CHAPTER 1: INTRODUCTION

Due to the increased demands that man places on the natural habitat for the basic requirements of life, the natural resources are slowly but surely being depleted. If the current human population increases at the given rate it can be deduced that the natural pasturage will not be able to provide ample resources such as meat, dairy products, grain and timber for the population (Bayer 1970; Allen 1972; Scheepers 1975; Asibey 1977; Mentis & Huntley 1982). It is therefore vital that the natural resources providing these amenities be maintained if not improved to be able to cope with future pressures being placed upon them.

The Grassland Biome Project (Mentis & Huntley 1982) was initiated to address this problem of increased destruction of natural resources because the most suitable area for agriculture falls within the grasslands of this country.

The aims of the Grassland Biome Project, which covers research on the grassland ecosystems in South Africa, are to analyse and interpret the gradients of climate, geomorphology and soils associated with the grassland vegetation. Together, the results of all research done in this area will be compared. New insight into the management of this area should then be available to the farmers, who ultimately own most of this area, the future of which is in their hands.

The study of this particular area (see Chapter 2, page 3) will be incorporated into the Grassland Biome Project, and will be compared with those of the surrounding areas (Deall 1985 & 1986; Bloem 1988; Turner 1989 and Matthews 1991).

The objectives of this study are:

a) to conduct a study on the vegetation types occurring in the land types Fa and Ac within the specified area;

b) to study relationships between plant communities and environmental factors;

c) to obtain a vegetation map of the area; and

d) to compare the vegetation types to those classified by Acocks for the same area.

2.1 LOCALITY

The area upon which this study is based occurs in one of the most ecologicaly important wetland areas in the Transvaal. The reason for this is that this area is situated at the highest altitude in the Transvaal (the average altitude being above 1 800 m), as well as the fact that three large rivers originate here namely the Sabie, Elands and Crocodile Rivers. Major towns serving this area are Belfast, Machadodorp, Waterval Boven, Dullstroom, Lydenburg and Sabie (Figure 1).

The study area comprises two parts, the main part situated between the latitudes 25° and 25° 44' South, and longitudes 30° and 30° 20' East, and a smaller study area which is bounded by latitudes 25° 05' and 20° 15' South and 30° 30' and 30° 40' East. The portion studied however only comprises the Fa and Ac land types in this area (Land Type Survey Staff 1984). Other land types were not studied for the reason that they are not grassland but forest or savanna, as well as the fact that they are considered as lowlands. Limited sample sites however were placed in the adjacent land types to compare the study area with its surrounding areas.

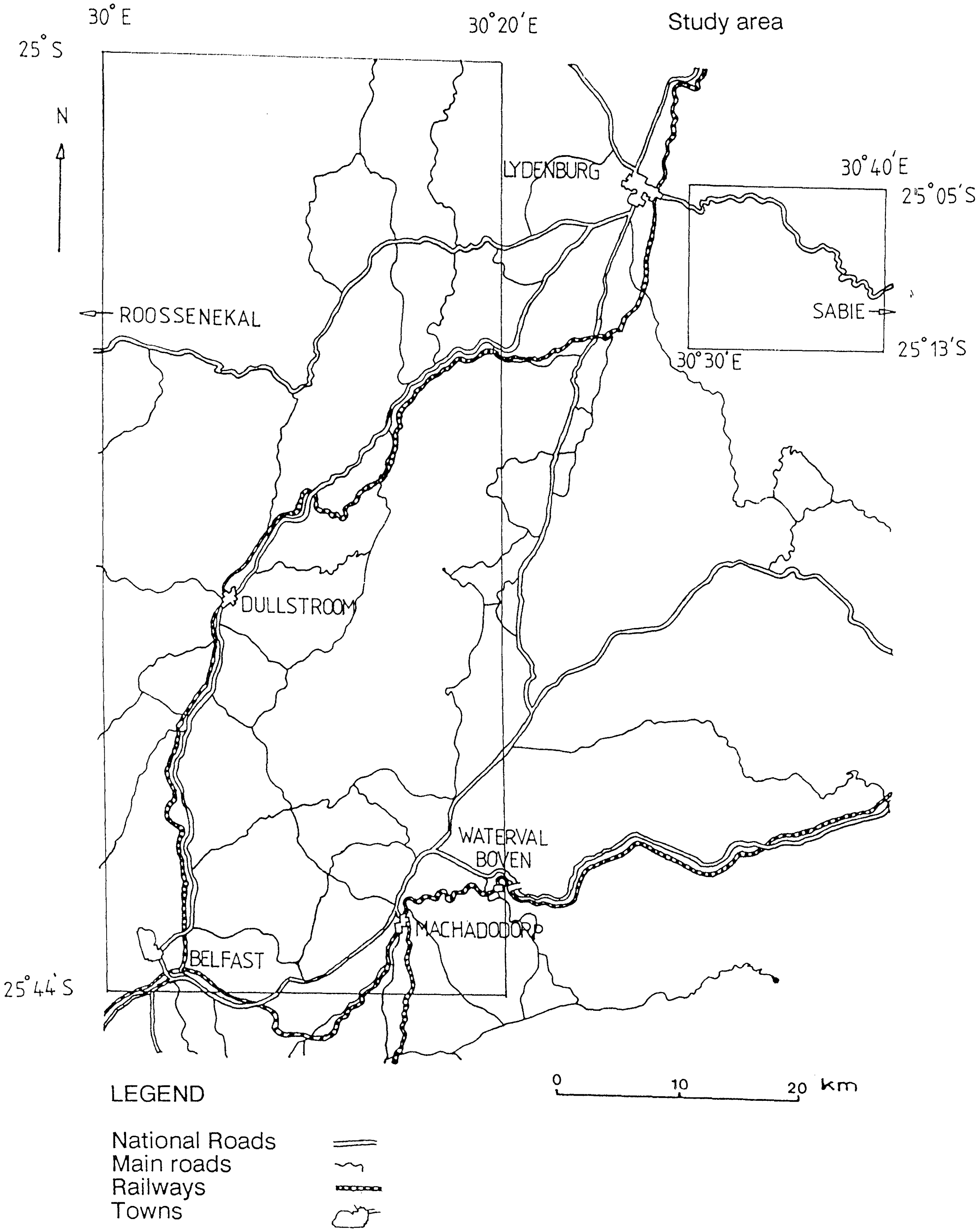


Figure 1. Location of the study area.

CHAPTER 3: PHYSICAL FACTORS AFFECTING THE VEGETATION

3.1 GEOLOGY

Geology is one of the environmental variables affecting the vegetation, physiography and ultimately the climate of the study area.

The geology is the principle factor determining the physiographic features of an area (Figure 2). These factors are then further modified by erosion over a period of time as determined by climatic processes.

Because the Magaliesberg Formation is more resistant to weathering than some of the other types of rock in the area the Escarpment comprises mainly this formation. This in turn causes the weather patterns to change from the lowlands to the highlands because of the altitude change (Figure 7). All these factors combined resulted in a significant change in the plant composition from the lowlands to the highlands.

All geological data described for this area follows the nomenclature of the South African Committee for Stratigraphy (SACS 1980).

Starting with the oldest, and proceeding to the youngest rocks (Figure 2), the stratigraphy of the study area will be described in the following contexts: Rocktypes comprising the groups, formations or series as well as the products of weathering.

3.1.1 Pretoria Group of the Transvaal Sequence.

The Transvaal Sequence forms the basis for the Bushveld Igneous Complex and dips beneath it, which indicates that the Bushveld Igneous Complex was formed after the Transvaal Sequence had been laid down (Figure 2). Due to ripple-marks, oolites and stromatolites it can be

GROUP	FORMATION		LITHOLOGY and Mb	Thickness (m)
PRETORIA	Dullstroom Basalt		Mafic to intermediate lava, felsite, some pyroclastics, arenite and hornfels	Up to 1 400
	Houtenbek		Quartzite Hornfels Carbonate and chert	140–255
	Steenkampsberg Quartzite		Quartzite, minor shaly rocks	470-630
	Nederhorst		Argillaceous quartzite, arkose Hornfels	200-800
	Lakenvalei Quartzite		Quartzite, feldspathic quartzite, arkose	160-300
	Vermont Hornfels		Hornfels, minor quartzite, dolomite and chert	450-800
	Magaliesberg Quartzite		Quartzite, minor shale	500
	Silverton Shale		Lydenburg Shale Mb Chert and dolomite. Machadodorp Member (tuff, agglomerate, basalt) Boven Shale Mb	1 000-3 300
	Daspoort Quartzite		Quartzite, some shale	5-90
	Strubenkop Shale		Shale, minor quartzite	20-80
	Dwaalheuwel Quartzite		Quartzite Siltstone, some shale Conglomerate	40-110
	Hekpoort Andesite		Andesite with pyroclastics, some quartzite and shale	0-500
	Boshoek		Siltstone and shale Quartzite, subgreywacke Conglomerate	0-90
	Timeball Hill		Shale with diamictite Quartzite, siltstone, ironstone Shale and mudstone	900-1 600

Figure 2. The deposition of the Pretoria Group in the eastern Transvaal.

assumed that these rocks were formed in shallow water. A large inland basin prevailed at the time, and rivers and streams running into this, had algae growing in their shallow still waters. The reason for the Pretoria Group being rich in metals is the fact that the algal structures trapped heavy particles (metals), thus forming a sedimentation bed through which the algae grew (Truswell 1970). The algae containing the metals as well as other deposits were later compressed due to the weight of the layers above them. Thus we have rocks with layers of metals in between them (eg. Timeball Hill ironstone, Figure 2).

The Pretoria Group (Figure 2) is dominated by quartzite and shale with a prominent volcanic unit combined with some conglomerate and also some chemical members.

Volcanic eruptions occurred intermittently and were normally localised. These eruptions were especialy prevalent in the Dullstroom and Hekpoort Formations.

In the eastern Transvaal the Pretoria Group is divided into fourteen formations, which will be discussed briefly.

Timeball Hill Formation: The lowest layer that is present in the study area as belonging to the Pretoria Group is this Formation. It is composed of laminated shale, mudstone and occasional diamictite, and quartzite layers occur above this and overlaying these are more shale and diamictite. This Formation is found in the smaller study area only (Figure 3). Soils originating from the mother-rock are not deep and vary in richness of minerals depending on the content of the mother-rock (SACS 1980).

Boshoek Formation: This Formation comprises medium-grained quartzite in the centre with subgreywacke and conglomerate at the base and siltstone at the top, and is present in the smaller study area only (Figure 3). The soils derived from this Formation are fine-grained, poor, sandy soils (SACS 1980).

Hekpoort Andesite Formation: This Formation is made up of fine to medium-grained andesitic lavas, brecciated at the top and having amygdales in the centre. This Formation is found also only in the smaller study area, (Figure 3) and the soils that originate from it are normally rich loams (SACS 1980).

Dwaalheuwel Quartzite Formation: This Formation consists of medium-grained quartzite, interlayered with shale, and is also found only in the smaller study area (Figure 3). The quartzite weathers to a course sand, while the shale weathers to a fine loam or a clay loam (SACS 1980).

Strubenkop Shale Formation: This formation consists of fine-grained shale and interlayered shaly sandstone, with hornfels in places and is to be found in the smaller study area only (Figure 3). Soils are poor and shallow if conditions during weathering were dry, and are deeper and richer if conditions were moist during weathering (eg. dry hill tops and moist valleys).

Daspoort Quartzite Formation: This Formation is composed of medium-grained, current-bedded, quartzite with gritty layers and occasional conglomerate as well as shale. It occurs in the south-eastern corner of the larger study area, covering a very small area. It also occurs in the smaller study area (Figure 3). Soils derived from this Formation are generally sandy and can be rich or poor in nutrients depending on the weathering process (SACS 1980).

Silverton Shale Formation: This Formation is made up of three Members namely, the Boven Member, the Machadodorp Member and the Lydenburg Member.

The Boven Member consists of greenish, fine-grained shale and mudstones with tuff, and some layers of carbonatious rocks as well as hornfels in places. This Member is found in the area around Waterval Boven (Figure 3). Following on this is the Machadodorp Member consisting of two parts; a) a pale-green tuff with pyroclastic layers, which was formed by the deposition of ash from volcanoes in the area, and b) a course-grained, deeply weathered pillow lava. The pillow lava is formed by hot magma coming into contact with a large area of water. This Member is found east of Machadodorp and occupies an area in the south-eastern corner of

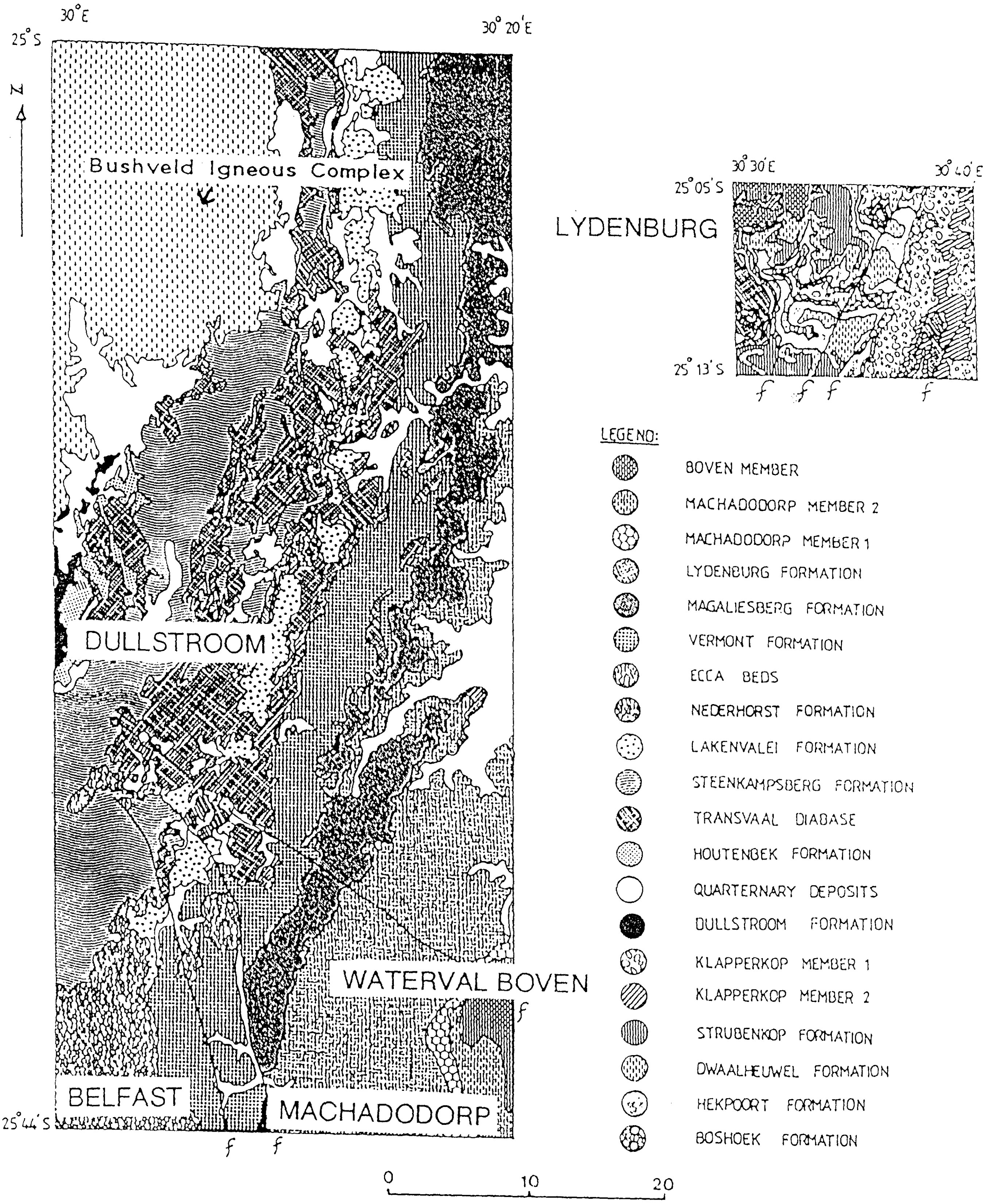


Figure 3. Geological Groups occurring in the study area.

the study area. The Lydenburg Member is the topmost Member and consists of a greenish fine-grained laminated shale with interlayered carbonate layers containing hornfels. This member is found near Machadodorp and extends over large areas of the eastern part of the study area.

The soils derived from these Members are generally very shallow and are poor in nutrients, except for the soils derived from the lavas which are richer in nutrients and are generally deeper (SACS 1980).

Magaliesberg Formation: This formation is made up of pure course-grained quartzite with scattered layers of shale in between. The upper part consists of siltstone, shale and quartzite, while the lower part consists mainly of shale. This Formation is to be found in a band extending from the north-eastern to the south-western part of the study area (SACS 1980), (Figure 3) and forms the Escarpment. Soils derived from this Formation are generally sandy but not deep, and are poor in mineral elements, the elements being leached to deeper layers (SACS 1980).

Vermont Formation: This Formation contains fine-grained hornfels together with silt and sandstone, with minor layers of carbonaceous (dolomite) and siliceous (chert) rocks, and is to be found throughout the study area in a broken, broad band from the north to the south (Figure 3). These rocktypes give rise to soils that are rich in minerals but the soils themselves are not deep.

Lakenvalei Formation: This Formation is made up of medium grained, cross-bedded, feldspathic quartzite with ripple marks, and has gritty lenses and thin conglomerate layers in between. This Formation is layed down in a broken band from the north-east to the south-western part of the study area (Figure 3), and gives rise to sandy loam or fine sand, depending on the mother material (SACS 1980).

Nederhorst Formation: This Formation consists of fine-grained hornfels with ripple marks, cross-bedding and mud cracks in the sedimentary layers and has medium- grained arenite at the top of the formation. It is layed down in the vicinity of the highest point of the railway in the Transvaal, called Nederhorst (Figure 3), and gives rise to relatively rich soils (SACS 1980).

Steenkampsberg Formation: This formation consists of medium- to fine-grained, cross-bedded quartzite with intermediate layers of purple-weathering arenite and shale with very little conglomerate. Although this is the Formation situated at the highest altitude, it is third from the top in the sequence (the Dullstroom Formation being the topmost Formation of the Pretoria Group), and makes up the Steenkampsberg on the eastern side of the study area, which is the highest mountain-range in the Transvaal (Figure 3). This indicates just how resistant to weathering this rock-type is. Products of weathering are sandy soils that are easily leached and are relatively poor in mineral elements. The arenite and shale give rise to poor mauve-coloured soils.

Houtenbek Formation: This Formation consists of fine-grained hornfels with argillaceous quartzite and arkose (a blend of quartzite and plagioclase or orthoclase) at the top, and many sedimentary structures in between, with carbonate and chert interspersed between the hornfels. Weathered products of this rocktype are relatively rich soils with little or no structure and their colours may vary. This Formation is layed down in the area of the farm Houtenbek, north-east of Dullstroom (Figure 3).

Dullstroom Formation: This Formation consists of black to darkgreen, fine-grained andesitic lavas with amygdales, together with some felsite and pyroclasts, and is the result of local volcanic activity in this area.

Weathered products of this Formation are normally rich deep soils with a red colour, and the amygdales remain as small stones that do not weather as fast as the mother rock (SACS 1980).

This Formation commences at the Tonteldoos Post Office, south-west of Lydenburg and consists of a belt of lavas that extend along the western side of the Steenkampsberg and disappear under the Ecca beds.

3.1.2 Bushveld Igneous Complex

Before the main outflow of magma of the Bushveld Igneous Complex there were minor eruptions which formed diabase sills and dykes that can be found at intervals all over the study area (Figure 4).

These intrusions also caused metamorphosis of the adjoining rocks, for example soft shale turned into a hard crystalline type of rock. Some of these intrusions are made up of other types of rocks (norite) but the whole group together is termed Transvaal Diabase (SACS 1980).

The soils derived from this rock-type are normally rich in elements and form a dark coloured loam. These sills and dykes of diabase can sometimes be noted from aerial photographs by the difference in the vegetation growing on them. This is because there is more water and mineral elements present here than in the surrounding soils. These diabase intrusions are thus responsible for certain vegetation patterns.

Following these eruptions came the main outflow of magma (Truswell 1970) which flowed up and over the Pretoria Group of sediments. This magma cooled and formed a disc of rock (mainly norite) while the fisures between the weak spots were filled with diabase.

This placement of a huge volume of matter must have been a long continued process and not a single occurrence, thus giving rise to many varying rocktypes (Du Toit 1954). The reason that so many different types of rock are formed from the same magma is that different minerals crystalize in a specific order. This sometimes forms false stratifications (pseudostratifications). The sizes of the crystals depend on the temperature at which crystalization took place (Truswell 1970).

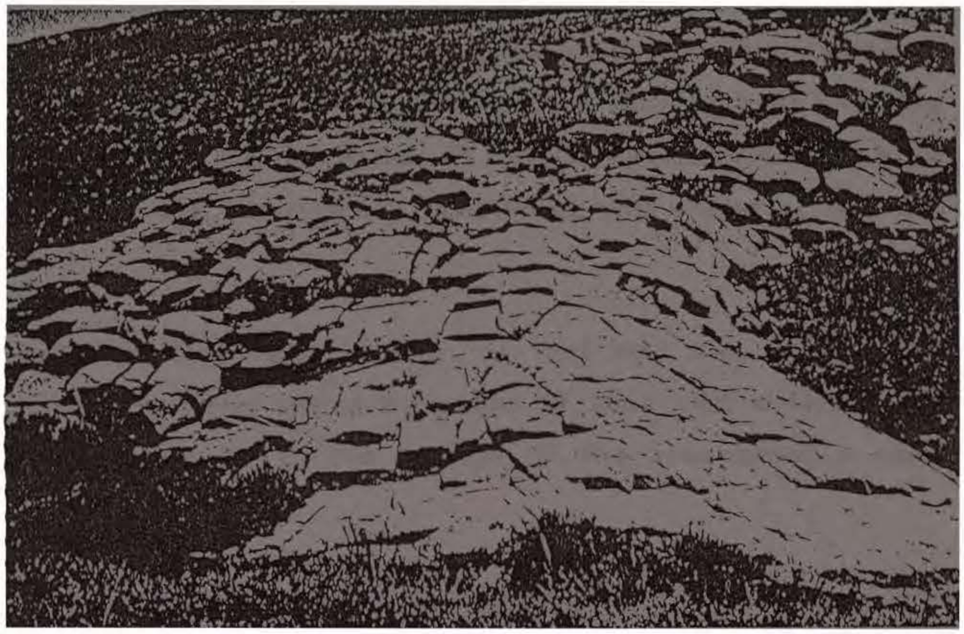


Figure 4. Example of a diabase intrusion near Dullstroom.

3.1.3 Ecca Series of the Karoo Supergroup

This series consists of sediments that were layed down in a fresh-water basin (Truswell 1970). Vegetation growing out into the swamps gave rise to the plant material being deposited thus forming coal. Shallow valleys were silted up by the deposition of material eroded from the higher areas giving rise to the sandstones, mudstones and shales of this Series (Du Toit 1954).

The most important fact however, is that coal was layed down in this area, and is normally mined by means of open cast mining. This way of mining is detrimental to the ecology of the area because much of the topsoil is lost or ruined.

This Series is found in the south-western parts of the study area around the town of Belfast (Figure 3).

3.1.4 Quarternary Deposits

These recent (Pleistocene) deposits occur in the study area in most of the river beds where the products of many years of erosion have been deposited. During their deposition there was a cooler climate present and glaciation was prevalent only as an enlarged Antarctica. The Drakensberg and Lesotho were not glaciated as has been determined from evidence found in caves (Truswell 1970). These deposits are loosely bound to each other due to the short time that sedimentation has taken place and occur in valleys and scree slopes of mountains and hills (SACS 1980)

3.2 MINING IN THE AREA

This aspect of the study is important because of the environmental impact that it could have on the region if mining practices were not of a conservative nature.

Platinum group metals

Platinum and the other metals in this group are mined from the Merensky Reef (Figure 5) of the Bushveld Igneous Complex. The Reef is a regularly layered band consisting of pyroxenite varying from 75 to 100 mm in thickness, interspersed with chromite seams. The pyroxenite layer is covered by a suite of norite and anorthosite which is overlain again by a pyroxenite band often called the "Bastard Reef" because of the low platinoid values (Coetzee 1976).

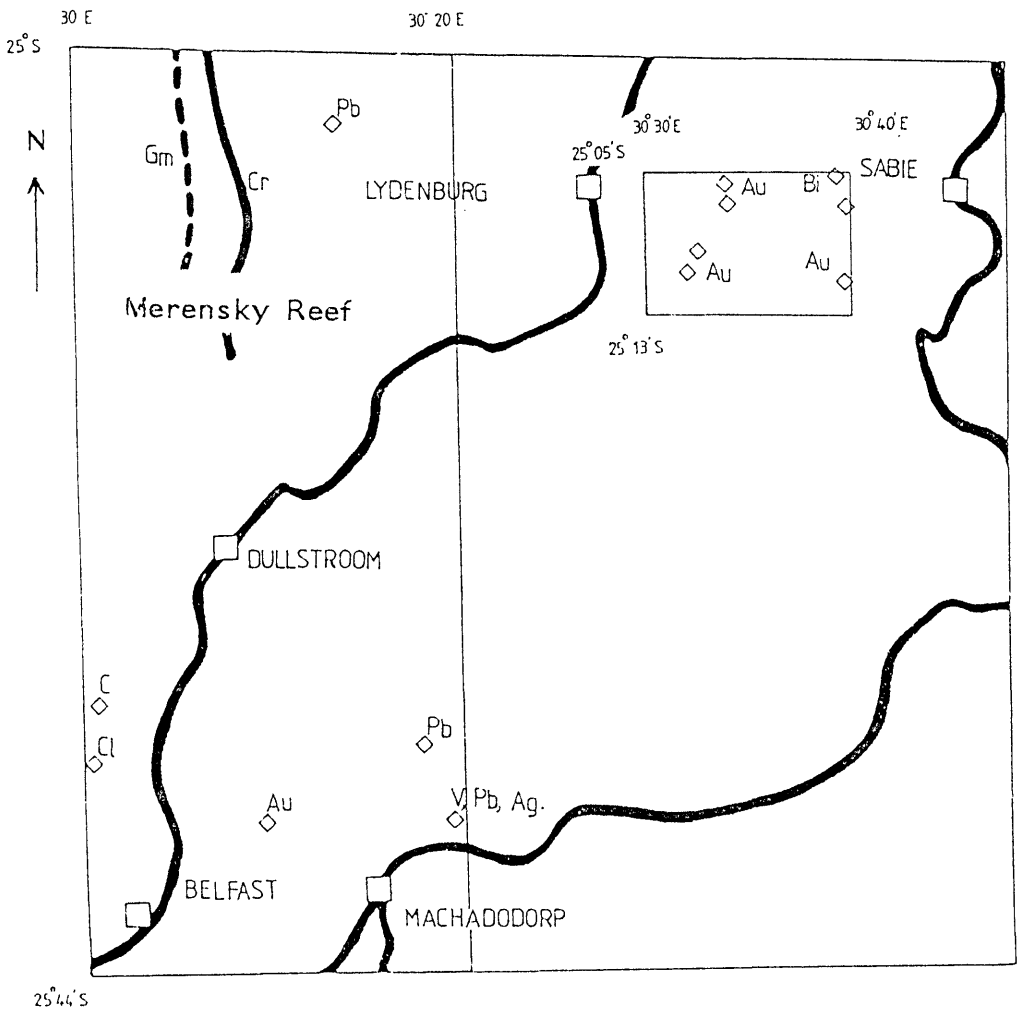
The Merensky Reef has been prospected in the eastern belt along a strike of 120 km, and boreholes indicate that it continues to a vertical depth of over 1 900 m. Chrome is mined extensively from chromite seams in the Merensky Reef, and nickel and copper are also mined from these seams. Chrome is mined on the farm De Kafferskraal in the north-western section of the study area (Coetzee 1976).

Gold

Gold is mined extensively in the study area (Figure 5) and occurs in the lowermost beds of the Timeball Hill Formation, as well as the higher beds of the Daspoort Formation, and the uppermost beds of the Dwaalheuwel Quartzite Formation. Gold occurs together with silver, copper and bismuth (Coetzee 1976). Small amounts of gold also occur in the pyroxenite of the Merensky Reef, in addition to the platinum-group metals found there (Coetzee 1976).

Silver

Silver is mined on the farm Slaaihoek (540 JT) near Waterval Boven (Figure 5) together with gold from this area (Coetzee 1976).



LEGEND:

Ag	Silver	Cr	Chrome
Au	Gold	Gm	Gemstones
Bi	Bismuth	Pb	Lead
C	Coal	V	Vanadium
Cl	Clay		

Figure 5. Mines and mining activities found in the study area.

Iron

Iron is found in the lower Timeball Hill Formation as magnetite- quartzite, and in the Daspoort Formation as hematite and limonite. Iron is mined on the farm Elandshoek (339 JT) and Slaaihoek (540 JT) which lie to the east (Figure 5) of the study area (Coetzee 1976).

Vanadium and lead

Vanadium and lead are mined in the north-western part of the study area and both are found in the Merensky Reef. An additional lead mine occurs on the farm Kennedy's Vale (361 KT) in the Lydenburg District (Coetzee 1976; Figure 5).

Coal

Coal is mined west and north of Belfast (Figure 5) and occurs in the Middle Ecca Stage of the Karoo Supergroup (Coetzee 1976).

Clays

Semi-flint fire clay is mined between Dullstroom and Belfast on the farm Zwartkoppies (316 JT), and is the result of the burning of a coal seam in the Lower Ecca Group in recent times (Coetzee 1976).

Dimensional stone

Dimensional stone used for building purposes, like gabbro, norite and dolerite are mined east of Dullstroom (Coetzee 1976).

Other

Diamonds are being mined from a kimberlite pipe between Dullstroom and Machadodorp (personal communication).(1)

Other developments in this field are the buying of farms by large mining companies in the area where the Merensky Reef occurs. This is being

(1) Mr. N. Venter P.O. Box 74 Machadodorp.

done to provide the larger mining companies with enough land for future expansion of their mining activities.

3.3 LAND TYPES

According to the land type maps of the Barberton area (2530) the Fa and Ac land types as shown in Figure 6 were studied.

Fa and Ac land types differ from each other in terms of microclimate, terrain form and geology (Land Type Survey Staff 1979).

Fa land types differ from each other in terms of their macroclimate while the same is true for different Ac land types.

Fa land types are found principally on Vermont sandstone, Magaliesberg shale and Steenkampsberg quartzite, while Ac land types occur on the shales of the various geological groups.

Each land type incorporates areas of similar geology and terrain forms (Land Type Survey Staff 1979) thus each land type is associated with specific landscapes. It would therefore follow that slope magnitudes and terrain units give an indication of the landscape associated with each land type (Land Type Survey Staff 1979).

Slopes of land type Ac are generally shallow and may reach considerable lengths. This may form systems of catenas giving rise to gently undulating landscapes in the southern part of the large study area.

Fa land types have steeper slopes and are to be found in the broken areas of both study areas (Figure 6). These land types give rise to the deep gorges and valleys and steep sloped mountains. Land type Fa, (Glenrosa and Mispah Forms) makes up approximately half of the study area and consists of relatively young soils. The main soil forming process is weathering of the parent material which results in the formation of orthic topsoils. The B horizons are formed by clay illuviation. Although Glenrosa and Mispah Forms are the most common Soil Forms, other Forms may also

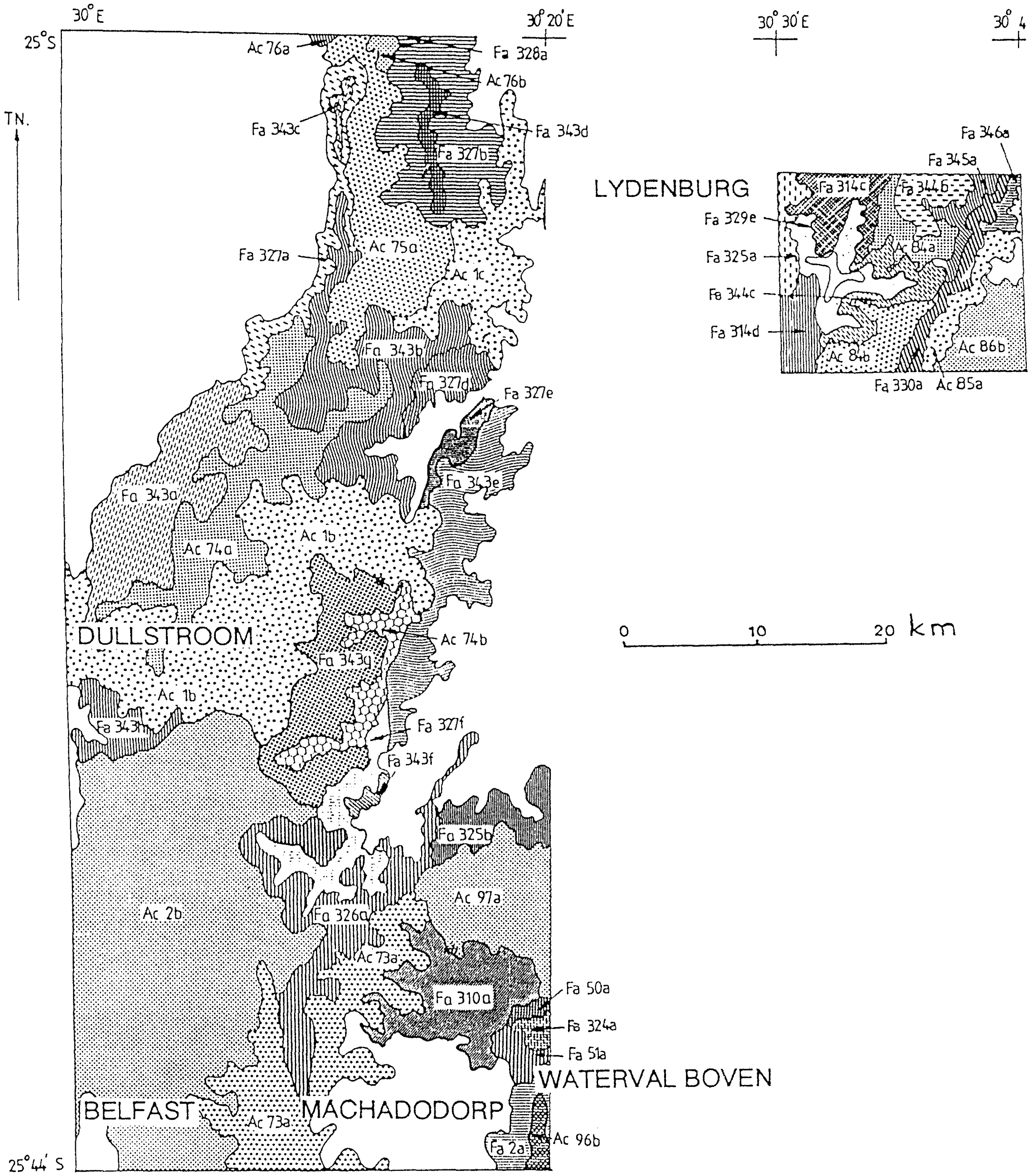


Figure 6. Land types occurring in the study area.

occur in this land type. The surface area covered by these other Forms is then minimal, being less than 7%.

The other half of the region is covered by the land type Ac. This Form is defined as red-yellow apedal soils having free drainage, and are dystrophic or mesotrophic, and have a high base status. Soil Forms Hutton, Griffin, Clovely and Inanda are frequent although others may be present to a lesser extent (Land Type Survey Staff 1979).

3.4 PHYSIOGRAPHY

3.4.1 TOPOGRAPHY

The study area is mountainous and rugged with deep ravines and steep cliffs in places and gently sloping plains in others. The altitude is mainly above 1 800 metres (Figure 8) and rises to 2 331 metres, the highest point in the Transvaal called Die Berg. Deep ravines are situated at altitudes below 900 metres, thus an extreme range of altitudes can be found in this area.

The deep ravines are relatively frost free and frost sensitive plant species are often found growing there. The high mountains are frequently wind blown as well as frost covered in winter and sparse vegetation is to be found growing on them.

The topography of the study area was divided into five groups according to Scheepers (1988) as can be seen in Figure 9.

3.4.2 DRAINAGE

The important rivers occurring in the eastern Transvaal originate in this area namely; the Elands, Crocodile and Sabie Rivers (Figure 7). All three of these rivers have their origins in rather undistinguished-looking wetlands at higher altitudes. These rivers are all fed by smaller rivers also originating from wetlands in and around the study area.

Wetlands in this area are thus important for maintaining the flow of rivers. Disturbing them in any way would eventually disturb, or possibly even cause some rivers to have a diminished flow.

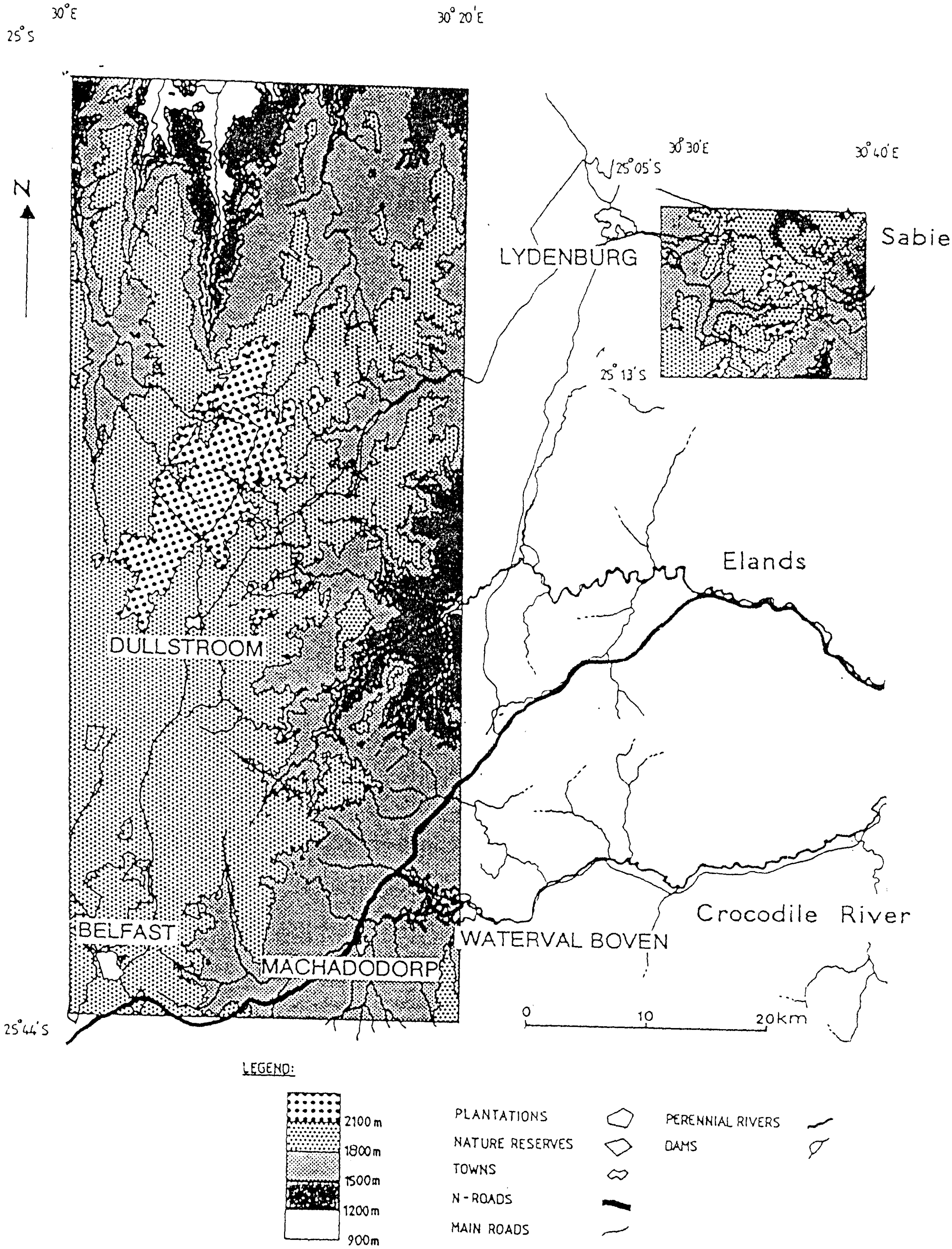


Figure 7. Map of the study area showing altitude and rivers.

The Steenkampsberg mountains form a deviding line between two watersheds in the larger study area. Thus rivers to the east of the Steenkampsberg flow eastwards, while rivers to the West of the Steenkampsberg flow in a north and north-westerly direction (Figure 7).

The rivers originating in the smaller study area originate from springs emerging from the heads of deep ravines and there are fewer wetlands due to the steeper gradients in this area. Rivers in this smaller study area flow predominantly eastwards (Figure 7).

3.4.3 ALTITUDE

This particular area is the highest part of the Transvaal and has a unique flora due to this fact (Stevens 1989), coupled with the rainfall (Figure 11) and temperature (Figure 16).

The altitude ranges from 900 metres (Figure 7), to 2 331 metres (Die Berg), which is the highest mountain in the Transvaal. Mount Anderson (2 284 m) is the second highest mountain in the Transvaal and lies just outside the bounds, to the north of the smaller study area (Figure 7). Gradients of up to 57° are not uncommon, and many vertical cliffs are to be found in the area. Differences in the topography and geology can be seen from the transect in Figures 8 and 9.

Plant species occurring at high altitudes such as those in this study area experience a great annual range of climatic conditions (Stevens 1989). This undoubtably has an effect on the plant communities found in this area.

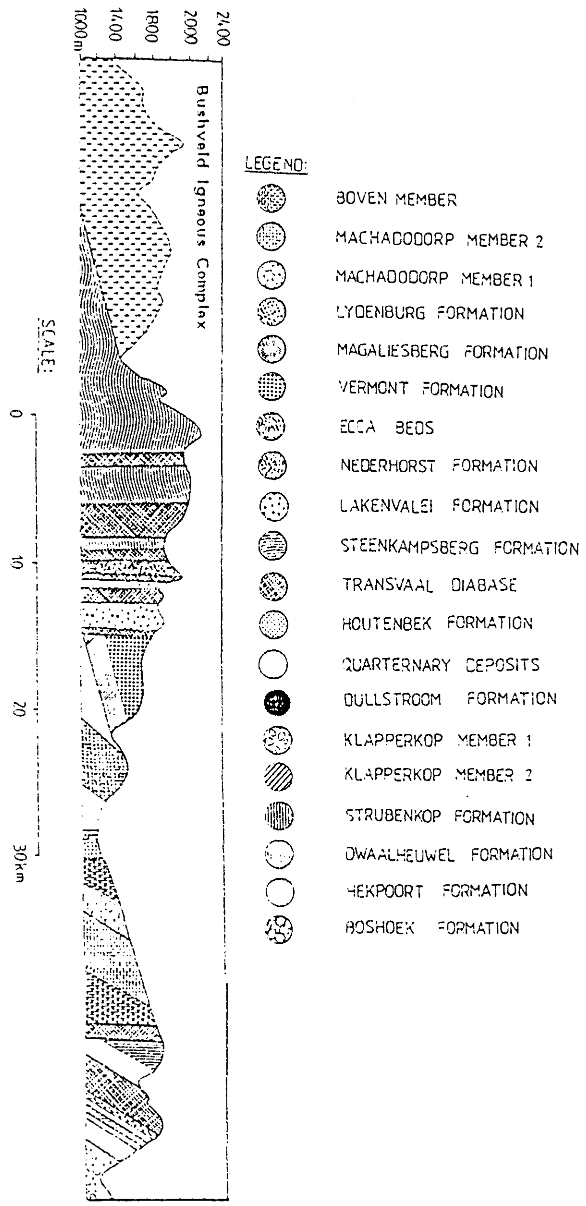


Figure 8. Transect of the study area including geological strata (this transect was taken from Figure 3).

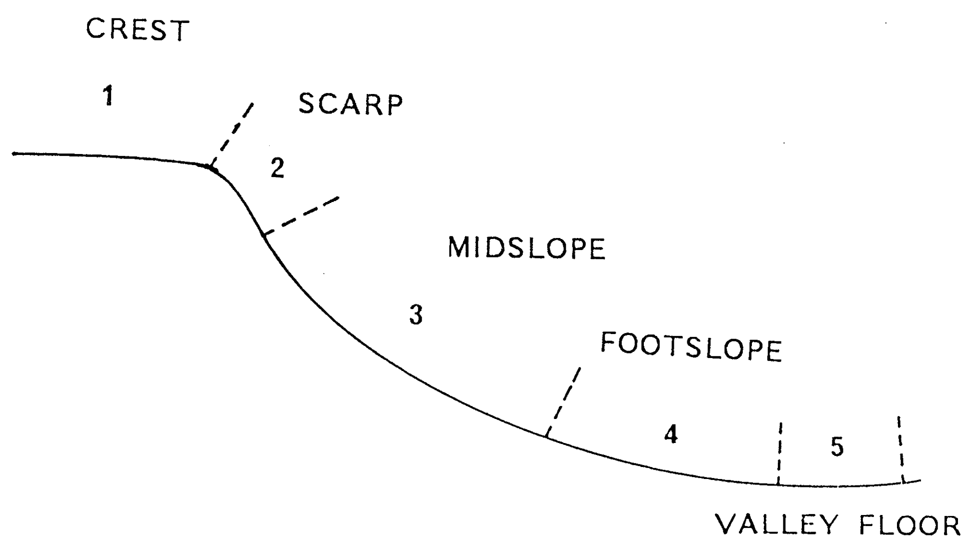


Figure 9. Different physiographical units occurring in the study area (Scheepers 1988).

3.5 CLIMATE

The climate of this region, according to the classification of Koppen (Schulze 1947), is a temperate, rainy climate with a dry winter season (summer rainfall). There is a C-type humidity province (sub-humid), with grassland as the characteristic vegetation, together with a precipitation (P) / evaporation (E) index of 32 to 63 (Schultze 1947). The area is also divided into subtypes of humidity provinces namely a w-type, which indicates a moisture deficiency in the winter.

3.5.1 INSOLATION

Incoming solar radiation is the most fundamental parameter present in the environment of the plant. Photosynthesis, photoperiodism and phototropism are all light dependent (Schulze & McGee 1978). Incoming radiation is subject to seasonal variation. Radiant flux densities during summer are higher than during winter (Granger & Schulze 1977). The presence and absence of cloud cover also affects the duration of bright sunlight during summer by 20-30% (Weather Bureau 1965 & Weather Bureau 1988).

Geographic variation of sunshine duration also occurs within the study area. Areas receiving mist (mistbelt) experience less than 60% of the possible sunshine, while areas in the lowlands (Low Country) experience 60 to 70% less sunshine. Summit areas experience a higher duration of daily sunshine due to rain-shaddow effects and the lack of mist (Weather Bureau 1965).

In addition to seasonal and geographic variability there exists also physiographic variation of insolation due to slope and aspect. Daily incoming radiant flux densities on sloping areas are a function of slope, aspect and season (Schulze 1975). In midsummer, steep slopes receive less radiation than do gentle slopes. This is true regardless of aspect (Weather Bureau 1988).

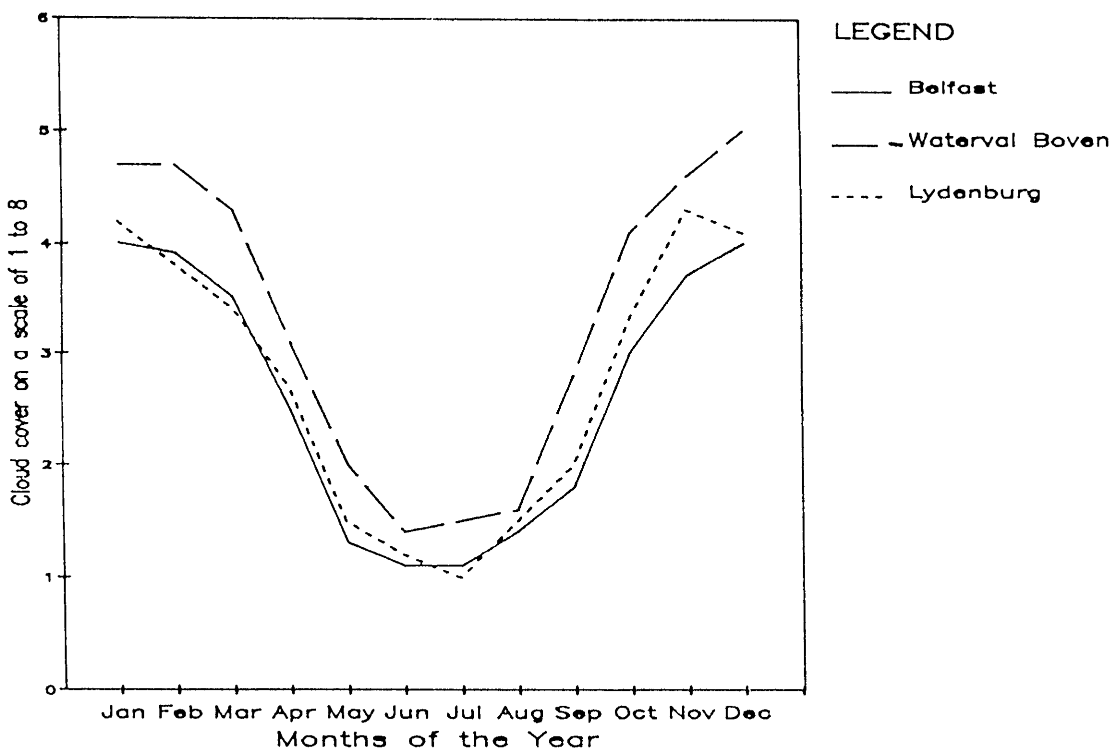


Figure 10. Line chart comparing the cloud cover of three weather stations in the area.

North-facing slopes receive a greater deal of radiation than those slopes with south-facing aspects. Incoming radiation on gentle slopes however is unaffected by aspect (Weather Bureau 1965 & Weather Bureau 1988).

Data from three stations given in Figure 10 shows that Waterval Boven has the most cloud cover possibly due to the clouds moving westwards from the escarpment. Belfast has the least cloud cover possibly due to the movement of the upper air masses at this high altitude.

3.5.2 TEMPERATURE

Temperature is a controlling factor in the presence or absence of a species because plants can only function within a certain temperature range. Certain species also only grow at certain temperatures (Larcher 1975).

Temperature affects the transpiration rate, evaporation rate and other processes of plants (Daubenmire 1974). These processes affect the germination rate, growth, maturation and reproduction as well as the vigour of the plant. Vigour in it's turn affects the plant's ability to compete and resist disease (Daubenmire 1974; Schulze & McGee 1978).

Temperature together with interactions of other climatic factors create environmental conditions which may limit the distribution of plant species (Krebs 1972). Severe frost and low minimum temperatures during winter, and high summer maximum temperatures together with the length of the frost-free period are possibly the most important direct temperature effects on plants (Daubenmire 1974; Schulze & McGee 1978).

Scheepers (1978) states that the temperature extremes (extreme maximum and extreme minimum temperature) plays a more important role in the presence or abscence of plants than does the average temperature.

Thus it can be seen from the following data for four stations in the study area that a great fluctuation in temperature occurs in this region (Weather Bureau 1988).

STATION	ALTITUDE	ABSOL. +	ABSOL. -	AVERAGE +	AVERAGE -
Belfast	1950m	32.2°C	-7.4°C	24.9°C	7.2°C
Lydenburg	1439m	34.5°C	-7.8°C	27.9°C	9.4°C
Sabie	1108m	37.5°C	-4.2°C	30.2°C	5.7°C
Waterval Boven	1430m	38.8°C	-6.7°C	29.2°C	9.4°C

This information was collected over a period of 40 years on average. Thus it is representative of the long-term weather fluctuations.

Comparisons show that Lydenburg is the coldest town in the study area with an extreme minimum of -7,4°C (Weather Bureau 1968b), while the highest maximum temperature is attained at Waterval Boven at 38,8°C. Sabie however has a maximum average of 30,2°C, which is higher than the other towns. The probable reason for this is that Sabie is in the Lowveld, while Lydenburg and Waterval Boven are at higher altitudes, but are surrounded by protective hills thus causing less air movement. The temperatures recorded for Belfast are lower due to the fact that Belfast is on an open, exposed, high-altitude plain where free airflow occurs.

Although Sabie is the warmest of the four stations it is not considerably warmer than the others. Lydenburg at an altitude of 1 439 metres above sea level is the coldest town with weather data recorded by the Weather Bureau but the town of Dullstroom at an altitude of 2 100 metres above sea level (no temperature data given) is considerably colder than the other towns in the area (personal observation of the author). Lydenburg and Waterval Boven have similar temperature ranges for the reason that the two are situated at nearly the same altitudes (Lydenburg at 1 439 m, and Waterval Boven at 1 430 m).

Plant species in this area show a large degree of phenotypic plasticity due to the fact that the climatic variations experienced during their lifetimes vary so much. These species can thus tolerate temperatures below -6° C in the winter and above 30° C in the summer with ease. Thus the distribution of these species would be wider than for species adapted to lowland areas (Stevens 1989), due to their tolerance of adverse conditions.

3.5.3 PRECIPITATION

Water is vital to the physiological and chemical processes occurring within plants. It is also the medium by which nutrients in the soil are moved into the plant (Odum 1971; Daubenmire 1974).

Water is an important factor in the distribution of a species as water can be a limiting factor in their occurrence (Odum 1971; Walter 1971; Krebs 1972; Schulze & McGee 1978). Because of the high rainfall in the area there is a higher species diversity that in most other parts of the country (Huston 1979; MacArthur 1972; Stevens 1989).

Rainfall

The higher parts of the Steenkampsberg receive more rainfall than surrounding areas (Figure 11). This is partly due to the higher elevation coupled to the fact that these mountains act as a barrier against which the rain falls. The same can be observed of the Escarpment (north-eastern part, Figure 11) which receives a higher rainfall than the areas surrounding it. Lower rainfall at the centre (Figure 11) is caused by the valley running from north to

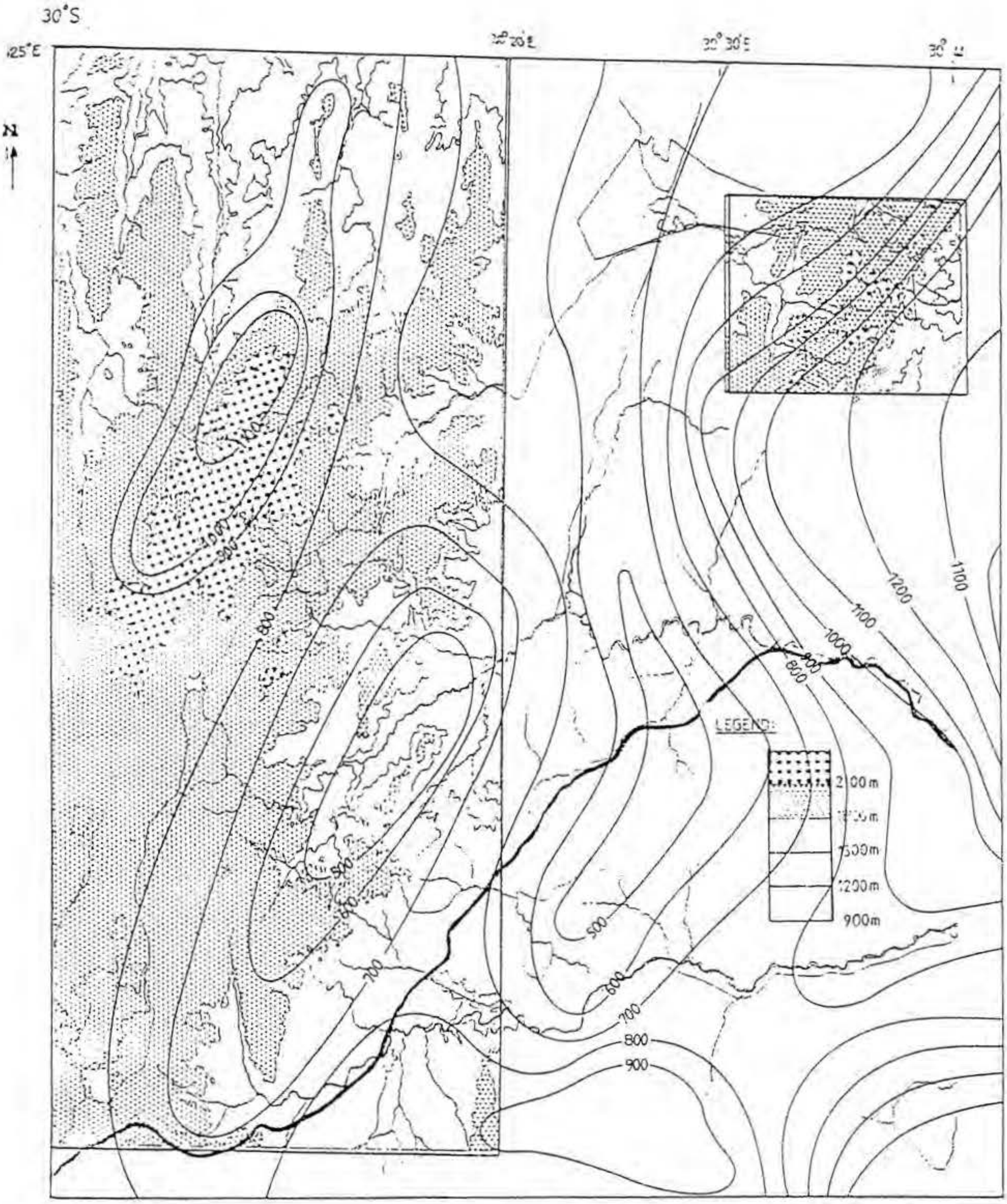


Figure 11. Rainfall map of the study area (Weather Bureau 1968a) underlain by topography.

south. The lack of rain here is caused by less convection currents in the valley as well as a rain-shadow formed by the escarpment.

From the Walter Climate Diagrams (Figure 16) it can be seen that Sabie undoubtably has a considerably higher rainfall than the other towns in the area. The other three towns receive more or less the same amount of rain, most of it occurring from October to April.

Fog or mist

Precipitation from mist and fog supplements the rainfall precipitation rather significantly in this area. Contributions to the soil moisture occur when mist or fog moves over the vegetation causing "fog-drip". The presence of fog or mist can also reduce evapotranspiration (Scheepers 1978). Mist occurring over most areas of the Transvaal is normally too neglegible to take into account, however this is not so in this case. Mist in this area is a common occurrence especialy during the months of October to February (Figure 12). The contribution made by mist to the total precipitation is quite considerable and many species probably cannot live without it (smaller forbs).

From the data (Figure 12) it can be seen that the most mist occurs in Belfast, but other areas that do not have ample weather stations for recording this phenomenon have much higher occurrences of mist. Areas above 2 000 m in altitude are shrouded in mist for most of the summer months, and mist can cover the entire escarpment area for three weeks at a time (personal observation of the author). The plants during this time are covered with small droplets and especialy species like *Tristachya leucothrix* which have hairy leaves are ideal traps for the mist.

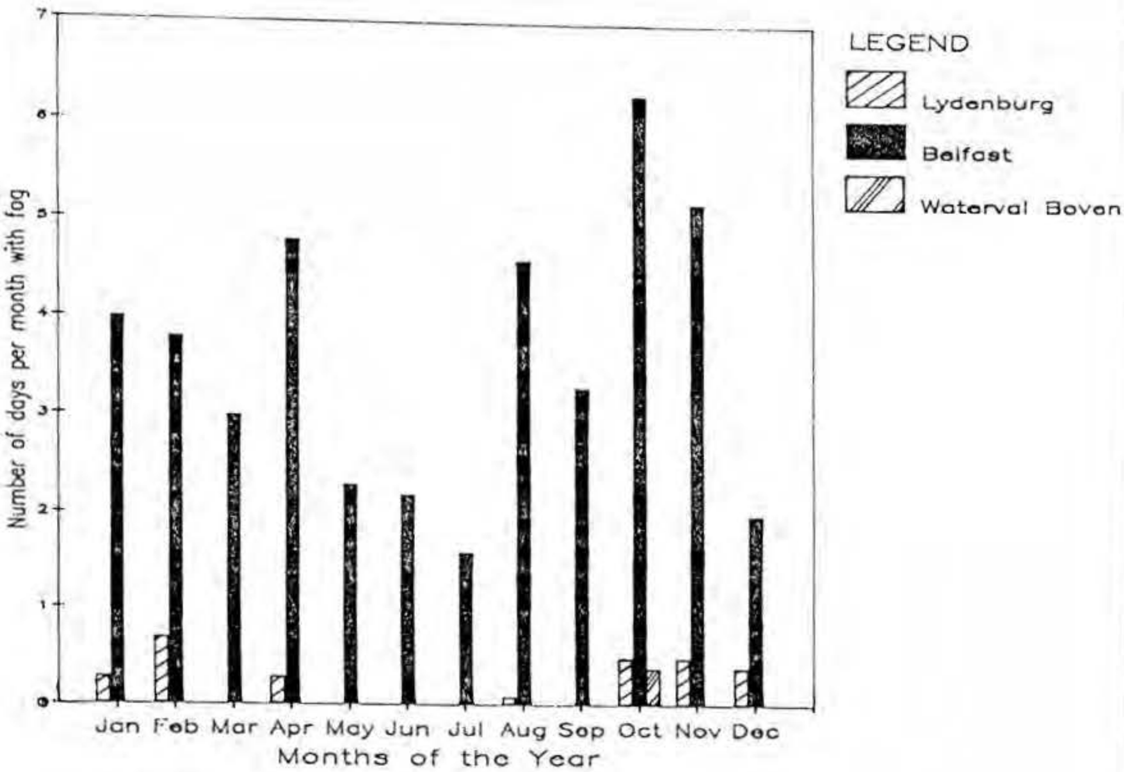


Figure 12. Line chart showing the monthly occurrence of mist at three weather stations in the area (Weather Bureau 1968b).

Hail

Hail frequently occurs in this area, Waterval Boven being prone to hail storms more than other weather stations in the area (Figure 13). The presence of hail is usually associated with convection thunderstorms and short periods of intense rain. Months that hail is most likely to fall are October, November, December and January which are the rainy months in this area. It must however be noted that the information from a weather station is only that data collected at one given spot, and the area in question is so heterogenous with regard to the patterns in weather, due to the broken nature of the terrain that it must not be accepted that this is the norm for surrounding areas (personal observation of the author).

Hail is of little ecological importance as it's effect on plant communities is unknown if any. Grasslands would be less affected than forest stands, as broad leaves offer a larger surface area for hail to strike upon than does grass (Deshmuhk 1984).

Frost

Frost occurs generally in the winter months in this area and is common on all slopes, crests, as well as in the valleys. Some areas may experience little or no frost due to the fact that they are sheltered by cliffs and deep valleys. Most plants in the area are frost resistant, or shed their leaves or die in the months when frost occurs, thus avoiding this phenomenon. Frost has been known to persist into the months of September and October in the southern parts of the study area (Figure 14). From Figure 14 it can be observed that Belfast has frost for a greater part of the year than does Waterval Boven.

The frost occurring in this area causes teracettes on slopes in this region (Van Zinderen Bakker & Werger 1974) by the daily frost-thaw process. These teracettes then are normally

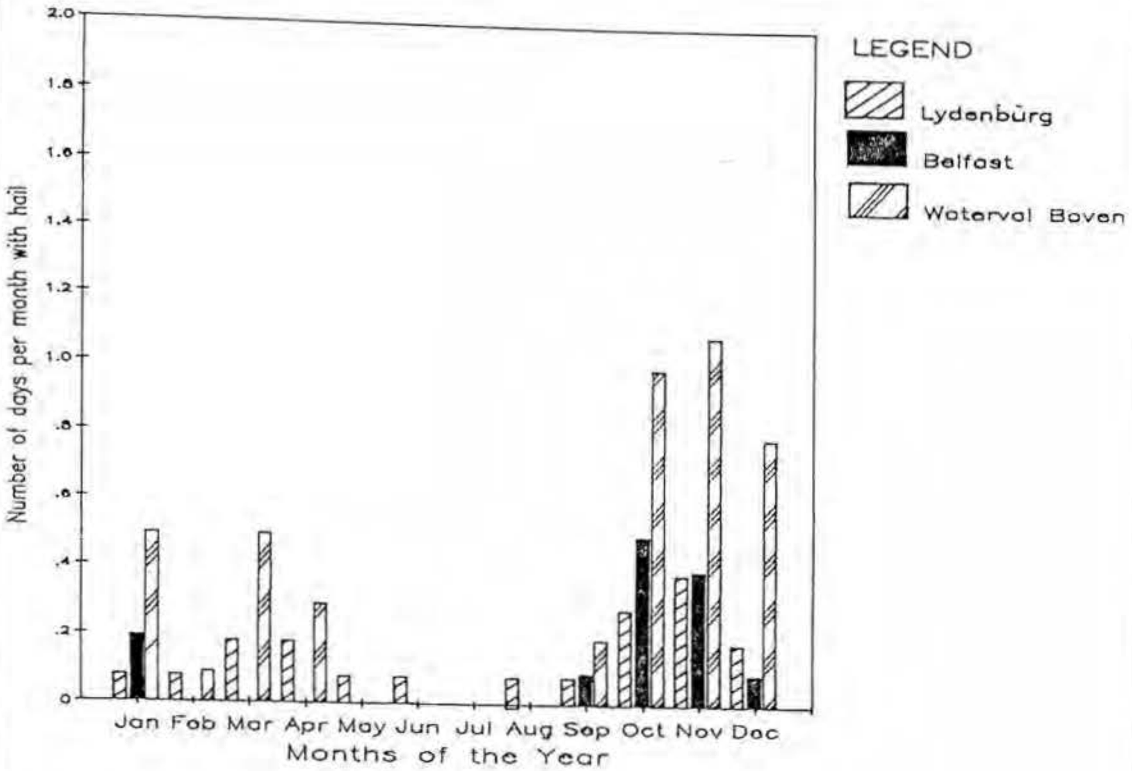


Figure 13. **Line chart of the monthly occurrence of hail at four stations in the study area (Weather Bureau 1968b).**

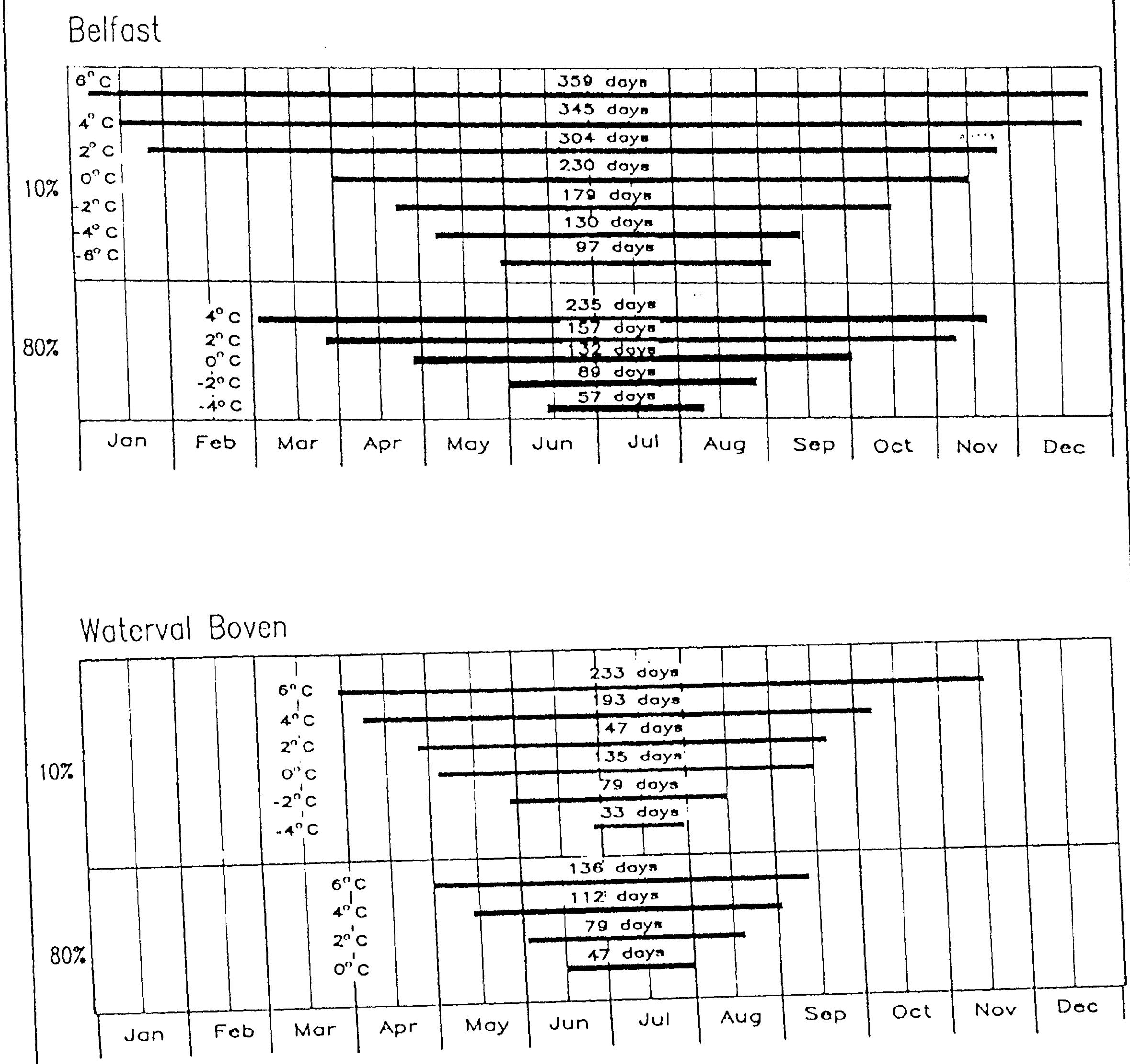


Figure 14. Duration of frost for two stations in the study area at 10% and 80% probabilities (Weather Bureau 1968b).

colonised by pioneers because they are basically disturbed areas. During rainy seasons these teracettes can be eroded thus losing valuable topsoil. The formation of frost-heaved tussocks is also an important process carried out by frost in this region (Sigafoos & Hopkins 1951; Hopkins & Sigafoos 1954).

Snow

Snow may increase soil moisture during winter and also act as an insulating blanket to protect plants from excessively low temperatures (Killick 1963).

Snow in this area is confined to the summits of the mountain ranges. The occurrence of snow in the late winter and early spring would then be beneficial to the high altitude plants whose soil moisture would be depleted at this stage of the year. Thus the increased soil moisture would enable these plants to commence seasonal growth before the first rains occurred.

Snowfalls are not uncommon in this area although the last falls at Dullstroom were in 1974 (personal communication). It must also be remembered that the Steenkampsberg Range are well above 2 000 m and that they form the tail-end of the Drakensberg Range, thus any extreme weather conditions caused by cold fronts moving northwards during winter months would cause snow on these mountains. The ecological importance of snow is little known in this area, and snow affecting the composition of plant communities has not been studied extensively in southern Africa as this phenomenon is very rare here.

From the following data it can be seen when the last snowfalls were received in the study area.

STATION	DATE	YEAR	PERIOD OF SNOW
LYDENBURG	20 JULY	1961	0,1 days

WATERVAL BOVEN	10 JULY	1956	0,2 days
BELFAST	30 SEPT.	1940	0,1 days
BELFAST	1 JUNE	1942	0,3 days
DULLSTROOM	JULY	1974	0,4 days

It is not recorded how deep the snowfalls were (Weather Bureau 1986).

Most species in the study area seem to have adapted to withstand the low temperatures associated with snow. Geophytes which are numerous simply lose their leaves and are not affected by snow. Other plants are dormant or die in the winter, leaving only seeds which are cold resistant, to grow when conditions become favourable again.

3.5.4 WIND

Wind is important in that it is one of the main mechanisms of seed dispersal for plants as well as the fact that grasses are pollinated by means of wind, and grasses are the dominant type of vegetation in this particular area. Wind influences the evaporation of water from the soil and strong winds can cause a water shortage in plants due to a high evapo-transpiration rate (Coupland 1979).

The plateau making up the interior of southern Africa has prevailing summer on-shore winds (south, south-east and east). These winds are normally moisture-laden and are associated with thunder storms (Jackson 1947), while prevailing winter winds are off-shore, (north, north-west and West) winds. Their moisture-content is low, thus causing wide temperature fluctuations due to the loss of radiation to the atmosphere (Jackson 1947).

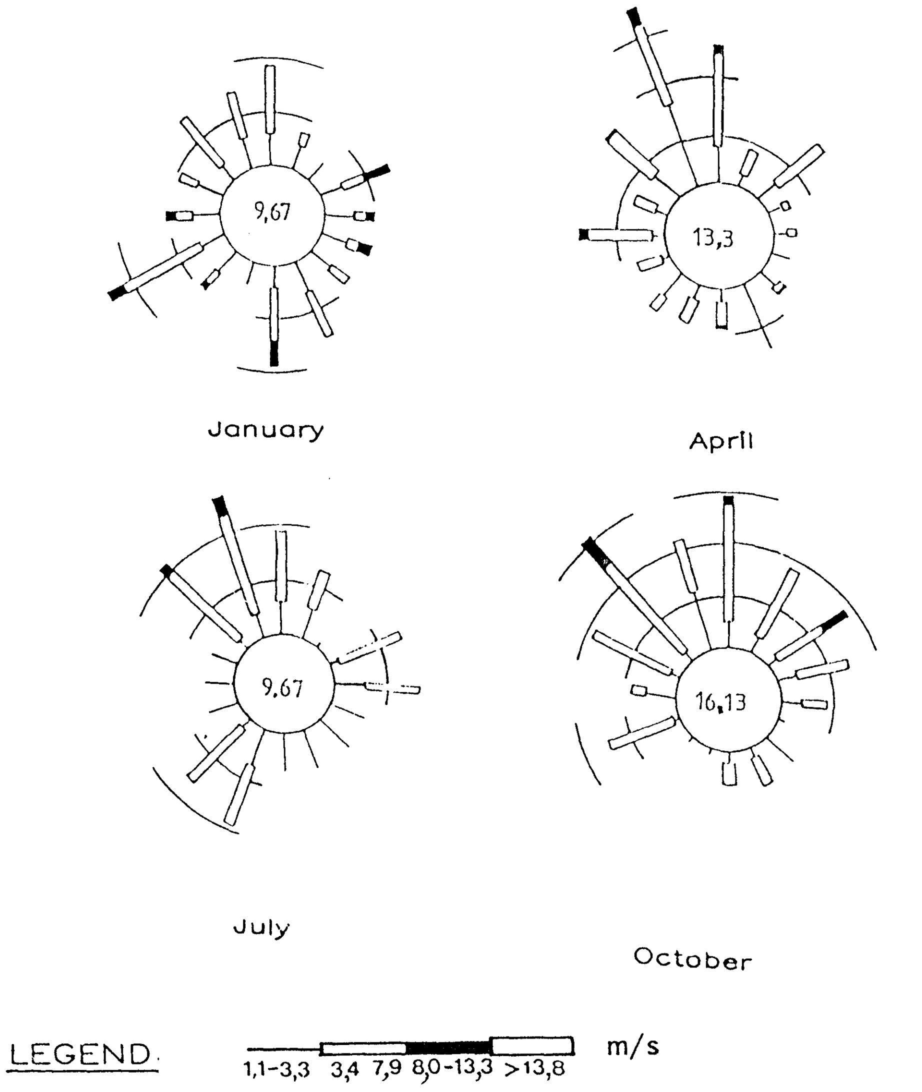


Figure 15. Wind roses for Lydenburg during four months of the year (Weather Bureau 1968b).

From Figure 15, it can be seen that at Lydenburg the wind is predominantly from the south and west-south-west as well as the north and north-West during the summer months, and from the north-west during the winter months. Winds occurring during the winter months seem to be generally less strong than those occurring during the summer months.

A tornado was spotted by the author in the month of October to the north-west of the town of Dullstroom.

CONCLUSION

From the Walter Climate Diagrams in Figure 16; it can be seen that the climate of the study area is very unique. It is situated at a high altitude which causes lower temperatures than what would normally be expected at this latitude (Schulze 1947). Snow and frost are thus common. The rainfall is relatively high (Weather Bureau 1988), and wind speeds are high all-year-round, contributing to many runaway fires. These combined factors give rise to a combination of species that is found only in this type of area. Geophytes flourish amongst the grasses and very few trees are present.

There also exists a relationship between precipitation and biomass production for grasslands (Deshmukh 1984). From the regression equation;

$$\text{peak biomass (kg h }) = 8.488 \times \text{precipitation (mm)} - 195.768$$

(Deshmukh 1984), the peak (climax) biomass for any specific part of the study area can be determined. This equation was determined using data from grasslands (Deshmukh 1984), and is thus ideal for use in this study as this is pure grassland together with some forbs and no trees. Thus it can be seen that areas receiving a high rainfall could be expected to have a higher peak biomass than areas that receive less rain, as can be seen in the field. Peak biomass per for the grasslands surrounding Belfast would be 6 976.60 kg per hectare per year. Values for the grasslands surrounding Lydenburg, Waterval Boven and Sabie would be 5 822.23, 7 010.54, and 9 427.10 kg per hectare per year respectively. Thus the high rainfall around Sabie has a positive influence on the biomass production of the vegetation of this area. The low biomass production for the grasses around Lydenburg is caused mainly by the lower rainfall that this area receives.

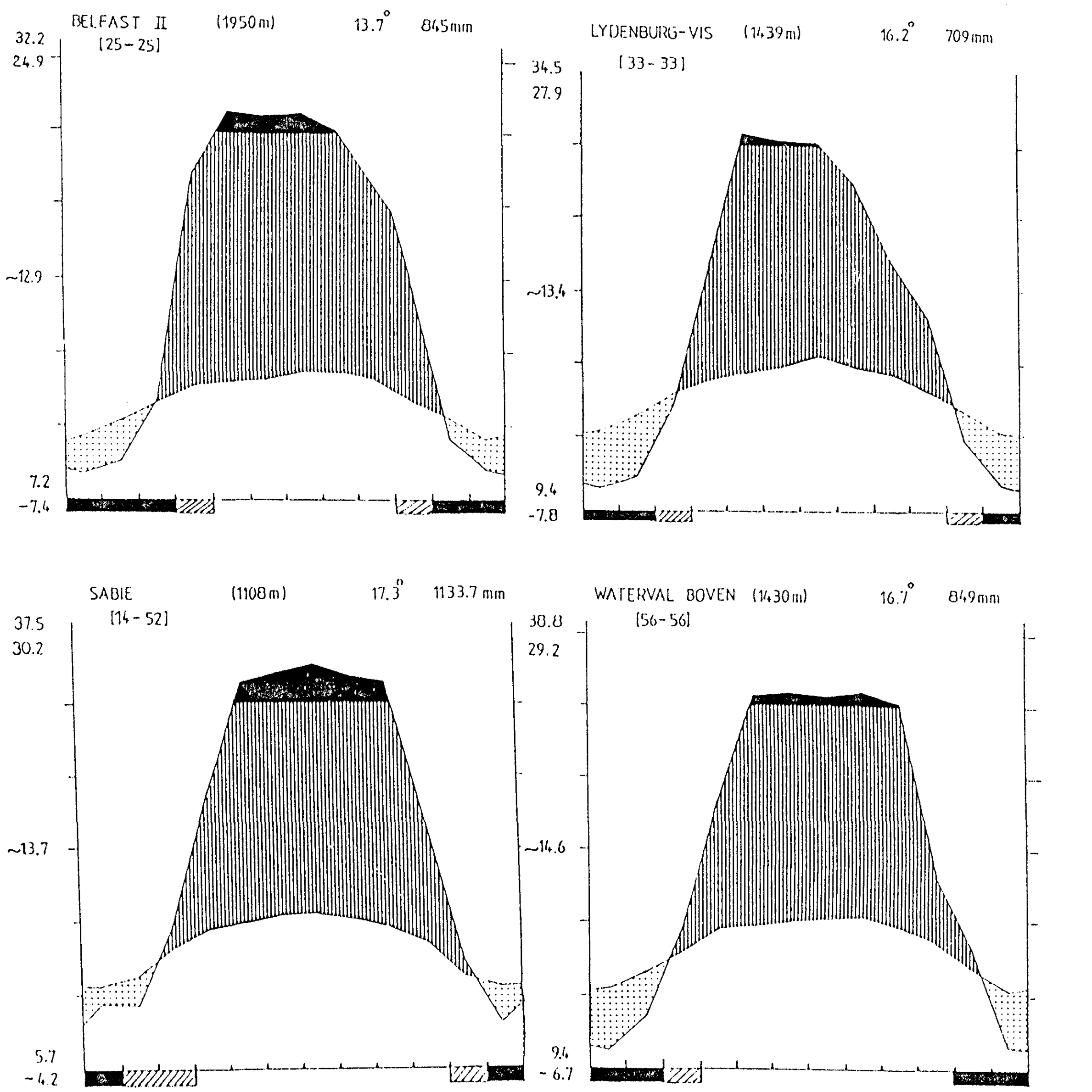


Figure 16. **Walter Climate Diagrams for four weather stations in the study area.**

These diagrams were compiled from data obtained from the Weather Bureau (Weather Bureau 1968b; Weather Bureau 1988).

CHAPTER 4: BIOTIC FACTORS AFFECTING THE VEGETATION

4.1 HISTORY

The history of this area is included, as certain ecological units are explained by events that took place in the past. History also gives us an idea of how the land was managed in past years.

The earliest evidence of human habitation in this area are artifacts that were found in a rock shelter at Heuningneskrans in the Lydenburg district. These were dated as being of the Late Stone Age (Fage & Oliver 1982). It is presumed that the makers and users of these tools learned this from the tribes in Zimbabwe and eastern Africa, who traded with tribes in the northern and eastern Transvaal.

It is believed that the tribes in this area were not pasturalists because the pollen of *Acalypha* sp., a species common in abandoned gardens which are reverting to forest, is prevalent in this area (Fage & Oliver 1982). Settlement ruins can also be seen in many parts of this study area (Figure 17)

The tribe of Venda probably arrived during the Iron Age and they mined iron in this area as well as traded copper and gold, mined at Phalaborwa and Lydenburg respectively. Also tools that were found indicate that the cultivation of crop-foods must have dominated in this area in the Late Iron Age. It is also known that most of the pasturalists were situated in central Zambia and parts of Natal, and were rare in the study area until around the eighth century A.D.. Pottery has also been found in this area (Klapwyk 1973), which was used to store grain in.

A personal observation of the author is the presence of terraces, especially in the areas where there is Transvaal diabase present. These terraces are still visible, being constructed of Transvaal diabase, although there are also some terraces in areas where quartzite is present. These crop-planting tribes must therefore have known that soils derived from diabase are richer than soils derived from quartzite.

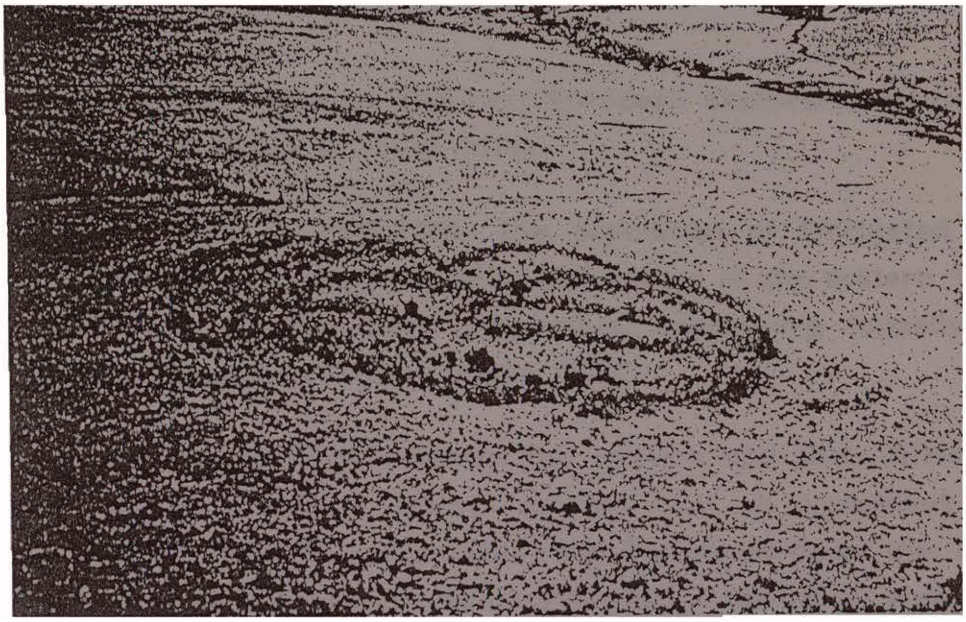


Figure 17. Ruins of an ancient settlement ± 2km east of Machadodorp.

Also in the Machadodorp area there are many strange stone structures (Figure 17), which, according to the local population, were studied by professor Raymond Dart, and were declared to be the same age as the Zimbabwe Ruins (personal communication). (2)

In the early nineteenth century the first European explorers and missionaries arrived in this area (Fage & Oliver 1976).

After the Great Trek in 1838-1850, the population of Ohrigstad moved to Lydenburg, which became the new settlement-centre in the eastern Transvaal. Later in 1856 because of political differences, Lydenburg formally declared itself a separate Republic (Fage & Oliver 1976).

There were repeated conflicts between the settlers and their African neighbours, and the Pedi chief, Sekwati entered into an agreement with the Lydenburg Republic in 1857, under which the Steelpoort River was recognised as the boundary of his kingdom (to the north-west of the study area). In 1860, Lydenburg rejoined the Transvaal Republic with Andries Pretorius as president.

Shortly after 1868, gold was found near Lydenburg and this brought hundreds of miners to the area. The excitement was short-lived however because there was very little gold and transport costs were enormous. This must have had a drastic effect on the ecology of the land around Sabie and Lydenburg because scars due to the mining activities can still be seen in this area. By 1874 most of the gold was depleted and most of the population had moved away. Lydenburg was still important to the transport-riders like Sir Percy Fitzpatrick, who made trips to the then "Delagoa Bay" (now Maputo) via Lydenburg, where they obtained supplies for trading purposes (Fage & Oliver 1976).

An interesting part of the study area is the legend of the Kruger Millions, which are believed to be in the study area somewhere near Machadodorp or Lydenburg. The facts about this treasure are these:

(2)Mrs A.V. Venter, P.O. Box 279 Machadodorp.

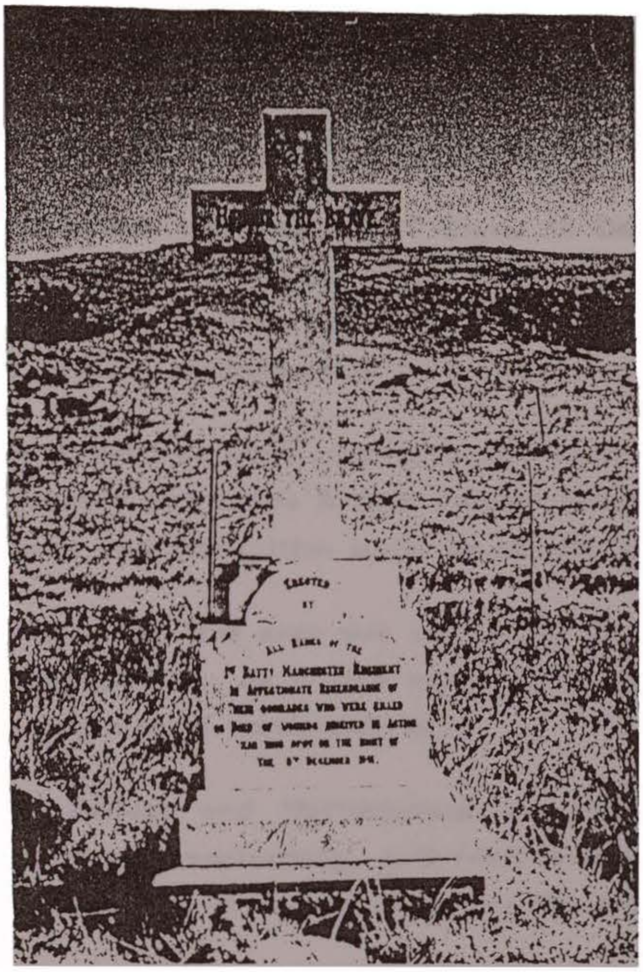


Figure 18. Graves from the Anglo-Boer war ±16 km north of Dullstroom on the road to Lydenburg.

On the 28th of May 1900, during the Anglo Boer War, Machadodorp was made the administrative capital of the Transvaal Republic after the British invasion of Pretoria. That very same day gold worth R 60 000 000 was moved from Pretoria and the East Rand, by rail to Machadodorp prior to the British invasion. In April 1901 General Botha announced that the "Staatskas" was empty due to debts that the government owed (Kruger 1979).

In June 1901 Lord Roberts marched from Pretoria to Delagoa Bay tearing up the railwayline as he went. In August the line up to Belfast was ripped up, and on the 26th and 27th of December 1901 the last great battle of the war was fought in this region, commemorated by a gravestone (Figure 18).

Whether the gold was used or went missing is still unknown, but no gold was moved out of the country due to the British that were monitoring all movements of gold, because arms and ammunition could be bought with it (Kruger 1979).

During the Anglo Boer War this area was utilized by farmers to breed horses used by the boer commandoes, as it is a particularly good area for breeding horses due to the abscence of horse-sickness.

Today Lydenburg, Belfast and Machadodorp are agricultural centres for farming practices such as sheepfarming, soft-fruit farming (especialy peaches) and cattle farming. It is also an important centre for trout- fishing.

4.2 PREVIOUS BOTANICAL AND VEGETATION SURVEYS IN THE AREA

From the PRECIS Data Bank of the National Herbarium it was found that well known collectors have collected many species in this area, however with regard to vegetation surveys in this area not much has been done.

Studies have been caried out in the Verlorenvalei Nature Reserve by Bloem (Bloem 1988), and the escarpment near Sabie has been studied by Deall (Deall 1985) and Matthews (Matthews 1991).

An important study was also performed by J.P.H. Acocks (Acocks 1988), who did a survey of veld types throughout the Republic of South Africa.

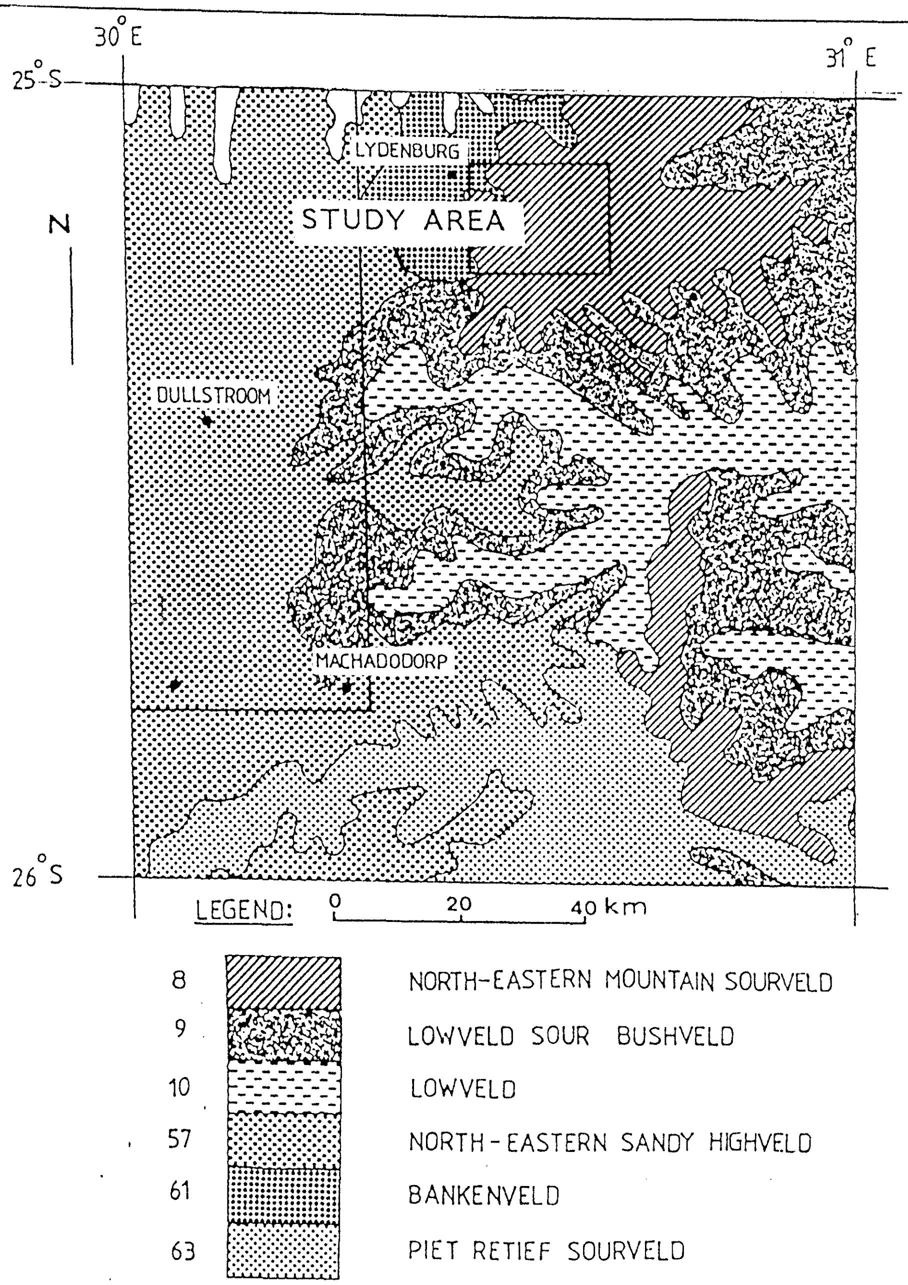


Figure 19. Acocks' classification of the eastern Transvaal (Taken from Acocks 1988).

This particular area according to Acocks falls into the North-eastern Sandy Highveld (Figure 19), which is sub-divided into the Near-Bankenveld Variation and the Near-Highland Sourveld Variation. The Near-Bankenveld Variation occurs more on the western sides of the watershed and does not include much *Themeda triandra*, it's ecological position being occupied by sourer species. Common grass species are *Tristachya leucothrix*, *Trachypogon spicatus*, *Heteropogon contortus*, *Eragrostis racemosa*, *Monocymbium ceresiiforme*, *Loudetia simplex*, *Ctenium concinnum* and *Microchloa caffra*.

The Near-Highland Sourveld Variation occurs more on the crests and eastern sides of the mountain ranges and *Themeda triandra* is dominant. Common species are much the same as the former variation however less *Loudetia simplex* and *Ctenium concinnum* are present.

Both these variations show affinities with the Bankenveld and form the transition between the *Cymbopogon* - *Themeda* Veld and the Highland Sourveld (Acocks 1988). A small area of isolated Bankenveld occurs near the town of Lydenburg and sample sites were placed in this area to determine it's affinity with the rest of the area.

4.3 EXPLOITATION AND LAND-USES

An estimated 30-35% of this study area is currently under cultivation (From aireal photographs of this area), with forestry being the most abundant practice. Other crops such as maize and fruit are important with crops such as sunflowers, flowers (tulips) and perrenial rye grass (*Lolium perenne*) being less important. Planted pastures of *Eragrostis curvula* are also common although most of the livestock is supported by the natural pasturage. Common domestic animals include cattle (dairy and beef), sheep and horses (which thrive here due to the apparent absence of horse sickness).

FAUNA.

Game is to be found on most of the farms in the area, while a private game reserve in the southern part of the larger study area abounds with blesbuck, black wildebeest, blue wildebeest, springbuck and ostriches.

Two nature reserves namely the Verlorenvalei Nature Reserve (VNR) and the Dullstroom Nature Reserve (DNR) are to be found in the larger study area, while the Lydenburg Nature Reserve (LNR) forms part of the smaller study area. These three Reserves have the following species residing in them (Batchelor *et al.* 1982) and according to Edwards (1974) more of this area should be conserved.

Common name	**Scientific name**	**Reserve**
Blesbuck	*Damaliscus dorcas phillipsi*	VNR, DNR & LNR
Wattled crane*	*Grus carunculata*	VNR & DNR
Crowned crane	*Balearica regulorum*	VNR, DNR & LNR
Blue crane	*Anthropoides paradisea*	VNR, DNR & LNR
Springbuck	*Antidorcas marsupialis*	DNR
Brown Hyaena	*Hyaena brunnea*	VNR & LNR
Blue wildebeest	*Connochaetes taurinus*	LNR
Duiker	*Sylvicapra grimmia*	VNR, DNR & LNR
Steenbuck	*Raphicerus campestris*	VNR, DNR & LNR
Oribi	*Ourebia ourebi*	VNR, DNR & LNR
Lynx	*Felis caracal*	VNR, DNR & LNR
Red rhebuck	*Redunca fulvorufula*	VNR, DNR & LNR
Grey rhebuck	*Pelea capreolus*	VNR, DNR & LNR

Other less conspicuous species are also to be found on all three nature reserves. The Verlorenvalei Nature Reserve is very special because it is the only Nature Reserve that has been set aside specifically as the breeding ground of wattled cranes, and is probably the Nature Reserve situated at the highest altitude in the Transvaal.

The wattled crane (*Grus carunculata*; Batchelor *et al.* 1982), which has it's breeding grounds in this area, is as yet still an endangered species.

The springbuck at the Dullstroom Nature Reserve were purchased by the Dullstroom Village Council and were re-introduced to the area. From the six originally sited there, one died and the remainder bred to reach a total of thirteen (personal communication).(3)

Various nature trails are also situated in these areas namely the Steenkampsberg Nature Trail, Elandskrans Nature Trail and a Nature Trail north of Lydenburg.

A large part of the study area consists of wetlands and plans are being made by the National Parks Board to conserve the Lakenvalei wetland, due to the wattled cranes that breed there, together with a few rare orchid species which are also to be found here.

FLORA

In addition to the naturally occurring species found in this area there are a number of alien species to be found. These include *Pinus sp.* found mainly in plantations. Other undesirable plant species are *Stoebe vulgaris* and *Pennisetum villosum* which have spread into natural grasslands.

Apart from the exotic plantations there is also a considerable problem with black wattle (*Acacia mearnsii*) in the drainage systems of the whole study area. This problem is being investigated by Mr. Johan Engelbrecht,(4) who together with his team are undertaking to chop some of these trees out especially in the area surrounding Lydenburg.

The removal ot these trees is vital to the recovery of the natural vegetation around the rivers (Mueller Dombois & Ellenberg 1974), however, the seed bank of seeds still remains viable for a long while after the trees have been removed. Other naturally occurring trees will be able to establish themselves after the removal of the wattles.

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(3) Dullstroom Village Council P.O. Box 1 Dullstroom.

(4) Mr. Johan Engelbrecht P.O. Box X 64 Pretoria, 0002.

Continued survival of a number of naturally occurring plant species in both study areas are threatened (Hall *et al.* 1980) due to the destruction of habitat resulting from agricultural and mining practices.

Endemics occurring in the area will be discussed later.

4.4 FIRE AND GRAZING

Grasslands found in the Belfast/Lydenburg/Dullstroom district are of fire climax vegetation as opposed to climatic climax vegetation (Tainton 1981). Here it can be seen that fire together with grazing maintains the grass cover (Burkhart 1975), and prevents the establishment of shrubs and trees. Thus fire started naturally (lightning) or by man, together with grazing, have created pressures with which the grasslands of Africa have co-evolved (Daubenmire 1974; Owen & Wiegert 1981; Tainton 1981; Mentis & Huntley 1982).

Fire has always been used by pasturalists for the management of the vegetation, but abuse by this tool can result in deterioration in the vegetation (Trollope 1989). Such misuse of fire is to be found in the study area where sheep farmers burn the veld out of season to obtain green growth for grazing. This causes a reduction of canopy cover, basal cover and a reduction of vigour (Tainton 1981; Trollope 1989) as well as an increased run-off area for rain. This then in turn causes soil erosion (Trollope 1989) which is most prevalent in the south-eastern part of the study area. This area is most susceptible to soil erosion because of the type of geology and soiltypes (Figure 3 and Figure 6) found there (Everson *et al.* 1989).

In areas of high rainfall such as this study area the biomass build-up is high per season (Roberts 1970). Build-up of old undesireable grazing material can then be removed by fire (Daubenmire 1968) thus preventing the grasses from becoming moribund (Trollope 1989).

Burning in the height of the summer months can have serious effects on the seed-banks of the grass seeds because the seeds themselves are burned before they can drop to the ground and form part of the seed-bank. Although the effect of a loss of seeds is not immediately noticeable, it will cause a diminishing of the species in question later on (Edroma 1984; Knapp 1985).

Grazing shortly after burning can also have an extremely detrimental effect on the quality of the natural grasslands (Bakker 1987) especially if camps are too small or herds are too large. Grazing too soon after a burn can cause a mosiac pattern to develop in grasslands (Belsky 1986). The mosiac pattern consists of palatable grasses and unpalatable grasses in patches. The unpalatable grasses can take over due to the fact that they are not grazed (Grubb 1977), and are thus not stressed. Later these unpalatable grasses dominate completely.

Under-burning can have as serious an effect on the condition of the grassland as can over-burning (Trollope 1989). This is a very important factor in the breeding habits of the wattled crane (*Grus carunculata*). These birds breed in the wetlands and, according to some local farmers (5) (personal communication), breed only in wetlands that have been burned the previous season. Thus if wetlands are left unburned the cranes will either move to a more suitable spot or would simply not breed that year due to unfavourable conditions. Most cranes however return to their territories each year to breed and not burning the wetlands may be a possible explaination for their low numbers.

According to Heyns (1985) wetlands of the Verlorenvalei Nature Reserve should be burned every third year to remove dead plant material.

The condition of the veld in the study area appears to be relatively undamaged although the farmers graze their cattle and sheep extensively on the natural vegetation. The reason for this is that under high rainfall conditions the plants recover quickly from the effects of the grazing.

There are some examples of over-burning in certain areas resulting in a low species diversity. Burning twice a year is also a common practice for some farmers. This is done to remove the older grass which is high in cellulose. This is normally done by sheep-farmers because the sheep prefer softer younger grass.

(5) Mr. Daan Botha P.O. Box 164 Lydenburg

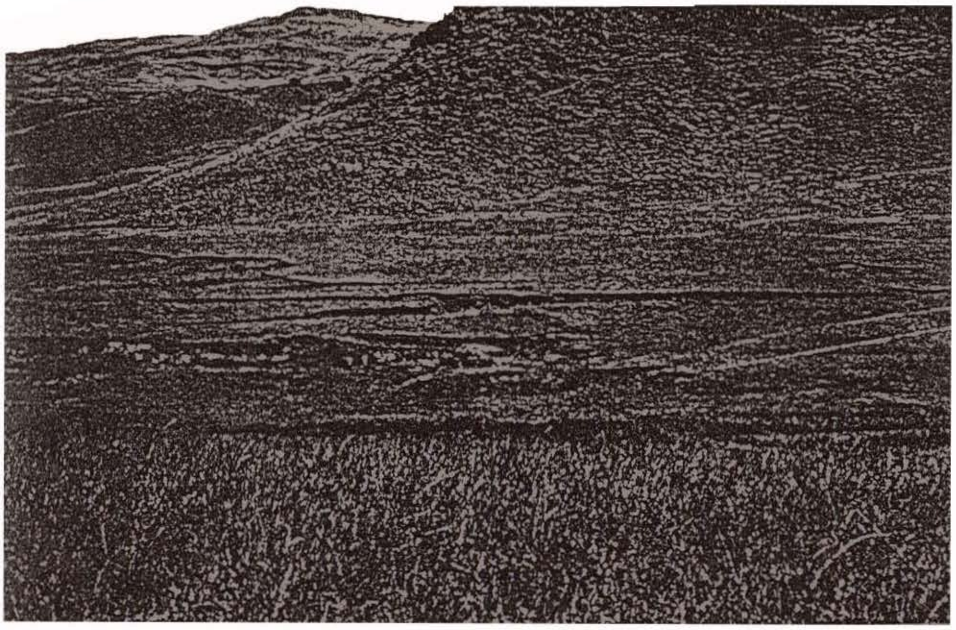

Figure 20. Sheet and donga erosion in the south-eastern part of the study area.

4.5 EROSION

Due to the steep gradients to be found in this area it is expected that there would be a high degree of erosion in this area. This however is not the case. Most of the area experiences sheet erosion which is not as serious as some other types of erosion. One exception however is the south-eastern areas where the Boven and the Machadodorp Members (Figures 3 and 20), are to be found. These are mainly shales and they are a type of rock that weathers and erodes very easily.

Thus if any degree of stress is placed on the soils derived from these rock types the result would be a high degree of erosion. This can be seen from Figure 20. Together with its's easily weathered nature, the soils derived from this type of rock are not very fertile, thus the plant cover is somewhat sparse, which in turn promotes a high degree of run-off, thus taking a great deal of topsoil with it.

Roads built on steep slopes also contribute to soil erosion, and can lead to the formation of dongas.

The movement of stock animals to and from watering points in this area also may lead to the formation of dongas.

CHAPTER 5 PHYTOSOCIOLOGICAL METHODS

Plants tend to grow together in groups and are seldom distributed in a random manner (Greig-Smith 1964; Daubenmire 1968).

Groups of species tend to occur in associations determined by their ecological tolerance of biotic factors, combined with interspecific and intraspecific interactions. Phytosociological classification seeks to investigate the interrelationships between species and their distribution patterns.

Classification as approached by the Braun-Blanquet (1932) method, and modified by Mueller-Dombois & Ellenberg (1974), Westhoff & Van der Maarel (1978) and Bredenkamp (1982), indicates that a correlation exists between specific environmental conditions and plant communities. Thus a sound ecological classification of the vegetation is produced (Bredenkamp & Theron 1978).

Two phases comprise this procedure of phytosociological classification namely; the analytical phase, where environmental and floristic data are collected during fieldwork. The second phase (synthetic phase) then results in a delimitation of communities derived from the classification of the data. These communities are then ordinated along environmental gradients (Moore *et al.* 1978; Westfall *et al.* 1982; Deall 1985 & Bloem 1988) to determine the most important environmental factor contributing towards the differentiation of each community.

5.1. ANALYTICAL PHASE

5.1.1 RECONNAISSANCE

As originally postulated in the Braun-Blanquet approach, sampling sites are chosen subjectively (Braun-Blanquet 1932). Thus a thorough reconnaissance of the study area had to be done to enable the phytosociologist to choose the sample sites so that all communities represented in the area were sampled.

5.1.2 SAMPLING STRATEGY

Subjectively placed sampling sites versus objectively placed sample sites have been both criticised and endorsed (Coetzee & Werger 1973; Werger 1974a; Mueller-Dombois & Ellenberg 1974). The current trend in phytosociological work is towards using more objective methods (Coetzee 1974; Bredenkamp & Theron 1978; Deall 1985; Bloem 1988; Westfall 1992) such as random, or stratified-random sampling.

In this study a stratified-random sampling method was used since it is more precise than strictly random sampling (Cain & Castro 1959). This also excludes over-and under-sampling and the exclusion of certain vegetation types is less likely to occur. This stratified-random sampling method was combined with extra subjective sampling by the author to avoid the exclusion of any vegetation types in the area.

5.1.3 DISTRIBUTION OF SAMPLE SITES

The distribution of sites was based on the random stratification concept to ensure that all differing types of communities would be sampled (Daubenmire 1968).

Stratification

Stratification was carried out using the different geological types together with the different land types as strata. The geological map, 2530 Barberton (scale 1:250 000) was made into a transparancy and placed over the land type map 2530 Barberton (scale 1:250 000). Each of the different geological types per land type were then taken as a unit of statification.

The whole surface area of the study area was then determined using a Li Cor 3100 planimeter. The surface area of individual land types were then determined as a percentage of the area. The percentage of each area compared to the whole was then determined. Units of stratification comprising a larger percentage of area thus contained more sample sites than those units of stratification comprising smaller areas. It was decided to have approximately 200 sample sites in the main study area and 75 in the smaller study area. From this it was then determined how many sites were to be placed in each of the units of statification using the percentage-cover for each unit of stratification as compared to the whole.

Randomness

Before the site positions were located all areas under cultivation were delineated so as to be excluded from the sampling. This was done by observing cultivation on the most recent aerial photographs (1988) of the region, and plotting these areas onto the map used.

The placing of the sites in each unit of stratification was in a random fashion using a random number table. A grid with x and y co-ordinates was placed over the map and random number co-ordinates then formed the site positions.

Number of sample sites

Besides the 200 sample sites in the main study area and the 75 sample sites in the smaller area it was decided that extra sampling was necessary due to the fact that the physiognomy of the area does not form part of the strata and this aspect also had to be investigated. Therefore if a particular site was situated in the valley, an extra site would have to have been positioned on the crest as well as on the slope (this was done only if it was found that the vegetation of these sites obviously differed). Thus the total number of sites in the large study area was 239 and the number of sites in the smaller study area was 80 due to extra sampling.

Placing sites

Sites were located in the field using 1 : 50 000 aerial photographs upon which the sites had been stipulated previously from the maps. This method is relatively rough and not totaly accurate in placing the sites, but no better method could be used. Finding the site-positions in the field from the aerial photographs is however very accurate and speeds up the process of sampling considerably.

An element of subjectivity was introduced as the sample site had to be placed in the most homogeneous area within the proximity of the site. This could only be done by means of personal observation to avoid ecotonal areas.

5.1.4 PHYTOSOCIOLOGICAL SAMPLING

Sample sites measuring 200 m^2 in area were sufficient to sample this vegetation type (Deall 1985; Bloem 1988). The square quadrat was not used because it is deemed less efficient than a rectangular quadrat (Cain & Castro 1959), and less variability is to be found between square quadrats (Greig-Smith 1964).

According to Mueller-Dombois & Ellenberg (1974) and Werger (1974a) size and shape have no influence on the effectiveness of the survey. There exists however a minimum area (Gleason 1925; Hopkins 1955) for sampling, determined by the vegetation (Werger 1974a). According to the species-area curve of the vegetation of the Verlorenvalei Nature Reserve (Bloem 1988) a sample site of 200 m^2 was recommended. This specific size of 200 m^2 was used due to the low species diversity of high mountain grassland (Bloem 1988). This is also the same size quadrat as recommended by Deall (1985) and used by Bloem (1988). Thus any correlation of data collected by these authors dan be done directly knowing all sample sites were of the same size.

For each quadrat the following data were gathered:

1. Location

Farm names or nearest beacons were used to specify the location of sample sites.

2. Stand co-ordinates

The co-ordinates of the sites were noted from a map (Land type series, 2530 Barberton 1979), eg. 2530 AA.

3. Relevé number and date

The site number and date when the data were collected, were noted.

4. Altitude

The altitude in metres was noted from the nearest contour on the topocadastral map (Land type series, 2530 Barberton 1979.)

5. Geology

The geological groups were noted for each site using the geological

6. Land types

The land types for each site were noted from the land type map (Land Type Series 2530 Barberton 1979).

7. Geomorphology

Slope positions are very important because they have an impact on the water run-off and water collection as well as the fact that soil depth is affected by the gradient of slopes (Munnik, Verster & Van Rooyen 1984).

The geomorphological classification system of Scheepers (1988) was followed. The landscape is divided into two major classes, namely facets (planes) and segments (curves). Further sub-divisions are made according to the position, the landscape (uplands and bottomlands) and the magnitude of the slope (flats, slopes and cliffs).

8. Aspect

The aspect of the sample sites was noted. Use was made of a compass to indicate the direction of strike of the slopes, in degrees. In addition directions (north clockwise to north-north-west) were noted for each slope. Measurements were corrected for an 18° West of true North magnetic declination.

9. Slope inclination

The inclination of each slope (if any) was noted using a clinometer.

10. Degree of exposure

The degree of exposure to the elements was noted according to the following scale:

0	Kloof	Very sheltered
1	Flat land enclosed by higher slopes	↓
2	Open flat land	
3	Intermediate slopes	
4	High land	
5	Summit	Highly exposed

11. Degree of disturbance

The degree of disturbance (if any) was noted and included disturbance due to road construction, exotic invaders, soil erosion, overgrazing, overburning, trampling and power line construction.

Different classes of grazing and erosion were scaled according to the following.

	Grazing		Erosion
0	No recent grazing	0	No visible erosion
1	Selectively grazed	1	Sheet erosion
2	Evenly grazed	2	Donga erosion
3	Heavily grazed	3	Sheet & donga erosion

12. Soil characteristics

a). Soil depth

The depth of the soil was measured in centimetres.

b). Soil texture

The texture of the soil was also noted using the method as prescribed by the F.S.S.A. (F.S.S.A. 1980).

c). Soil form and soil series

The soil form and soil series of the soils of the quadrats were noted following MacVicar *et al.* (1977).

5.1.5 FLORISTIC COMPOSITION

For the plant species that were present the following was noted;

a). Species name or number

The species that were present in the quadrat were noted. Unknown species were collected and numbered for later identification.

It will be noted that not all species occurring in the checklist (see attached checklist of species) are to be found in the phytosociological tables. This is due to the fact that the species were not collected only at the sample sites.

b). Cover-abundance scale

Cover-abundance values for every species present were recorded using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974)

r = individual with neglegible canopy cover
\+ = less than 1% canopy cover
1 = 1% - 5% canopy cover
2a = > 5% - 12% canopy cover
2b = >12% - 25% canopy cover
3 = >25% - 50% canopy cover
4 = >50% - 75% canopy cover
5 = >75% - 100% canopy cover

In most cases the canopy cover is over-estimated. Over-estimation is more common for larger plants than is under-estimation because over-estimation is correlated with the size of individuals (Floyd & Anderson 1987).

c). Height of vegetation

The height of the vegetation was noted. Most of the vegetation in the study area consisted of grasses although there were tree communities. Grasses were categorized into the following:

short	culms $<$ 20 cm
medium	culms $\pm$ 40 cm
tall	culms $>$ 60 cm

5.2 SYNTHETIC PHASE

5.2.1 CLASSIFICATION

The procedures of classification group floristically similar relevés together, forming units that are identified by diagnostic species. Diagnostic species are species occurring predominantly in one community, or species that are restricted to one community (Greig-Smith 1964; Whittaker 1978).

Classification of the field data was accomplished by using a TWINSPAN (TWo-way INdicator SPecies ANalysis) computer program (Hill 1979b). This program is a polythetic divisive technique where the entire set of field data is examined and successively divided into smaller groups. The divisions are based on floristic data (presence and abscence of species). Both the relevés and the species are grouped into a specific order (Noy-Meir 1973; Hill 1979b; Gauch & Whittaker 1981).

TWINSPAN performs a complete classification resulting in the smallest end-groups that can be distinguished by TWINSPAN. It is also possible for the user to stipulate a cut-off point for the level of divisions to be done by TWINSPAN (Hill 1979b).

TWINSPAN classification was carried out on the field data by using the BB NEW Programme Package, available at the University of Pretoria, and developed by Botes, Bredenkamp and Bezuidenhout.(6)

Running a TWINSPAN on the raw field data produced a rough table that was divided into three major communities by means of species and relevés falling into groups. The program classified these groups by ordinating the data by means of Reciprocal Averaging according to species presence and absence (Gauch 1982). This matrix was then refined by Braun-Blanquet procedures (Behr & Bredenkamp 1989).

Because of the size of the data set these communities were analysed seperately using TWINSPAN and refined by Braun-Blanquet procedures.

The syntaxonimic nomenclature of Barkman, Moravec & Rauschert (1986) was followed to obtain the names of the vegetation units, which involves the following:

The main vegetation unit has a single name, with the single name originating from a specific diagnostic species represented by the main vegetation unit.

The plant community (secondary unit) is represented by a binary name, where the first name is derived from the main vegetation unit (wherein the secondary unit occurs) and the second name from a dominant or diagnostic species present in the secondary vegetation unit.

Further subdivision of the secondary vegetation unit is characterised by a tri-nomial name of which the first and second part is the name of secondary vegetation unit, followed by the name of the dominant or diagnostic species of that specific vegetation unit, variant or zone.

No attempt however was made to fix formal syntaxon names. This will however will be possible when a synthesis of the vegetation of the eastern highland areas is made.

(6) Prof. G.J. Bredenkamp, Department of Botany, University of Pretoria, Pretoria.

Type relevés were chosen as the most representative relevé for a community. This was done subjectively by comparing relevés from the Braun-Blanquet tables (Tables 1, 2 and 3).

5.2.2 THE BRAUN-BLANQUET METHOD

This method (Werger 1974b) is also known as the Zurich-Montpellier school of phytosociology, the product of which is a two-way matrix (table) consisting of relevé numbers representing completed sample sites (x axis), and species names (y axis). The arrangement of this table is such that a completed table can at a glance divulge all the environmental data at each site, as well as the complete floristic data for each community. This includes dominant-, exclusive-, particular-, preferential-, constant- and character species. The stucture and affiliation of all communities can also be seen from this table. Environmental gradients responsible for the different communities usually run from one side of the table to the other.

The final product of this study is presented as three such tables (Tables 1, 2 and 3).

5.2.3 ORDINATION

With the many methods that are available to researchers in phytosociology today it must be decided which one would be most usefull for the specific type of work being done. Many papers have been published comparing different methods of ordination (Williams & Lambert 1959; Werger 1973; Kent 1977; Feoli 1977b; Hill & Gauch 1980; Allen & Shugart 1983; Oksanen 1983; Theron, Morris & Van Rooyen 1984; Dargie 1986).

It was found that Principal Component Analysis (hereafter PCA) done without previous data standardization delivered results that were determined mainly by the most abundant species, while Detrended Corespondence Analysis (hereafter DCA) and Reciprocal Averaging (hereafter RA) gave more equal weight to all species (Oksanen 1983). Results of PCA matched those of RA and DCA when the species were standardized to roughly equal weights. Distortion can occur in ordinations however due to species richness (Dargie 1986), especialy in a region like the study area where there are many species per community. The species data were then standardised before ordination was carried out.

In this study, ordination was done only on the main communities produced by the TWINSPAN program plus further refinement by Braun-Blanquet procedures. This was done to investigate the plant-environment relationships within a community.

The field data was ordinated using the computer program DECORANA, (DEtrended CORrespondence ANAlysis; Hill 1979a) because of the superiority of DECORANA over other ordination techniques (Hill 1979a & Whittaker 1978). These being:

1. No relationship exist between any of the axes, since they are all formed independently (Hill 1979a; Hill & Gauch 1980; Whittaker 1987).

2. No distortion of axes occurs since the distances between stands or species, and distances along the axes correspond to differences in species composition along environmental gradients (Greig-Smith 1964; Whittaker 1978; Hill 1979a; Hill & Gauch 1980).

The procedure followed during data synthesis is as follows:

1. Species data were entered into a Raw-data file on the main-frame computer at the University of Pretoria. This data were then checked by running the programme attached to the BB NEW package to indicate any possible mistakes made while entering the data. Mistakes were corrected.

2. TWINSPAN was run to obtain a preliminary classification, resulting in three main groups.

3. Environmental data was then loaded and TWINSPAN was run again, thus incorporating floristic and environmental data. Upon examination of the

results of the TWINSPAN run, it was found that no correlation existed between the environmental parameters and their communities.

4. DECORANA was then run on the data to determine whether this program would group the relevés according to the same species that TWINSPAN did, therefore supporting the TWINSPAN, or if there existed any correlation between environmental data, species and relevés, and the DECORANA plot. The following environmental parameters were used: land type, altitude, geology, lithology and slope. DECORANA analysis did support the main divisions of three large groups but failed to correspond in any way with TWINSPAN on a more detailed level.

As the complete data set was too large to manage, it was split into three parts, corresponding to the three main divisions obtained by TWINSPAN.

These three data sets (wetlands, boulderies and grasslands) were then used for further computer analysis.

The computer programme package CANOCO (Ter Braak 1986) was then used to determine if environmental factors were coupled to plant communities.

The results of the CANOCO programme run on the floristic and environmental data of the wetlands did not reveal any of the environmental factors to be associated with any specific community or communities.