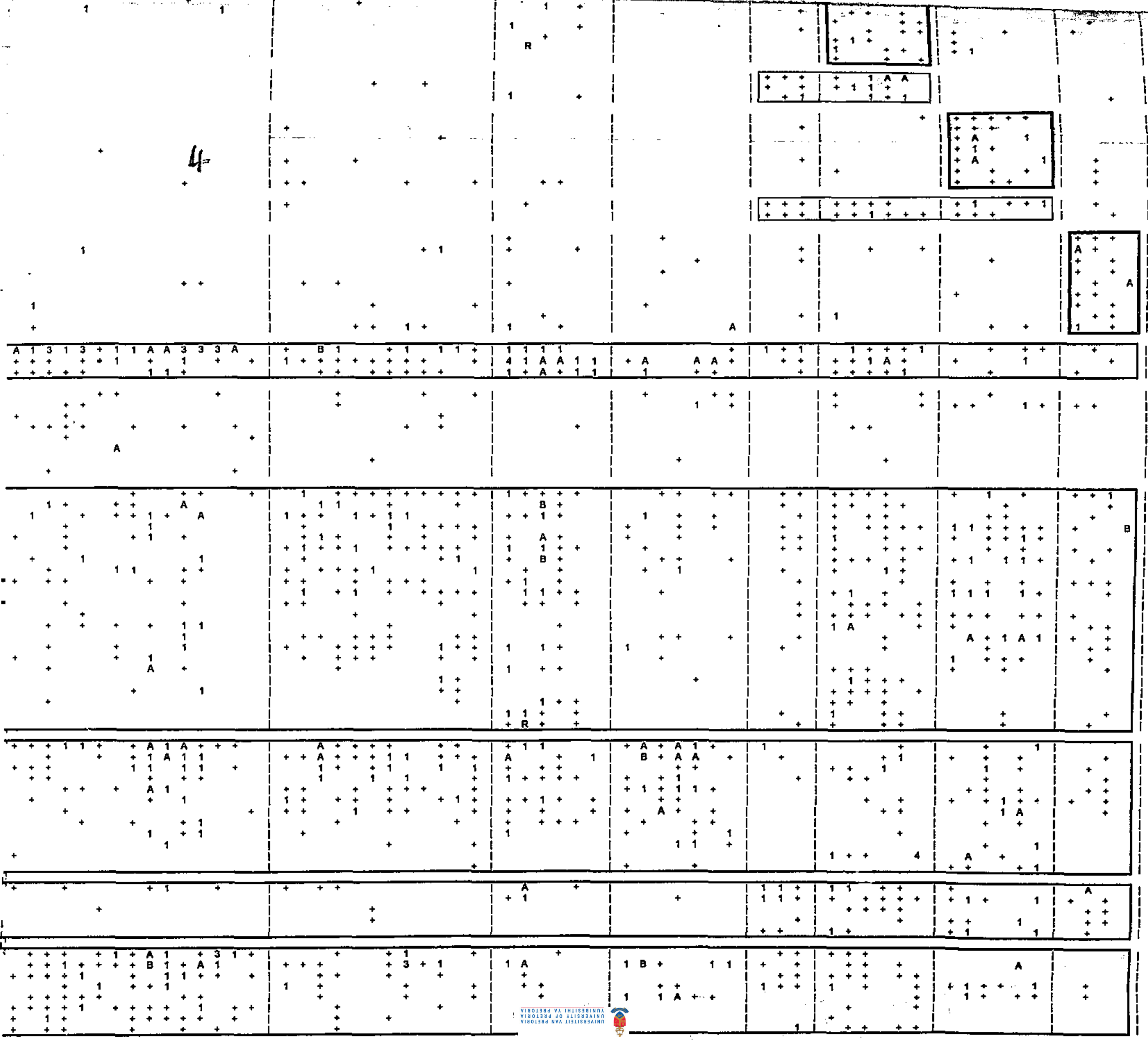
Helichrysum rugulosum	6	46	1				5	6	7	8	9				
Eragrostis racemosa	5	38						6	7	8	9			12	
Berkheya setifera	5	38					5	6	7	8			11		
Haplocarpha scaposa	4	31					5	6		8	9				
Eragrostis capensis	7	54	1				5	6	7		9			12	13
Panicum natalense	5	38			3				7	8				12	13
Heteropogon contortus	3	23							7	8	9				
Vernonia natalensis	3	23						6		8	9				
Setaria nigrirostris.	2	15		2							9				
Eragrostis chloromelas	2	15					5				9				
Hyparrhenia dregeana	2	15			3								11		
Monopsis decipiens	2	15	1											12	
Species Group W: Species associated with woodland communities															
Diospyros lycioides	5	38		2			5	6				10	11		
Diospyros whyteana	4	31										10	11	12	13
Cheilanthes viridis	2	15											11		13
Senecio oxyriifolius	2	15												12	13
Vangueria infausta	2	15										10		12	
Species Group X: Species associated with over utilization															
Eragrostis plana	7	54	1	2	3	4		6				10	11		
Eragrostis curvula	7	54				4	5	6	7		9	10	11		
Conyza podocephala	6	46		2	3		5	6				10	11		
Melinis repens	5	38					5	6				10	11	12	
Hypochoeris radicata	5	38	1			4		6			9			12	
Spermacoce natalensis	3	23				4	5	6							
Verbena venosa	2	15		2				6							
Senecio isatideus	2	15				4							11		
Prominent species which do not occur within this veld type															
Pogonarthria squarrosa	0	0													
Kalanchoe paniculata	0	0													
Aristida sciurus	0	0													
Indigofera hilaris	0	0													
Acacia karroo	0	0													
Perotis patens	0	0													
Acacia caffra	0	0													
Dicerocaryum eriocarpum	0	0													
Trichoneura grandiglumis	0	0													
Combretum apiculatum	0	0													
Acacia nilotica	0	0													
Aristida diffusa	0	0													
Nidorella anomala	0	0													
Gnidia caffra	0	0													
Andropogon schirensis	0	0													
Tephrosia multijuga	0	0													
Albuca spp	0	0													
Faurea speciosa	0	0													
Sclerocarya birrea	0	0													
Raphionacme burkei	0	0													
Peltophorum africanum	0	0													
Ozoroa paniculosa	0	0													
Ficus glumosa	0	0													
Bauhinia galpinii	0	0													
Cyphostemma lanigerum	0	0													
Maytenus undata	0	0													
Trifolium africanum	0	0													
Annona senegalensis	0	0													

Tabel 25.c: Phytosociological table reflecting the cover abundance estimates of the species

Veld type	South-eastern Mpumalanga Hills and Lowlands Veld Type																																																	
Ecosystem	1			1									1						1								2									2														
Cutlevel 2	1.1			1.2									1.2						1.2								2.1									2.1														
Cutlevel 3				1.2.1									1.2.1						1.2.2								2.1.1									2.1.1														
Cutlevel 4				1.2.1.a									1.2.1.b														2.1.1.a									2.1.1														
Cutlevel 5																																																		
Cutlevel 6																																																		
Community	1			1									1						1								2									2														
Sub-community				1.2.a									1.2.b														2.1.a									2.1.														
Cluster	1			2									3						4								5									6														
	189	192	172	139	344	176	248	178	332	223	207	253	243	337	371	323	234	247	330	360	351	3[illegible]9	372	358	362	211	252	340	224	383	242	339	339	255	254	249	289	237	384	233	331	341	343	345	348	361	362	381	325	326
Diagnostic Species Group A																																																		
Clifforta nitidula	+	A		+																																														
Watsonia densiflora	+	+						1																																										
Diagnostic Species Group B																																																		
Polygonum lapathifolium				+	+	1	+	A	+	1			1	1	+	+	1						+	1																										
Miscanthus junceus			+	4	3	1	1						A	3	1	B		+																																
Diagnostic Species Group C																																																		
Arundinella nepalensis						5	1	E	A	B	B		1	A												+																								
Senecio affinis			+		+	+				1	+		+	+						+							+			+											+								+	
Diagnostic Species Group D																																																		
Sporobolus africanus			3									1		1		A	1	+			+	+					1			1										1	+	+							+	+
Schoenoplectus corymbosus				+									3			A	1					+				+																								
Mariscus congestus							3		+	1				+		+	1							+																										
Cirsium vulgare									+						+	+		+																																
Agrostis eriantha									+				+	1			1		+							+																								
Diagnostic Species Group E																																																		
Oenothera tetraptera					+				+						+	+			+	+	+	+	+													+					+		+					+		+
Lippia javanica													1						+	+	+						+									+				+										
Diagnostic Species Group F																																																		
Anthospermum rigidum													+								+						+	+	+	+						+	+	+	R	+	+	+	+	+	+	+	+	+		
Helichrysum nudifolium																		1									A	+	+		+	+				1	+	1	1										+	+
Diagnostic Species Group G																																																		
Paspalum scrobiculatum							+							+						+							+	+			+	1	+	1	1		+			+			+							
Vernonia oligocephala																											1		+		+	+		1	+													B		
Moraea pubiflora									+																		+	+	+	+		+					+				+								+	
Trachyandra spp.				+									+														+	+				+	+	+		+							+				+	+		
S[illegible] elaeagnifolium										+																	+		+			+	+	+			+													
R[illegible]tula										+							+	+									1	+			+	+	1				+			+			+							
T[illegible]a atriplicifolia													+														+		1				+	+	+			+												
C[illegible] confusus																													+	+				1	+	+		+											+	+
S[illegible] wilmsii				+												+			+				+					+				+	+		+				+				+							+
A[illegible]eyanus							+																							+	+	+		+				+										1		
D[illegible] galpinii																											1			+				+	+	+														
S[illegible]blata																											+				+	+		+		+	+	+			+								+	+
A[illegible] setifera																												+		+		+	+										+						+	
R[illegible]olor									+																				A		+	+	1																+	+
D[illegible]ic Species Group H																																																		
C[illegible]btusiflorus																			+										+														+							
Dicoma zeyheri																																		+		+			+	+	+								+	
Pentanisia angustifolia																							+				+						+		1	+	+	+				+	+				+	+		
Ledebouria ovatifolia											R																			+							+				+							1		
Diagnostic Species Group I																																																		
Helichrysum cephaloideum									+																			+		1	+						1		+							+	+			
Adonanthelium osmitoides																																																		
Gerbera piloselloides																			+							+										+	+													
Brachiaria serrata																			+				+								+	1					+									+				
Diagnostic Species Group J																																																		
Indigofera comosa																							+						1	1							+	1		A		1	1	+	+			A	+	
Zornia milneana									+																		+	+										+			+		+		+		+	+	+	+
Diagnostic Species Group K																																																		
Clutia monticola																																																		
Hibiscus aethiopicus				+					+							1		+									+							1	1	+	+	+	+							1	+	+		
Aloe dewyana																													+											+										
Cyanotis lapidosa																																																		
Lopholaena segmentata															+																																			
Diagnostic Species Group L																																																		
Oxalis purpurea			1					1	+																	+							+																	
Hermania transvaalensis																																													+	+	+		+	
Walafrida tenuifolia										+								+																										+						
Diagnostic Species Group M																																																		
Myrsine africana																																																		
Aloe marlothii																													+					A	+															
Tetradenia riparia																																			+															
Aristida congesta subsp. congesta																																					+				+								+	
Rhus rigida																																																	+	
Rhus chirindensis																																																		
Cussonia spicata																																																		
Justicia anagalloides																													+	+								1		+			+						+	
Acokanthera rotundata																																																		
Diagnostic Species Group N																																																		
Diheteropogon amplectens																														1			1						+								+			
Cephalanthus natalensis																	+											+					A																	
Athrixia elata																											+		+		+																			
Euclea natalensis																																																		
Dicoma anomala																													+																					
Panicum maximum																																																		
Berkheya zeyheri										+																		+				+																		
Pteridium aquilinum																	1																				+													
Stachys natalensis						+							+																+								+													
Rubus rigidus			+										+									+				+						+	1		+															
Cussonia paniculata																																																		
[illegible]																																		+																

.b	2 2.1 2.1.2 2.1.2.1 2.1.2.1.a	2 2.1 2.1.2 2.1.2.1 2.1.2.1.b	2 2.1 2.1.2 2.1.2.2	2 2.2 2.2.1 2.2.1.a	2 2.2 2.2.1 2.2.1.b	2 2.2 2.2.2 2.2.2.a	2 2.2 2.2.2 2.2.2.b
1	2 2.2.a 7	2 2.2.b 8	2 9	2 10	3 11	3 12	3 13
244 346 286 238 375 232 250 251 333 336 288 338 364 324 353	175 117 246 245 138 141 327 174 145 376 379 142	122 182 222 230 112 180	136 188 135 171 191 137 133	347 148 349	240 342 360 241 282 365	143 173 140 190 169 170	134 146 147 179

Pteridium aquilinum			1			+
Stachys natalensis		+	+		+	+
Rubus rigidus	+		+	+ +	+ 1 +	
Cussonia paniculata						
Berkheya seminivea					+	
Diagnostic Species Group O						
Zanthoxylum capense						
Eucomis autumnalis				+		+
Maytenus heterophylla		+			1 1	+
Diagnostic Species Group P						
Tetraselago wilmsii					+	
Pelargonium luridum						
Helichrysum aureonitens	+	+ 1		+		+
Pavetta edentula						
Helichrysum coriaceum						
Vernonia sutherlandii						
Cyanotis speciosa	+					+
Diagnostic Species Group Q						
Pellaea calomelanos					+ + +	+
Rhoicissus tridentata						
Diagnostic Species Group R						
Sporobolus pectinatus						
Cymbopogon excavatus				+ +	A 1	+ +
Zantedeschia albomaculata						
Waltheria indica						
Elionurus muticus					+ +	+ +
Digitaria monodactyla						
Helichrysum pilosellum						+
Agapanthus nutans						
Alloteropsis semialata					+	+
Constant Species Group S						
Hyparrhenia hirta		+ 1 1 +	1 1 3	+ 1 1 1 1 +	B 1 B B 1 B A A	A 1 3 A A B 3 3 + A 1 A 3 + +
Themeda triandra	1	+ 1 + 1	1 1	+ + +	1 1 + + +	+ 1 + + + + 1 1 +
Setaria sphacelata	+ + 1	1	1 1 1 +	+ +	1 + + + A + +	+ + + + + 1 + +
Species Group T: Species associated with wetland ecosystems						
Paspalum dilatatum	1 1	+ + A B A 1	1 1 1 A	+ 1 1 + 1 + A		+ + + + + + +
Cyperus esculentus	+	+ + + 1 1 3 1	A + + 1 +	+ + + + + +		+ +
Verbena brasiliensis	+	1 + + + +	1 1 + 1 +	+ 1 + + + + +		+
Phymaspermum athanasioides	1 +	+ + + 1 + +	+ 1 1 + +	+		+ + A + +
Wahlenbergia undulata		+ + + +	+	+ + + + + +	+ +	+ +
Imperata cylindrica	1 +	1 1 1 + 1 + 1	A + +	A	1	1
Kyllinga alba	1	A + + + +	+	+ + +		
Coleochloa setifera		A A A	1 + +	+ + 1		
Species Group U: Species associated with terrestrial ecosystems						
Tristachya leucothrix					1 1 1 1	
Cymbopogon plurinodis		1 +	1 1		1 B A A + A 1 A	1 A A + B 1 1 1
Hypoxis rigidula					+ + +	+ + + 1 1 1
Commelina africana	1	+ + + 1	+	+	1 + 1	+
Acalypha angustata		+ +		+	1 + + 1	1 + + +
Senecio venosus		+			+ +	+ + + +
Trachypogon spicatus					1 1 1 + + 1	+ 1 + +
Scabiosa columbaria		+			1 1 + + + +	1 + + + +
Hypoxis iridifolia		+		1		+ + + + +
Loudetia simplex			1		1 1 +	1
Phyllanthus parvulus		+ +			+ + + + +	+ + + + 1 + +
Eriosema cordatum		1	+	+	+ + + 1	+ 1
Eulalia villosa				+	A 1 + 1 1 +	1 + +
Microchloa caffra						+ +
Gladiolus elliotii						+ +
Bulbostylis burchellii	A 1		+			+ +
Berkheya echinacea					+ 1	+ +
Schistostephium crataegifolium		1 +	+		1 + 1 + 1	+ +
Clutia pulchella					+ 1 + A 1 +	
Sebaea grandis		+			+ 1	+ + +
Rhus dentata					+ A 1	
Asparagus laricinus					+	
Species Group V: Species associated with grassland communities						
Helichrysum rugulosum	+ + 1		+	+	+ 1 1 1 +	+ + + A + + + + + + + A + +
Eragrostis racemosa			1 +		1 1	+ + 1 1 + + 1 1 + + + + +
Berkheya setifera			A		+ 1 1 1 1 A + 1 1	+ 1 1 + 1 + 1 1 +
Haplocarpha scaposa		+	1		+ 1 + + +	+ + + + + + + + + +
Eragrostis capensis	+ +			1	1 + + + + + 1	+ + + + + + + +
Panicum natalense		+	+ + +		+ 1 +	+ + 1 + + +
Heteropogon contortus		1		+	1 +	+ + + +
Vernonia natalensis				+	1 + 1	+ + + + + + + +
Setaria nigrirostris.	A	1 B 1 1			A	+
Eragrostis chloromelas					1 + 1 1 1	A 1
Hyparrhenia dregeana			1 + 1	1	1	1
Monopsis decipiens	1 +	+		+ +		
Species Group W: Species associated with woodland communities						
Diospyros lycioides		+ 1 1 1		+ +	1 1 + 1 + +	+ + + + + + +
Diospyros whyteana						
Cheilanthes viridis		+	+	+		
Senecio oxyriifolius					+	
Vangueria infausta					1	
Species Group X: Species associated with over utilization						
Eragrostis plana	+ 1	+ 1 A A A B 1 A	1 1 +	+ 1 1 1 1 +	1	1 A + 1 A + 1 1 + 1 + 1
Eragrostis curvula	+	A		1 + + 1	A + 1 1	+ 1 1 A + + + +
Conyza podocephala		1 + + +	+ + +	+	1 + + 1 1	+ + + B + + 1 + + +
Melinis repens		+ 1	+ 1		+ 1 1 1 + 1 1 1	+ 1 + A + + + + +
Hypochoeris radicata	1 1	+ +	+ +	+ + +	+	+ + + + + + + 1 +
Spermacoce natalensis		+ +	+ +	+ 1 + + + +	+ + + + + + + +	+ + + + 1 +
Verbena venosa		+ + + +	+	+ +	+ +	+ + + + +
Senecio isatideus		+	+ +	+ 1 +	+	+ + 1
Prominent species which do not occur within this veld type						
Pogonarthria squarrosa						
Kalanchoe paniculata						
Aristida aciurus						
Indigofera hilaris						
Acacia karroo						
Perotis patens						
Acacia caffra						
Dicerocaryum eriocarpum						
Trichoneura grandiglumis						
Combretum apiculatum						
Acacia nilotica						



Species Group T: Species associated with wetland ecosystems																																																		
Paspalum dilatatum	1	1			+			+	A	B	A	1	1	1	1		A		+	1	1		+	1	+	A										+	+		+	+		+		+				+		
Cyperus esculentus			+		+	+	+	1		1	3	1	A	+	+		1	+	+	+		+	+	+		+										+			+											
Verbena brasiliensis	+						1		+	+	+	+	1	1	+	1		+	+	1	+		+	+		+															+									
Phymaspermum athanasioides	1		+		+	+	+	1		+		+	+	1	1		+	+	+																	+				+	A	+							+	
Wahlenbergia undulata				+			+			+	+			+					+	+		+		+	+	+		+							+				+						+					
Imperata cylindrica	1	+				1	1	1	+	1	+	1	A			+		+					A					1										1												
Kyllinga alba			1	A			+		+		+	+		+					+			+		+																										
Coleochloa setifera							A	A				A				1	+	+	+	+		1																												
Species Group U: Species associated with terrestrial ecosystems																																																		
Tristachya leucothrix																													1		1	1		1																
Cymbopogon plurinodis							1		+				1					1									1	B	A	A	+		A	1	A	1	A	A	+		B							1	1	1
Hypoxis rigidula																											+	+		+						+		+	+			1	1					1		
Commelina africana			1	+	+			+		1			+										+						1					+	1				+											
Acalypha angustata								+	+										+								1		+			+	1					1	+							+		+		
Senecio venosus								+																										+	+			+	+		+									+
Trachypogon spicatus																												1	1	1	+	+	1									+	1		+		+			
Scabiosa columbaria											+																1			1	+	+	+	+		1	+	+	+				+							
Hypoxis iridifolia						+																	1													+						+	+					+	+	
Loudetia simplex																	1														1	1	+							1										
Phyllanthus parvulus					+				+																			+			+	+		+	+			+			+		+			+	1		+	+
Eriosema cordatum						1							+										+				+	+	+						1	+		1												
Eulalia villosa																										+		A	1		+	1	1	+									1			+	+			
Microchloa caffra																																											+				+			
Gladiolus ellioti																																										+	+							
Bulbostylis burchellii		A	1											+																						+				+										
Berkheya echinacea																															+	1									+								+	
Schistostephium crataegifolium									1	+			+															1	+	1	+	1							+											+
Clutia pulchella																											+		1		+	A	1		+															
Sebaea grandis									+																						+	1										+	+			+				
Rhus dentata																												+	A					1																
Asparagus laricinus																																	+																	
Species Group V: Species associated with grassland communities																																																		
Helichrysum rugulosum	+	+	1													+					+						+	1	1	1	+					+		+	+	A	+		+	+	+	+	+	A	+	+
Eragrostis racemosa													1					+									1	1								+		+		1	1	+	+	1	1	+	+		+	+
Berkheya setifera													A														+	1	1	1	1	A	+	1	1	+	1	1	+				1		+	1	1	+		
Haplocarpha scaposa									+				1															1	1	1		+	+	+			+	+	+		+		+			+	+	+	+	+
Eragrostis capensis		+	+																1									1	+	+	+	+		1		+		+	+			+		+					+	+
Panicum natalense						+							+	+			+												+				1	+						1		+			+		+			
[illegible]*gon contortus*									1												+								1	+						+		+					+							+
[illegible] *natalensis*																					+							1	+	1							+			+		+	+			+			+	+
[illegible]*igrirostris.*			A			1		B	1		1																					A										+								
[illegible]*s chloromelas*																												1		+		1		1	1		A											1		
[illegible]*nia dregeana*													1		+	1							1											1					1											
[illegible] *decipiens*		1	+			+																				+	+																							
[illegible] **Group W: Species associated with woodland communities**																																																		
[illegible]*s lycioides*					+	1			1	1											+		+						1	1		+	1	+	+	+			+	+	+		+		+				+	
[illegible]*s whyteana*																																																		
[illegible]*es viridis*					+								+							+																														
[illegible]*oxyrifolius*																														+																				
[illegible]*a infausta*																																	1																	
Species Group X: Species associated with over utilization																																																		
Eragrostis plana	+	1			+	1	A	A	A	B	1	A	1				1	+	+	1	1	1		1	+								1				1	A	+	1	A		+	1	1	+	1		+	1
Eragrostis curvula	+							A											1				+		+	1	A				+		1		1	+			1		1		A		+	+			+	+
Conyza podocephala									1	+	+	+	+			+		+			+						1	+	+	1			1			+	+	+			B		+		+		1	+	+	+
Melinis repens						+			1							+	1										+	1	1	1	+		1	1	1	+		1	+	A	+		+			+			+	
Hypochoeris radicata		1	1						+	+							+	+	+	+					+		+												+	+	+	+		+	+	+	1		+	
Spermacoce natalensis							+			+						+		+	+		1	+	+	+	+		+	+		+	+	+	+	+	+		+	+	+			+					1			
Verbena venosa					+			+	+	+			+							+		+					+		+							+						+	+						+	+
Senecio isatideus										+			+		+						+		1	+							+							+				+	1							
Prominent species which do not occur within this veld type																																																		
Pogonarthria squarrosa																																																		
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Trichoneura grandiglumis																																																		
Combretum apiculatum																																																		
Acacia nilotica																																																		
Aristida diffusa																																																		
Nidorella anomala																																																		
Gnidia caffra																																																		
Andropogon schirensis																																																		
Tephrosia multijuga																																																		
Albuca spp.																																																		
Faurea speciosa																																																		
Sclerocarya birrea																																																		
Raphionacme burkei																																																		
Peltophorum africanum																																																		
Ozoroa paniculosa																																																		
Ficus glumosa																																																		
Bauhinia galpinii																																																		
Cyphostemma lanigerum																																																		
Maytenus undata																																																		
Trifolium africanum																																																		
Annona senegalensis