

**TITLE: An Ecological Study of the Plant Communities and Degraded Areas  
of the Highveld National Park, North West Province, South Africa**

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## PREFACE

The research described in this dissertation was carried out in the School of Environmental Sciences and Development, North West University (Potchefstroom) and in the proposed Highveld National Park (HNP), from 2005 to 2007, under the supervision of Prof. Sarel Cilliers and co-supervision of Dr. Hugo Bezuidenhout

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any other University. Where use has been made of the work of other authors it has been duly acknowledged in the text.

## **ACKNOWLEDGEMENTS**

**I would like to thank God for keeping me strong and courageous. “He brought me this far and I know he is going to take me all the way”.**

I would also like to express my deepest gratitude towards the following persons and institutions for positive contributions towards the completion of this study:

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- Mr. Abbey Legari for his help with the field work; without him this project would not have been completed.
- To my wife and kids, whose love makes my life so complete.

## ABSTRACT

The objectives of the study were to identify, classify, describe and map the plant communities in the proposed Highveld National Park, including the degraded Spitskop areas. Vegetation sampling was done by means of the Braun-Blanquet method and a total of 108 stratified random relevés were sampled. A numerical classification technique (TWINSpan) was used and the result was refined by Braun-Blanquet procedures. The final results of the classification procedure were presented in the form of phytosociological tables and twelve plant communities were described. For indirect ordination, a Detrended Correspondence Analysis (DCA) algorithm was applied to the data set to confirm the phytosociological association and to assess floristic relations between communities. For direct environmental gradient analysis the Canonical Correspondence Analysis (CCA) was applied to the data using the CANOCO software program. The plant communities were combined into six management units based on similarities regarding vegetation composition, habitat, topography and soil characteristics.

Characterization of land degradation was done by grouping erosion into different classes and different degrees of severity. Degraded areas in need of rehabilitation and restoration were identified and described. Recommendations were made with regard to rehabilitation and monitoring of all degraded areas in the HNP.

**Keywords:** Braun-Blanquet, classification, degradation, erosion, Highveld National Park (HNP), management units, ordinations, plant communities.

## OPSOMMING

Die doelwitte van hierdie studie was om die plantgemeenskappe in die voorgestelde Hoëveld Nasionale Park, insluitende die gedegradeerde Spitskopareas, te identifiseer, klassifiseer, beskryf en karteer. Plantegroeiopnames is gedoen met behulp van die Braun-Blanquetmetode en 'n totaal van 108 gestratifiseerd-ewekansige relevés is gedoen. 'n Numeriese klassifikasietegniek (TWINSPAN) is gevolg en die resultaat is deur middel van die Braun-Blanquetprosedure verfyn. Die finale resultate is in die vorm van fitososiologiese tabelle aangebied en twaalf plantgemeenskappe is beskryf. Vir indirekte ordening is 'n DCA (Detrended Correspondence Analysis) algoritme op die datastel toegepas om fitososiologiese assosiasies te bevestig en om moontlike floristiese verhoudings tussen gemeenskappe te bepaal. Vir direkte omgewingsgradiëntanalise is 'n CCA (Canonical Correspondence Analysis) algoritme met behulp van die CANOCO-rekenaarprogram op die data toegepas. Die plantgemeenskappe is op grond van ooreenkomste ten opsigte van plantegroeisamestelling, habitat, topografie en grondeienskappe in ses bestuurseenhede saamgevoeg.

Velddegradasie is gekarakteriseer deur erosie in verskillende klasse en grade van hewigheid te groepeer. Gedegradeerde gebiede wat rehabilitasie en restorasie benodig is geïdentifiseer en beskryf. Aanbevelings is ten opsigte van rehabilitasie en monitering van alle gedegradeerde gebiede in die HNP gemaak.

Sleutelwoorde: bestuurseenhede, Braun-Blanquet, degradasie, erosie, Hoëveld Nasionale Park (HNP), klassifikasie, ordenings, plantgemeenskappe

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# CHAPTER 1

## INTRODUCTION

### 1. 1 BACKGROUND

The effort to establish the proposed Highveld National Park (HNP) on the urban fringe of Potchefstroom in the North West Province resulted in an immense enthusiasm between the different stakeholders. The Potchefstroom City Council together with the South African Defence Force and the Highveld Barolong Local Community donated a core area of more than 10 000 hectares of commonage for the establishment of the HNP (Legari *et al.*, 2004). The land consolidation goals for the HNP are aiming primarily to the rationalisation of the park boundaries, the proclamation of properties incorporated but not yet proclaimed and the identification and development of opportunities to link the park to other conservation areas (Spies, 2004).

South Africa stands at the threshold of important and difficult socio-political decisions with respect to land (Hoffman & Meadows, 2002). Within conservation biology, human factors are treated as driving forces of biodiversity loss, yet there are few empirical studies on how human actions affect biodiversity (Forester & Machlis, 1996). Ecosystem conservation in southern Africa (in particular South Africa, Zimbabwe, Botswana, and Namibia) is characterised by high levels of past and present conflicts (Fabricius *et al.*, 2001). More recently, after 1990, there were many interrelated aspects to redressing land tenure inequity in the country and two of these are land restitution and land redistribution. These new policies allowed communities a better access to natural resources, called for their participation in protected area management, and facilitated the restitution of land from which they had been forcibly removed. Conservation strategies are being developed to expand the number and size of protected areas by incorporating communal lands (Fabricius *et al.*, 2001). In some cases conservation agencies were able to expand the size of the protected wildlife estate by entering into

negotiations with local residents. This has resulted in a new category of protected areas called “contractual parks”, where communal land is incorporated into game reserves so that it can be used for conservation and development purposes (Fabricius *et al.*, 2001). The Richtersveld National Park in South Africa and the more recent agreement with the Makuleke people for co-management of the northern parts of the Kruger National Park are examples of this development (Archer, 1999; Steenkamp, 1999). Although the HNP is not regarded as a contractual park, all the stakeholders (South African National Parks, Barolong Community, North West Parks & Tourism Board and Potchefstroom City Council), will constitute what is known as the “ Founding Partners” and have an agreement (Memorandum of Understanding) which regulates their respective rights and obligations within the park. This agreement also defines roles and responsibilities of different partners as well as defining the ongoing management and administration. Effective communication is seen as an essential element and attention must be given to ensure the success of this initiative.

The HNP is aimed at conserving a considerable area of the western Grassland Biome in South Africa and aesthetically it is one of the most scenic landscapes in the western Grassland Biome (Mucina & Rutherford, 2006). The HNP is situated in the Grassland Biome which will conserve the characteristic biological qualities of the Highveld and Bankenveld grasslands (Rutherford & Westfall, 1986). Land cover data (Fairbanks *et al.*, 2000) indicated that almost 30% of the Grassland Biome of South Africa has been permanently transformed, primarily as a result of cultivation (23%), plantation forestry (4%), urbanisation (2%) and mining (1%). A further 7% has been severely degraded by erosion, agricultural improvement and other factors (Mucina & Rutherford, 2006). According to the State of Environment Report, the formally protected areas in North West amount to approximately 2.44% of the Province, which falls well below the 10% of each vegetation type suggested by the Rio Convention to be set aside for officially protected areas (Mangold *et al.*, 2002). The Grassland Biome also contains 640 Red Data Species (Hilton-Taylor, 1996), excluding species categorized as ‘not

threatened', of which 136 are threatened with extinction and six are already extinct. The need to conserve the Grassland Biome cannot be overemphasized and the inventiveness towards the establishment of the HNP is therefore a positive strategy towards achieving the goal set to prevent the decline of biodiversity.

The need to address the global problem of land degradation is also increasingly urgent (Hannah *et al.*, 2002) and can no longer be ignored when undertaking vegetation studies. Barrows (1994) referred to land degradation as a reduction in rank or status of the land. Hill *et al.* (1995) defined land degradation as a process which implies a reduction of potential productivity of the land. In summary, land degradation is considered to be a collective degradation of different components of the land such as water, biotic and soil resources (Hennemann, 2001). Loss of vegetation cover and change in species composition are probably the first visible forms of degradation, although it remains difficult to separate changes in veld condition due to environmental factors (such as fluctuations in mean annual precipitation) from those due to mismanagement (Hoffman & Meadows, 2002).

An increase in the human population also has an impact on land degradation due to the increased demand on soil resources, resulting in soil degradation (Hurni, 1988; Lal, 1997; Hennemann, 2001). The area allocated for the HNP has already been altered by human use to a great extent and, according to Beckerling (1989), stock farming in the Highveld region has become increasingly important as a result of the decrease in profit made on annual maize production. This problem resulted in an inevitable increase in the number of livestock in the Highveld region. Hoffman *et al.* (1999), however, certainly highlights that many, if not all, of the changes occurring across the communal lands in particular are components of degradation expressed as, for example, human-induced reduction in productivity and loss of biodiversity.

The natural resources of the HNP are essentially characterized by two important elements, namely the landscape with its associated underlying soils and geology and the biotic communities which exist within this environment (Davies, 2003). Both of these aspects have been impacted to some degree in the past and the vegetation has been subjected to long and heavy utilization, probably from overgrazing. It was observed that the main causes of degradation contributing towards severe soil erosion in the area proposed for the HNP are overgrazing, trampling by livestock and fire (Bezuidenhout, 1993). This resulted in severe soil loss in some areas as well as to a change in species composition and vegetation structure (Davies, 2003). Land degradation requires rehabilitation and restoration as it contributes to loss of biodiversity (Wilson, 1988; Meffe & Carroll, 1994; Primack, 1994), species extinction and loss of the earth's biomass and bio-productivity (Chown *et al.*, 2003).

The terms rehabilitation and restoration are frequently used interchangeably, although incorrectly, to describe the same process and there is no common and agreed upon set of definitions for these two terms (Roe & Van Eeten, 2002). According to Rhoads *et al.* (1999), the National Research Council defines rehabilitation as 'a partial structural or functional return to the pre-disturbance state'. Callicot *et al.* (1999) defined ecological rehabilitation as the process of returning, as nearly as possible, an ecosystem to a state of health or biological integrity. Bradshaw (2002) defined ecological restoration as 'the return of an ecosystem to a close approximation of its condition prior to disturbance with ecological damage to the resource repaired and the structure and functioning self-regulating system that is integrated within the landscape in which it occurs'. The Society for Ecological Restoration (SER) gives its own definition of ecological restoration as 'the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed' (Ormerod, 2003). According to Coetzee (2005), rehabilitation emphasizes the reparation of the ecosystem process, productivity and services. It returns some of the functions of the original pre-disturbance ecosystem and the historical or pre-existing ecosystem.

Restoration shares with rehabilitation the repair of ecosystem processes, to as close to the original structure and function as possible, but differs in that it also includes the re-establishment of the pre-existing biotic species composition and community structure (Coetzee, 2005). Restoration generally requires more post-rehabilitation after-care and it takes much longer to achieve the desired result (Coetzee, 2005).

Biodiversity loss is largely viewed as a function of human action (Soulé, 1991; World Resource Institute, 1992) and case studies are often used as subjective evidence (Dale *et al.*, 1994; Kattan *et al.*, 1994; Downing *et al.*, 1990). Specific human activities such as agricultural practices, deforestation *etc.*, which may influence biodiversity loss, have been empirically examined and found to be crucial (Rudel, 1989; Koopowitz *et al.*, 1994). These potential driving forces of land degradation and ultimately biodiversity loss include human population growth (Meffe *et al.*, 1993; Meffe & Carroll, 1994), habitat loss, habitat fragmentation, introduced species and diseases, population, and climate change (Soulé, 1991). In order to achieve biodiversity objectives, it is therefore important to conserve elements such as vegetation and soil as their loss enhances erosion and reduces the productive value of the land (Hoffman & Todd, 2000; O'Brien, 2004). An understanding of the existence of specific plant communities and their associated habitats is of fundamental importance for compiling sound management and conservation strategies (Cleaver *et al.*, 2005). The description of plant communities and mapping of both vegetation and degraded areas will serve as the basis for formulating the management plan for the HNP.

## **1.2 AIMS OF THE STUDY**

The aims of this study are:

- To obtain data on the floristic composition and structure of the plant communities in the HNP.
- To classify, describe and map the plant communities in the HNP including the degraded areas around Spitskop.
- To identify the soil erosion types in the Spitskop area and their extent of severity.
- To provide recommendations towards effective future management of the HNP based on specific management units.

## **1.3 CONTENT OF THIS THESIS**

The thesis consists of eight chapters including this introductory chapter. In Chapter 2, an overview of the materials and methods is given with particular reference to the study area; history of the park; climate; geology; land types and soil; vegetation; and cultural, historical and archeological resources. The description of the scientific methods employed in the execution of this study is also discussed in this chapter.

In Chapters 3 and 4, the classification and description of the vegetation of the HNP and Spitskop degraded areas are given. Chapter 5 deals with the soil erosion and other factors such as fire, overgrazing and wood harvesting contributing to degradation in the Spitskop area. Chapter 6 entails the identification and description of management units in the HNP. The management recommendations for the HNP with regard to soil erosion control, eradication of exotic species, fire regime and monitoring of degraded areas are provided in Chapter 7. Chapter 8 provides the concluding remarks concerning the study as a whole.

## **CHAPTER 2**

### **MATERIALS AND METHODS**

#### **2.1 STUDY AREA**

##### **2.1.1 Proposed area**

The study area is situated between latitudes 26° 32' E – 26° 51' S and 26° 51' E – 27° 08' S west of Potchefstroom (Figure 1). The area for park development lies between the N12 running from Potchefstroom to Klerksdorp, Ikageng, Promosa and the Eleazer road. The core area of the park occupies approximately 10 200 hectares, and consists of the Potchefstroom local authority land (5 500 ha), the farm Modderfontein belonging to the Defence Force (2 700 ha), the farm Nooitverwacht (1 500 ha) and a farm belonging to the Agricultural college (500 ha).

##### **2.1.2 Historical overview**

The proposal for the development of the HNP dates back from as early as 1984, when the Department of Agriculture decided to inspect the campsites of the townlands of the surrounding area of Potchefstroom with the aim to rent it (Visser, 2005). During this stage it became clear that the value of the HNP grassland was by far higher than the mere agricultural value and the thought of establishing the park was brought into perspective. During 1990 the Department of Agriculture started an initiative to investigate the possibility of the conservation of grassland as well as the development of a national park in Potchefstroom (Visser, 2005). Due to the fact that the land belonged to the municipality the challenge was to convince the local municipality of the importance of the conservation of the grassland in order for them to donate the land to the National Parks Board. During this period of negotiations, a working committee was

established to gather information and to negotiate with the municipality with regards to the development of the HNP (Visser, 2005). The development of the HNP was approved by the National Parks Board (now known as SANParks) in 1992. However, due to pending land claim issues from the Barolong community, the process of the development of the HNP was put on hold, but it was revived again during 1996 and eventually led to the launching of the HNP in February 1997.

The park warden was appointed in 1996 and the Minister of Environmental Affairs and Tourism formally approved the project for the development of the HNP in August 1997. At this stage, which is known as the second phase in the development of the HNP, the City Council of Potchefstroom donated some 5500 ha for the park, while negotiations to acquire a further 2700 ha (Modderfontein) from the South African National Defence Force (SANDF) was well advanced. During 1997, the South African Parks Trust purchased a nearby farm, Nooitverwacht. This opened a corridor to privately owned land to the west which was needed for viable park development. Plans were also completed to fence the land and introduce game (Visser, 2005).

Due to the Barolong's determination of pursuing their land claims at all cost in 1997 and 1998, the SANDF withdrew from the project on 19 June 1998. A written promise was made to the City Council that, if the current problems are resolved, SANParks could again consider the opinion in future. This was a major blow to tourism development in Potchefstroom, because of the loss of a great opportunity (Visser, 2005). The third phase of the development of the HNP started again during July 2001 with the consent of SANParks to investigate the renaissance of the HNP. One of the recommendations during the third phase was to ensure that the land claim issue has been laid to rest. At a special meeting in Potchefstroom on 6 August 2002, all parties (including the Barolong and SANDF) were in full agreement that the HNP was a hidden treasure which

could be a first national park for the North West Province and must therefore be re-instituted (Visser, 2005).

The Barolong seemed to be very positive about the development of the HNP, as it holds many benefits for them. The development of visitor facilities in the HNP will be undertaken primarily through partnership with the Barolong community, private sector developers and Small Medium and Micro Enterprises (SMMEs) (Davies, 2003). The land of the Barolong that will be incorporated into the park will be utilized as a community conservation area, where a community lodge will be developed in the park (Visser, 2005). It was stated that, in 2004, SANParks and the North West Parks and Tourism Board were negotiating with the SANDF and private landowners to incorporate their land into the park. It was generally accepted that the development would commence in 2005.

### **2.1.3 Climate**

The area experiences a cool dry steppe climate with summer rainfall (Van der Walt & Bezuidenhout, 1996). The rainfall is erratic and varies from an average of 600 mm per annum to exceptional occurrences of more than 900 mm per annum (Figure 2). The area is characterised by great seasonal and daily variation in temperature, being very hot in summer (daily average temperatures may exceed 32°C in January) and mild to cold in winter with average minimum monthly temperatures of up to -12°C (ISCW, 2003). Hail occurs sporadically in summer, with the southeast part of the province receiving 3–5 hailstorms per year and the rest of the province approximately 1-3 per year (Mangold *et al.*, 2002).

Relative humidity is also typically low throughout the province, being below 28% in the northern part of the province in July and between 28 – 30% for the central and eastern regions (Mangold *et al.*, 2002). No long-term data is available for wind speed and dominant wind direction for the North West Province, although, the predominant wind direction is from a northerly direction (Mangold *et al.*,

2002). There is a trend that August to November are the windy months (Mangold *et al.*, 2002).

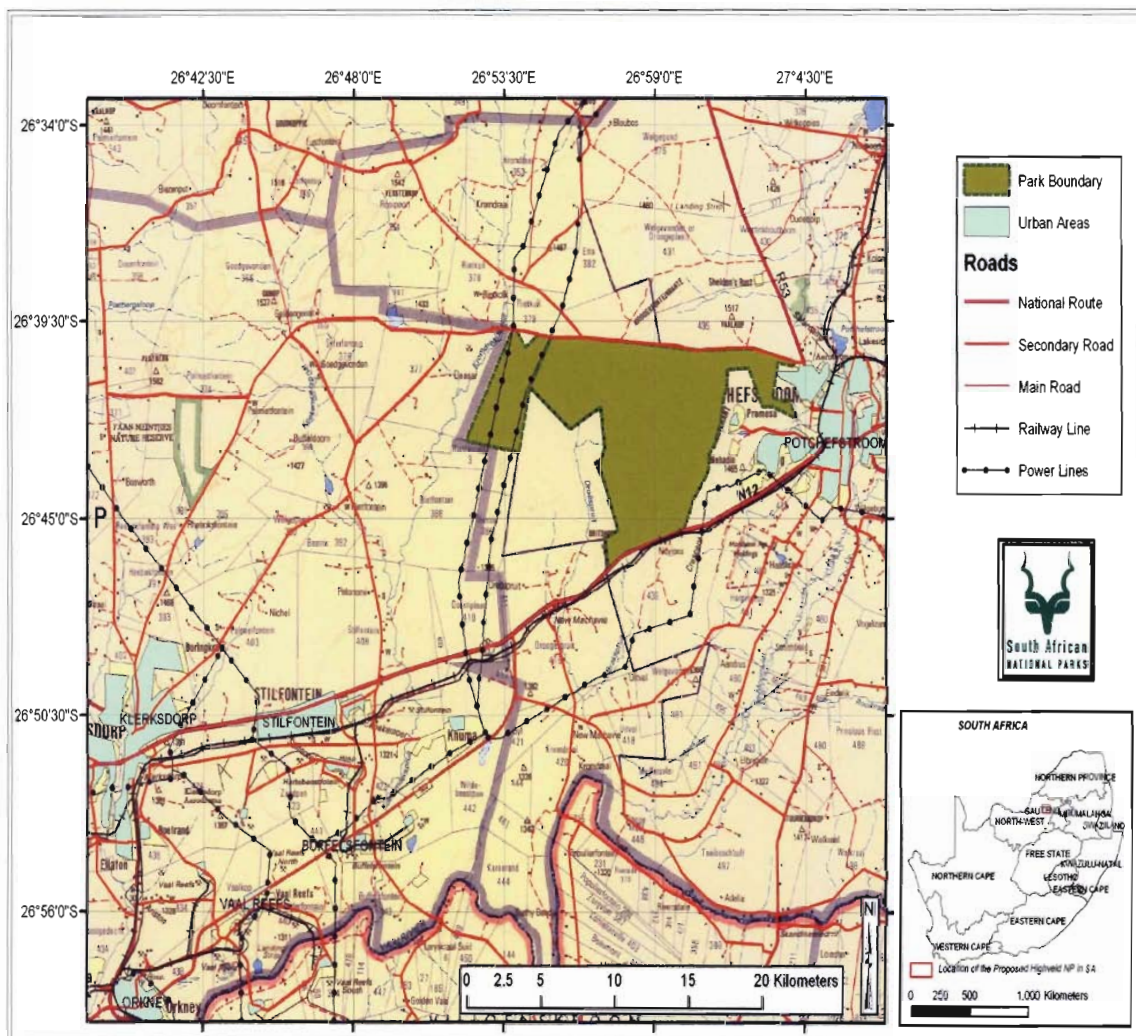


Figure1. Location of Potchefstroom, North West Province, South Africa, showing the Highveld National Park.

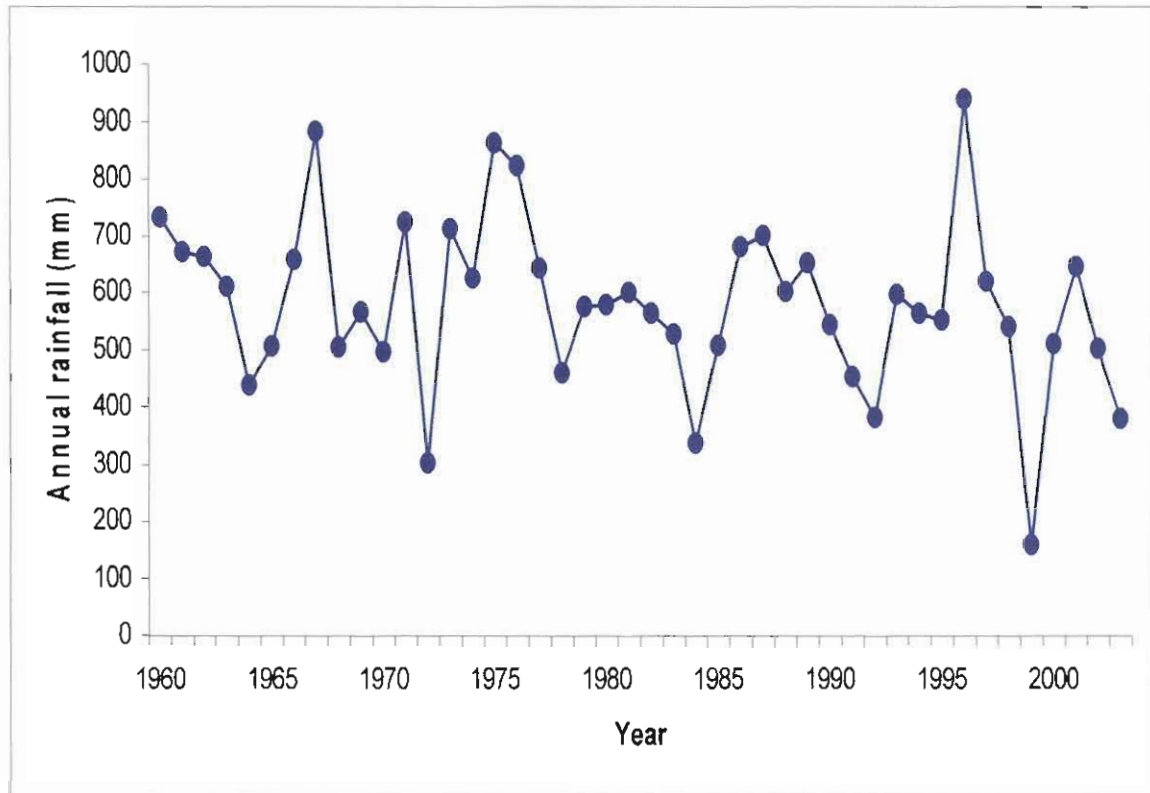


Figure 2. The average annual rainfall (mm) for the area allocated for the Highveld National Park.

#### 2.1.4 Geology

The geology of the area is diverse and the core area is mainly represented by the Transvaal Sequence. Three groups based on lithological differences have been established under the Transvaal Sequence (Bezuidenhout, 1993), of which the Chuniespoort Group forms part of the study area. The dolomite of the Chuniespoort Group (Malmani Subgroup) is found in the study area representing the Fa-land type and continues to the south-west to Stilfontein and Orkney (Bezuidenhout, 1993; Truswell, 1977). Rocky outcrops of dolomite and chert are abundantly present (Bezuidenhout, 1993; Holness, 2003) and characterized by the presence of sinkholes (Von Backström *et al*, 1953). The flat or undulating plains of the dolomites are dissected by prominent chert ridges (Bezuidenhout, 1993).

### 2.1.5 Land types and soil

A land type denotes an area that can be shown at 1:250 000 scale and that displays a marked degree of uniformity with respect to terrain form, soil pattern and climate (Land Type Survey Staff, 1984). Researchers such as Bredekamp & Theron (1978), Bredekamp *et al.* (1983), Bezuidenhout *et al.* (1988), Cilliers (1998) and others have established that geology; soil and climate are important environmental factors which correlate well with plant communities of South African grasslands. Land types therefore played an important role in the stratification of study areas in a number of major studies in the Grassland Biome (Bezuidenhout, 1993).

Four land types occur in the HNP, namely the Ba-, Bc-, Fa- and Fb-land types (Bezuidenhout, 1993). The soil forms as well as technical terms used are according to MacVicar *et al.* (1977). The Ba-land type is characterized by red and/or yellow apedal soils. Dystrophic and/or mesotrophic soils predominate over red and/or yellow apedal soils that are eutrophic and in which red soils occupy more than a third of the area (Land Type Survey Staff, 1984). The dominant soil form in the Ba-land type is Hutton. The Bc-land type is dominated by both Hutton and Mispah soil forms (21 % of the land type). The dominant soil forms in the Fa-land type are Glenrosa and Mispah (50 % of the land type), while the Hutton soil form (39 % of the land type) is also present. The Fb-land type indicates land where lime occurs regularly (in small quantities) in one or more valley bottom soils. The dominant soil forms in the Fb-land type are Glenrosa (25 % of the land type) and Mispah (24 % of the land type) with rocks (20 % of the land type) also prominent in this land type (Bezuidenhout, 1993).

### 2.1.6 Vegetation

The North West Province encloses two major biomes, viz. the Grassland and the Savanna Biome (Mangold *et al.*, 2002; Mucina & Rutherford, 2006). Louw (1951) and Acocks (1953) have done a broad vegetation description of the area in which the HNP is situated. Detailed vegetation studies of the western Transvaal grassland, including the area allocated to HNP, were also undertaken by Bezuidenhout & Bredenkamp (1990, 1991), Bredenkamp *et al.* (1989) and Bezuidenhout *et al.* (1994a, b, c, e). The Barikenveld vegetation type (Veld type 61) which Acocks (1953) described as a false grassveld type is dominant in the HNP. The climax of this veld type is open *Acacia karroo* woodland. Low & Rebelo (1996) classified this area under the Dry Sandy Highveld Grassland (Veldtype 37). Only 0.29% of the Dry Sandy Highveld Grassland is currently being conserved (Bredenkamp & Van Rooyen, 1996). The conservation status of this vegetation type is very poor. Ploughing for cultivation of maize and overgrazing by cattle and sheep have resulted in very few remnants of this vegetation type (Bezuidenhout *et al.*, 1994c).

*Acacia karroo* woodland, as well as several grassland communities, occurs on the plains, while *Acacia caffra* woodland occurs on the rocky outcrops and hills (Bezuidenhout *et al.*, 1994a). The vegetation of the Fb-land type in the HNP is relatively undisturbed and is well worth conserving, especially as it is highly threatened by mining and industrial activities elsewhere. The Ba-land type vegetation corresponds with the poorly conserved Dry Sandy Highveld Grassland (Bezuidenhout *et al.*, 1994e, Bredenkamp & Van Rooyen, 1996b). The vegetation of the Ba- and Bc-land types (Bezuidenhout & Bredenkamp, 1991) are under severe pressure from agriculture. The Fa-land type consists of dolomitic and chert grassland with shallow rocky soils. The floristic and habitat diversity of the Fa-land type, especially the *Rhus lancea* – *Acacia erioloba* community has a high conservation status (Bezuidenhout *et al.*, 1994b).

The vegetation classification by Mucina & Rutherford (2006) classified the study area within the Grassland and Savanna Biomes. The Grassland Biome is represented by the Dry Highveld Grassland Bioregion Unit of which the study area is represented by Vaal Reefs Dolomite Sinkhole Woodland (Gh 12), Rand Highveld Grassland (Gm 11), Klerksdorp Thornveld (Gh 13), and Carletonville Dolomite Grassland (Gh 15). The conservation status of the Rand Highveld Grassland is endangered and whilst the conservation target is 24%, only 1% is statutorily conserved. This vegetation unit has been transformed mostly by cultivation, plantations, urbanisation or dam-building. The conservation status of the Klerksdorp Thornveld (Gh 13) is vulnerable and only about 2.5% statutorily conserved. Almost a third is already transformed by cultivation and urban sprawl (Mucina & Rutherford, 2006). This vegetation unit has a high grazing capacity which leads to overutilization and degradation, and subsequent invasion of *Acacia karroo* into adjacent dry grassland. Due to the great habitat and floristic diversity and for aesthetical reasons, the landscape deserves to be conserved (Mucina & Rutherford, 2006). The conservation status of the Carletonville Dolomite Grassland (Gh 15) is vulnerable and whilst the conservation target is 24%, only a small extent is currently protected and 23% is considered to be transformed, mostly by cultivation (17%), urbanization (4%), forestry (1%) and mining (1%) (Mucina & Rutherford, 2006).

The Savanna Biome is represented by the Central Bushveld Bioregion Unit of which the study area is represented by Andesite Mountain Bushveld (SVcb 11) (Mucina & Rutherford, 2006). According to Mucina & Rutherford (2006), the proposed HNP is supposed to conserve a considerable area of the Vaal Reefs Dolomite Sinkhole Woodland vegetation unit (Gh 12). The conservation status of the Vaal Reefs Dolomite Sinkhole Woodland vegetation unit (Gh 12) is vulnerable and whilst the conservation target is 24%, only a small patch is conserved in the statutory conservation area of the Sterkfontein Caves (Mucina & Rutherford, 2006). Almost a quarter of this vegetation unit is already transformed, mainly by mining, cultivation, urban sprawl and road-building.

## **2.1.7 Cultural, Historical and Archaeological Resources**

There is no direct evidence of any cultural, historical or archaeological resources within the HNP (Davies, 2003). However, these issues must always be considered when planning any new developments. They must form an integral part of any Environmental Impact Assessment which is undertaken for setting out any new infrastructure, as well as when removing old infrastructure if appropriate (Davies, 2003)

## **2.2 METHODOLOGY**

### **2.2.1 Vegetation Sampling**

Vegetation sampling was firstly undertaken for the entire park consisting of 88 stratified, random, 900 m<sup>2</sup> (30 m x 30 m) sample plots in accordance to Bredenkamp & Bezuidenhout (1993). Stratification was done on 1: 50 000 scale aerial orthophotographs, on the basis of relatively homogeneous physiographic and physiognomic units (Bezuidenhout, 1993). Secondly, vegetation sampling was undertaken in the Spitskop area, consisting of 20 stratified, 900 m<sup>2</sup> sample plots located in the degraded areas. Stratification was done on 1:50 000 enlarged (x10) aerial orthophotographs of the Spitskop area. The approach of Bezuidenhout (1993) for further stratification was followed, namely recognition of the terrain types with topographical positions such as crest, scarp, midslope, footslope, valley bottomlands and floodplains.

Plant species were identified in each plot during the time of sampling and the cover abundance of each species was visually estimated using the Braun-Blanquet scale (Mueller-Dombois & Ellenberg, 1974) (Table1). Plant species names were used according to Germishuizen & Meyer (2003). Exotic species are indicated by an asterisk in the phytosociological tables. Additionally, average height and canopy cover of tree, shrub and herbaceous strata were estimated.

The structural vegetation classification system for this study followed that of Edwards (1983). Environmental data included identification of soil type, slope (where applicable) and rockiness of the soil surface. The soil depth was determined by using the soil auger and the soil forms were identified. The soil clay content was determined by the 'feel-ribbon method' (Foth *et al.*, 1978) and was expressed as a percentage. An estimation of the rockiness of the soil surface was expressed in percentage rocks or stones covering the total sample plot.

### **2.2.2 Vegetation data processing**

The TWINSpan classification algorithm (Hill, 1979a), which is regarded as a very successful approach by many phytosociologists all over the world (Mucina & Van der Maarel, 1989; Bredenkamp & Bezuidenhout, 1995; Cilliers, 1998) was used as a first analysis for the floristic data. The TWINSpan classification was then refined further by application of Braun-Blanquet procedures by means of the BBPC-program (Bezuidenhout *et al.* 1996). For indirect ordination, a Detrended Correspondence Analysis (DCA) algorithm (Hill 1979) was applied to the data set to confirm the phytosociological association and to assess floristic relations between communities. For direct environmental gradient analysis, the Canonical Correspondence Analysis (CCA) was applied using the CANOCO software program (Ter Braak, 1986). Descriptive terms such as differential species, dominant species and co-dominant species were used according to Kent & Coker (1992).

**Table 1. Braun-Blanquet cover-abundance scale used for species in phytosociological studies (Mueller-Dombois & Ellenberg, 1974)**

| <b>Cover values</b> | <b>Description</b>  |
|---------------------|---|
| <i>r</i>            | One or few individuals with less than 1% cover of the total sample plot area                                |
| <b>+</b>            | Occasional and less than 1% cover of the total sample plot area   |
| <b>1</b>            | Abundant with low cover, or less abundant but with higher cover, 1 – 5% cover of the total sample plot area |
| <b>2</b>            | Abundant with >5 – 25% cover of the total sample plot area, irrespective of the number of individuals       |
| <b>2a</b>           | >5 – 12.5% cover  |
| <b>2b</b>           | >12.5 – 25% cover   |
| <b>3</b>            | >25 – 50% cover of the total sample plot area, irrespective of the number of individuals                    |
| <b>4</b>            | >50 – 75% cover of the total sample plot area, irrespective of the number of individuals                    |
| <b>5</b>            | >75% cover of the total sample plot area, irrespective of the number of individuals                         |

### **2.2.3 Characterization of degraded areas**

Characterization of the degradation in Spitskop followed that of Torrion (2002) and this method was modified in the present study when measuring sheet erosion (Table 2). Sheet erosion mostly occurs on the non-gradual slopes and it is therefore very difficult to measure the amount of topsoil removed (Macdonald *et al.*, 1990; Coetzee, 2005).

The description of soil erosion forms follows that of Macdonald *et al.* (1990).

- Sheet erosion: is the progressive removal of topsoil across extensive areas by wind and water. This is not always easy to detect with certainty and may need to be inferred from other soil surface features, such as eroded material or surface nature. When at an advanced stage, many sheeted surfaces are covered by layers of gravel or stone left behind after the erosion of finer material.
- Rill erosion: terrain deformation as a result of surface runoff forming shallow, well-defined channels (less than 30 cm deep)
- Gully erosion: terrain deformation as a result of surface runoff forming deeper, well-defined channels (more than 30 cm deep).

Expanded upon the Torrion (2002) classification, 'compacted soil' was added to the degradation classes (Table 2). These areas are often overgrazed which resulted in an advanced stage of degradation indicated by large areas of bare, compacted soil (Bredenkamp *et al.*, 1988; Bezuidenhout, 1993).

**Table 2: Field attributes describing soil degradation classes and the extent of severity in the Highveld National Park (modified from Torrion, 2002).**

| Sub type            | Class          | Sub class<br>(Torrion)   | Subclass<br>(Modified)  | Severity                             |
|---------------------|----------------|--|---|--------------------------------------|
| Loss of Topsoil     | Sheet Erosion  | Loss of topsoil <5 cm<br>Loss of topsoil 5-15 cm<br>Loss of topsoil 15-25 cm<br>Loss of topsoil > 25 cm                                | Bare soil 0 – 25 %<br>Bare soil 25 – 50 %<br>Bare soil 50 – 75 %<br>Bare soil > 75% | Slight<br>Moderate<br>High<br>Severe |
| Terrain deformation | Rill Erosion   | Shallow rills <3 cm<br>Incision rills occurring on steep slopes <10 cm<br>Wider braided rills 10-15 cm<br>Wider braided rills 15-20 cm |   | Slight<br>Moderate<br>High<br>Severe |
|                     | Gully          | Shallow gully 30 cm-1 m<br>Deep gully 1-5 m<br>Very deep gully >5 m<br>Extremely deep >30 m  |   | Slight<br>Moderate<br>High<br>Severe |
| Trampling           | Compacted Soil |  | Bare soil 0 – 25 %<br>Bare soil 25 – 50 %<br>Bare soil 50 – 75 %<br>Bare soil > 75% | Slight<br>Moderate<br>High<br>Severe |

## CHAPTER 3

### CLASSIFICATION AND DESCRIPTION OF THE VEGETATION OF THE HNP

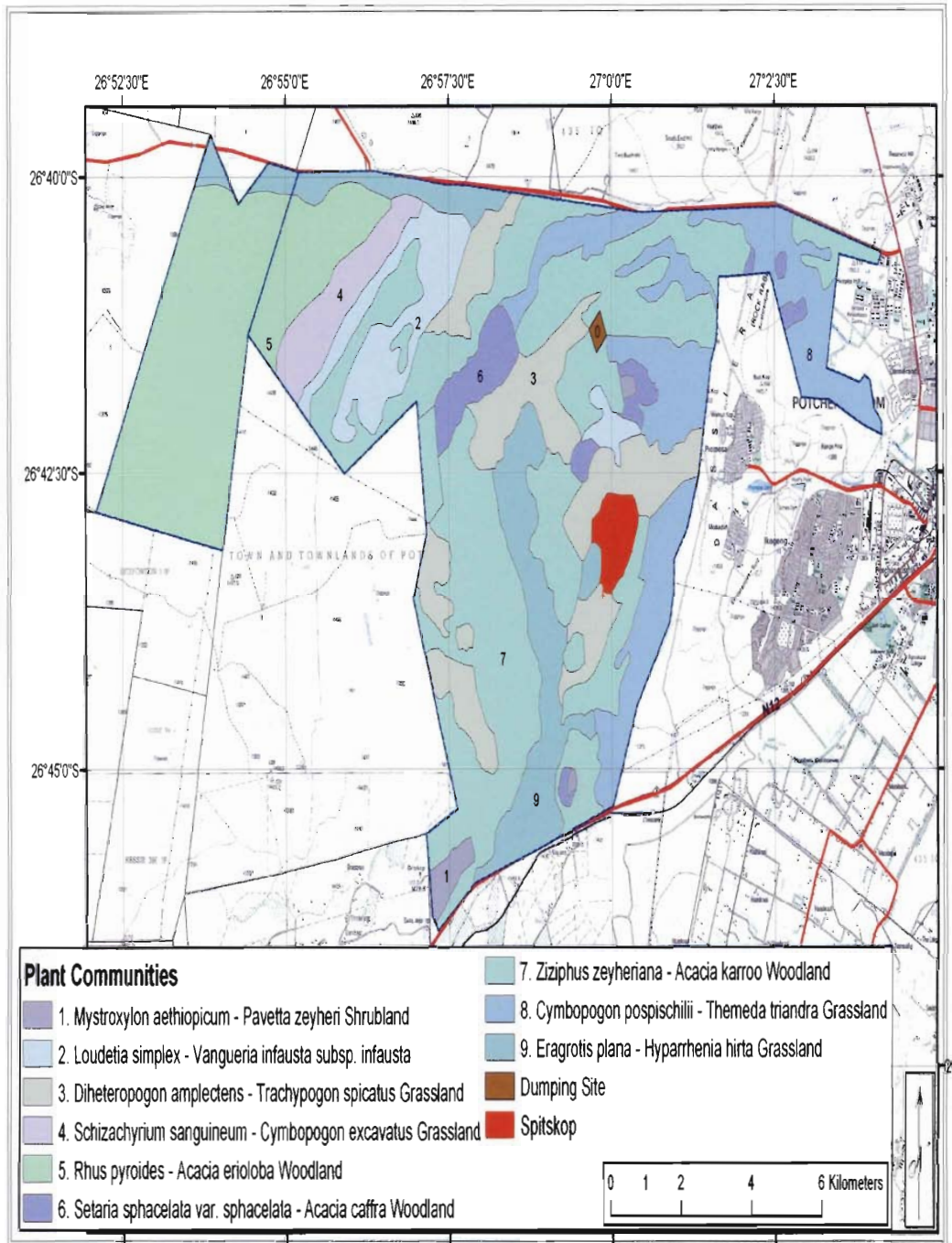
#### 3.1 INTRODUCTION

The aim of this chapter was to classify, describe and map the plant communities occurring in the HNP. The floristic composition of the different plant communities was also obtained. The geology of the area, soil forms, terrain units, and rockiness of the surface area was used when describing the plant communities. The percentages of exotic species in different communities were also indicated to show their extent of invasion and the need for management intervention. A comparison (where applicable) was also made between the plant communities found in the HNP and communities previously described by other researchers in the former western Transvaal grassland.

#### 3.2 CLASSIFICATION

The vegetation analyses are given in a phytosociological table (Table 3) and resulted in the formulation of a vegetation map (Figure 3) and the recognition of nine major plant communities. The non-hierarchical classification of these communities is as follows:

1. *Mystroxydon aethiopicum* - *Pavetta zeyheri* Shrubland
2. *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland
3. *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland
4. *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland
5. *Rhus pyroides* - *Acacia erioloba* Woodland
6. *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland
7. *Ziziphus zeyheriana* - *Acacia karroo* Woodland
8. *Cymbopogon pospischilii* - *Themeda triandra* Grassland
9. *Setaria incrassata* – *Hyparrhenia hirta* Grassland



**Figure 3. Vegetation map of the Highveld National Park.**

### 3.3 BRIEF DESCRIPTION OF PLANT COMMUNITIES

1. The *Mystroxydon aethiopicum* - *Pavetta zeyheri* Shrubland was mainly limited to the plateaus of the rocky quartzite hills and ridges.
2. The *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland was associated with the midslopes of the rocky chert outcrops and quartzite ridges.
3. The *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland occurred on stony plains and midslopes of quartzite hills.
4. The *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland was associated with the midslopes of the shallow rocky soils of the chert outcrops.
5. The *Rhus pyroides* - *Acacia erioloba* Woodland was limited to the valley bottomlands of the chert and dolomitic areas.
6. The *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland was associated with the midslopes of the rocky outcrops and quartzite hills.
7. The *Ziziphus zeyheriana* - *Acacia karroo* Woodland occurred on the footslopes of the quartzite hills, valley bottomlands and along the drainage lines.
8. The *Cymbopogon pospischilii* - *Themeda triandra* Grassland was associated with the midslopes of the rocky outcrops.
9. The *Setaria incrassata* - *Hyparrhenia hirta* Grassland was restricted to the bottomlands and floodplains in or along drainage lines.

### 3.4 DETAILED DESCRIPTION OF PLANT COMMUNITIES

#### 1. *Mystroxydon aethiopicum* - *Pavetta zeyheri* Shrubland

This community was mainly limited to the plateaus of the rocky quartzite hill and ridges of the Bc- and Fb- land types. The soil surface was relatively rocky (> 10%) and the soil forms consisted of Mispah, Glenrosa and Hutton. The soil was relatively shallow (< 0.2 m) with a relatively low clay content (< 10%).

The differential species of this community were those of species group A (Table 3). They included mainly indigenous species such as the shrubs *Pavetta zeyheri*, *Mystroxyton aethiopicum*, *Grewia occidentalis*, *Vangueria parvifolia*, the indigenous trees *Pappea capensis*, *Olea europaea* subsp. *africana* and the grass *Panicum maximum*. Other species in this community included *Vangueria infausta* subsp. *infausta* (species group C, Table 3), *Zanthoxylum capense* (species group C, Table 3) and *Rhus magalismsontana* (species group C, Table 3) forming the major component of the shrub stratum (canopy cover of 38% and up to 2.6 m tall). The indigenous fern, *Pellaea calomelanos* var. *calomelanos* (species group C, Table 3), the tree, *Acacia caffra* (species group N, Table 3), the herbaceous climber *Clematis brachiata* (species group N, Table 3) and the indigenous *Aloe greatheadii* var. *davyana* (species group N, Table 3) were also found in this community. Species of general occurrence were found in species group U (Table 3) and included two grasses, *Themeda triandra* and *Elionurus muticus*. The average height of the tree stratum was 5.3 m with a canopy cover of 19% (Table 4). The average height of the herbaceous stratum was 0.9 m and with a canopy cover of 41% (Table 4). An average number of 33 species was recorded per sample plot of which 1.2% was exotic species. Exotic plants included species such as *Gomphrena celosioides* and *Opuntia ficus-indica* (species group V, Table 3).

















**Table 4. Average height and cover values of the trees, shrubs and herbaceous layers of the different plant communities in the Highveld National Park.**

| <b>Community</b>   | <b>Stratum</b>            |                          |                           |                          |                           |                          |
|--|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|
|  | <b>Trees</b>              |                          | <b>Shrubs</b>             |                          | <b>Herbaceous</b>         |                          |
|  | <b>Average height (m)</b> | <b>Average Cover (%)</b> | <b>Average height (m)</b> | <b>Average Cover (%)</b> | <b>Average height (m)</b> | <b>Average Cover (%)</b> |
| 1. <i>Mystroxydon aethiopicum</i> – <i>Pavetta zeyheri</i><br>Shrubland                    | 5.3                       | 19.0                     | 2.6                       | 38.0                     | 0.9                       | 41.0                     |
| 2. <i>Loudetia simplex</i> – <i>Vangueria infausta</i> subsp. <i>infausta</i><br>Shrubland | 4.6                       | 6.8                      | 1.5                       | 12.9                     | 0.8                       | 53.6                     |
| 3. <i>Diheteropogon amplexans</i> – <i>Trachypogon spicatus</i><br>Grassland               | 4.6                       | 3.8                      | 1.5                       | 9.0                      | 0.9                       | 65.0                     |
| 4. <i>Schizachyrium sanguineum</i> – <i>Cymbopogon excavatus</i><br>Grassland              | 6.8                       | 1.5                      | 3.0                       | 17.3                     | 0.7                       | 66.3                     |
| 5. <i>Rhus pyroides</i> – <i>Acacia erioloba</i><br>Woodland                               | 5.7                       | 4.8                      | 2.8                       | 15.6                     | 0.8                       | 67.0                     |
| 6. <i>Setaria sphacelata</i> var. <i>sphacelata</i> – <i>Acacia caffra</i><br>Woodland     | 5.0                       | 11.2                     | 1.9                       | 17.9                     | 0.9                       | 61.7                     |
| 7. <i>Ziziphus zeyheriana</i> – <i>Acacia karroo</i><br>Woodland                           | 4.5                       | 17.2                     | 1.8                       | 21.9                     | 0.9                       | 66.5                     |
| 8. <i>Cymbopogon pospischillii</i> – <i>Themeda triandra</i><br>Grassland                  | 5.4                       | 9.8                      | 1.2                       | 8.2                      | 0.9                       | 77.0                     |
| 9. <i>Setaria incrassata</i> – <i>Hyparrhenia hirta</i><br>Grassland                       | 3.0                       | 6.0                      | 0.8                       | 1.3                      | 0.9                       | 69.0                     |

## **2. *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland**

This community was associated with the midslopes of the rocky chert outcrops of the Fa-land type and quartzite ridges of the Fb-land type. The Mispah soil form was associated with the rocky chert outcrops, whereas the Glenrosa soil form was associated with the quartzite ridges. The soil in this community was relatively shallow (< 0.2%) with relatively low clay content (< 10%) and more than 10% surface rocks.

The differential species of this community were found in species group B (Table 3). These included indigenous species such as the grass *Loudetia simplex*, the shrub *Mundulea sericea* and the forb *Helichrysum kraussii*. The dominating shrubs in this community included species such as *Vangueria infausta* subsp. *infausta* (species group C, Table 3) and other conspicuous species such as *Zanthoxylum capense* and *Rhus magalismontana* (species group C, Table 3) forming the shrub component of this community (average canopy cover of 12.9% and average height of 1.5 m, Table 4). The average height of the tree stratum was 4.6 m and the average canopy cover was 6.8% with *Acacia caffra* (species group N, table 3) forming the major tree component of this community. The average canopy cover of the herbaceous stratum was quite high with 53.6% and an average height of 0.8 m (Table 4). Species forming the herbaceous layer included grasses such as *Trachypogon spicatus*, *Andropogon schirensis* (species group E, Table 3), *Schizachyrium sanguineum*, *Brachiaria serrata*, *Diheteropogon amplexans*, *Eragrostis racemosa*, *Melinis nerviglumis*, *Aristida meridionalis* (species group F, Table 3), *Setaria sphacelata* var. *sphacelata*, *Eragrostis curvula* (species group T, Table 3), the forb *Senecio venosus* (species group E, Table 3) and the succulent *Aloe greatheadii* var. *davyana* (species group N, Table 3). An average number of 34 species was recorded per sample plot of which 1.6% was exotic species. Exotic plants included species such as *Tagetes minuta* (Species Group L, Table 3), *Verbena officinalis* (Species Group

S, Table 3), *Conyza bonariensis*, *Achyranthes aspera* and *Nicotiana longiflora* (Species Group V, Table 3).

Cilliers *et al.* (1999) described a closely related community (*Vangueria infausta* subsp. *infausta* – *Rhus pyroides* Shrubland) sharing a similar habitat with *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland. A similar community, the *Vangueria infausta* subsp. *infausta* – *Acacia caffra* Woodland was described for the Bc-land type by Bezuidenhout & Bredenkamp (1991). Although the habitats were quite similar in the communities described, the dominance of the grass *Loudetia simplex* in the *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland currently described was one of the major differences between this and other previously described communities (Bezuidenhout & Bredenkamp, 1991; Cilliers *et al.*, 1999).

### **3. *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland**

The *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland occurred mostly on the stony plains and midslopes of quartzite hills of the Bc- and Fb-land types. The soil was relatively shallow (< 0.2 m) and consisted of the Hutton, Mispah and Glenrosa soil forms with relatively rocky surfaces (> 10%).

The species of species group D (Table 3) were the differential species of this community. These species included the grass *Brachiaria nigropedata*, the forbs *Helichrysum nudifolium* var. *nudifolium* and *Chascanum adenostachyum* and the succulent *Aloe zebrina*. The dominant grass species in this community were *Diheteropogon amplexans* (species group F, Table 3) and *Trachypogon spicatus* (species group E, Table 3). These species are typically characteristic for the relatively dry habitats with shallow rocky soils (Bezuidenhout *et al.*, 1994d). Other dominant grass species occurring in this community included *Cymbopogon excavatus*, *Schizachyrium sanguineum*, *Brachiaria serrata*, *Eragrostis racemosa*, *Melinis nerviglumis* (species group F, Table 3) and *Heteropogon contortus*

(species group Q, Table 3). The forbs included species such as *Senecio venosus*, *Gnidia capitata* (species group E, Table 3), *Dicoma anomala* (species group F, Table 3), *Aloe greatheadii* var. *davyana* (species group N, Table 3), *Teucrium trifidum* (species group Q, Table 3) and *Vernonia oligocephala* (species group T, Table 3). The average height of the herbaceous stratum was 0.9 m and the canopy cover was quite high with 65%. The average height of the tree stratum was 4.6 m with a canopy cover of 3.8% and *Acacia caffra* (species group N, Table 3) formed the main component of this stratum. The average height of the shrub stratum was 1.5 m with a canopy cover of 9.0% and consisted of species such as *Acalypha angustata*, *Elephantorrhiza elephantina* (species group F, Table 3) and *Ziziphus zeyheriana* (species Group Q, Table 3). An average number of 33 species was recorded per sample plot of which 0.2% was exotic species. *Conyza bonariensis* (species group V, Table 3) was the exotic species found in this community.

A similar community, the *Diheteropogon amplexens* - *Trachypogon spicatus* Grassland from the dolomitic region in the Potchefstroom – Ventersdorp – Randfontein area (Bezuidenhout & Bredenkamp, 1990) was previously described. Other closely related communities described include the *Diheteropogon amplexens* – *Schizachyrium sanguineum* Grassland from the Fb-land type (Bezuidenhout *et al.*, 1994b) and the *Schizachyrium sanguineum* - *Diheteropogon amplexens* Grassland in the Lichtenburg area (Bezuidenhout *et al.*, 1994d). Cilliers *et al.* (1999) also described a closely related community (*Diheteropogon amplexens* – *Schizachyrium sanguineum* Grassland) of the natural and semi-natural areas in the municipal area of Potchefstroom.

#### **4. *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland**

This *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland community was associated with the midslopes of the relatively shallow rocky soils of the chert outcrops in the Fa-land type. Mispah and Glenrosa soil forms were

dominant in this community. The ground surface was relatively rocky (> 10%) with relatively shallow soil (< 0.2 m).

No differential species were identified in this community but it was characterized by the absence of the species of species groups A and C (Table 3). The dominant species were the grasses *Schizachyrium sanguineum* and *Cymbopogon excavatus* (species group F, Table 3). Other species such as the grasses *Brachiaria serrata*, *Diheteropogon amplexans* (species group F, Table 3), *Heteropogon contortus* (species group Q, table 3), *Eragrostis curvula* (species group T, Table 3), and the forbs *Dicoma anomala* (species group F, Table 3) and *Pseudognaphalium undulatum* (species group S, Table 3) in some of the sample plots, had large cover abundance values. The average height of the herbaceous stratum was 0.7 m and it had a canopy cover of 66.3 %. The average height of the tree stratum was 6.8 m with a poor canopy cover of 1.5%. *Celtis africana* and *Acacia erioloba* (species group G, Table 3) were the only tree species occurring in this community and were very poorly represented. The average height of the shrub stratum was 3 m and the canopy cover was 17.3%. *Rhus pyroides* (species group M, Table 3) was the dominant shrub in this community. An average number of 54 species was recorded per sample plot of which 0.7% was exotic species. Exotic plants included species such as *Conyza bonariensis* and *Achyranthes aspera* (species group V, Table 3).

Bezuidenhout & Bredenkamp (1990) described a closely related community, *Aristida diffusa* – *Cymbopogon excavatus* Grassland, also occurring on the stony chert areas. Another related community, *Cymbopogon excavatus* - *Diheteropogon amplexans* Grassland, found in the dolomitic and chert outcrops was described by Bezuidenhout (1994a).

## 5. *Rhus pyroides* - *Acacia erioloba* Woodland

The *Rhus pyroides* - *Acacia erioloba* Woodland was limited to the valley bottomlands of the chert and dolomitic areas of the Fa-land type. This community was characterized by relatively rocky ground surface (> 10%) and relatively shallow soil (< 0.2 m) with a clay content of less than 10%. Sinkholes were characteristically present in this habitat which was underlain by dolomite and mostly filled by deep sandy soil (> 1.2 m). Mispah was the dominant soil form in this community.

The differential species in this community were found in the species group G (Table 3) and included grasses such as *Eragrostis superba*, *Sporobolus africana*, *Eragrostis trichophora*, *Celtis africana*, *Acacia erioloba*, *Diospyros lycioides* subsp. *guerkei*, *Ipomoea oblongata*, *Sida dregei* and *Striga asiatica*. Dominant plants included species such as *Rhus pyroides* (species group M, Table 3) and *Acacia erioloba* (species group G, Table 3). The average height of the tree stratum was 5.7 m with a canopy cover of 4.8%. The trees were normally restricted to the deep sandy soils in the sinkholes. The average height of the shrub stratum was 2.8 m with a canopy cover of 15.6 m. Other dominant species in this community included the exotic weed *Tagetes minuta* (species group L, Table 3), the shrub *Ehretia rigida* (species group L, Table 3), the grasses *Triraphis andropogonoides* (species group H, Table 3) and *Cymbopogon pospischilii* (species group Q, Table 3). The average height of the herbaceous stratum was 0.8 m with a high canopy cover of 67%, with the succulent *Lithops lesliei* also found in this community (species group V). An average number of 40 species was recorded per sample plot of which 4.5% was exotic species. Exotic plants included species such as *Tagetes minuta* (Species Group L, Table 3), *Conyza bonariensis*, *Achyranthes aspera*, *Bidens bipinnata* and *Solanum nigrum* (Species Group V, Table 3).

A closely related community, *Rhus lancea* – *Acacia erioloba*, was described by Bezuidenhout *et al.* (1994b). This community shares a similar floristic composition with the *Rhus pyroides* - *Acacia erioloba* Woodland, except for the fact that *Rhus pyroides* was the dominant species in the *Rhus pyroides* - *Acacia erioloba* Woodland described in this study.

#### **6. *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland**

The *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland was associated with the midslopes of the rocky outcrops and quartzite hills. The habitat was relatively dry with shallow soil (< 0.2 m) and a well-drained system and was characterized by a relatively low clay content (< 10%). Mispah, Glenrosa and Hutton were the dominant soil forms.

The differential species in this community were found in species group I (Table 3). These included species such as the grasses *Digitaria eriantha*, *Eragrostis rigidior*, *Aristida transvaalensis*, the forbs *Crabbea angustifolia*, *Blepharis integrifolia*, *Indigofera heterotricha*, *Chaetacanthus costatus*, the tree *Euclea undulata* and the shrub *Rhus leptodictya*. Dominant species in this community included species such as *Setaria sphacelata* var. *sphacelata* (species group T, Table 3) and *Acacia caffra* (species group N, Table 3). Other co-dominant species in this community included the forbs *Pseudognaphalium undulatum*, the succulent *Aloe greatheadii* var. *davyana*, the climber *Clematis brachiata* (species group N, Table 3), the shrub *Ziziphus zeyheriana* (species group Q, Table 3) and the tree *Acacia karroo* (species group S, Table 3). The average height of the tree stratum was 5.0 m and had a canopy cover of 11.2%. The average height of the shrub stratum was 1.9 m with a canopy cover of 17.9%. The herbaceous stratum was 0.9 m high on average, and had a canopy cover of 61.7%. An average number of 40 species was recorded per sample plot of which 6.6% was exotic species. Exotic plants included species such as *Tagetes minuta* (Species Group L, Table 3), *Verbena officinalis* (species group S, Table 3), *Paspalum dilatatum*,

*Conyza bonariensis*, *Achyranthes aspera*, *Bidens bipinnata*, *Gomphrena celosioides*, *Schkuhria pinnata*, *Verbena bonariensis*, *Gulleminea densa*, *Plantago lanceolata*, *Solanum sisymbriifolium*, *Chenopodium album*, *Opuntia ficus-indica*, *Oxalis corniculata*, *Zinnia peruviana*, *Oenothera tetraptera* and *Cirsium vulgare* (Species Group V, Table 3).

Bezuidenhout *et al.* (1994c) and Cilliers *et al.* (1999) described a closely related community, *Rhus leptodictya* – *Acacia caffra* Woodland. The reason for the difference in floristic composition between these two communities might be due to the fact that the vegetation was often subjected to overgrazing, resulting in degradation and the subsequent presence of many pioneer species and exotic species. Another related community, *Vangueria infausta* – *Acacia caffra* Woodland, described by Bezuidenhout & Bredenkamp (1991), occurs in a similar habitat but with *Eragrostis curvula* and *Panicum coloratum* as dominant grasses. The *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland described in this study consists of *Setaria sphacelata* var. *sphacelata*, *Digitaria eriantha*, *Eragrostis rigidior* and *Aristida transvaalensis* as dominant grasses. Uncontrolled fires, gathering of firewood and accompanying disturbances such as trampling and soil compaction are the most important threats to these communities (Cilliers *et al.*, 1999).

### **7. *Ziziphus zeyheriana* - *Acacia karroo* Woodland**

The *Ziziphus zeyheriana* - *Acacia karroo* Woodland occurred on footslopes, valley bottomland areas, and along the drainage lines and midslopes of the quartzite hills. This community was characterized by relatively deep soil (> 0.5 m) with a relatively high clay content (> 25%). Hutton and Shortlands were the dominant soil forms in this community.

The differential species in this community were found in species group J (Table 3). These species included *Delosperma herbeum*, *Nidorella anomala*, *Sida*

*spinosa*, *Pavonia burchellii*, *Pollichia campestris*, *Pentzia globosa* and *Eragrostis lehmanniana*. Dominant plants included species such as *Ziziphus zeyheriana* (species group Q, Table 3) and *Acacia karroo* (species group S, Table 3). Other co-dominant species in this community included species such as *Asparagus suaveolens* (species group K, Table 3), *Ehretia rigida* (species group L, Table 3), *Aloe greatheadii* var. *davyana* (species group N, Table 3), *Clematis brachiata* (species group N, Table 3), *Acacia caffra* (species group N, Table 3), *Cymbopogon pospischilii* (species group Q, Table 3), *Ziziphus zeyheriana* (species group Q, Table 3), *Teucrium trifidum* (species group Q, Table 3), *Cynodon dactylon* (species group S, Table 3), *Asparagus larycinus* (species group S, Table 3) and *Setaria sphacelata* var. *sphacelata* (species group T, Table 3). The average height of the tree stratum was 4.5 m and it had a canopy cover of 17.2% (Table 4). The average height of the shrub stratum was 1.8 m with a canopy cover of 21.9%. The average height of the herbaceous stratum was 0.9 m and had a canopy cover of 66.5% (Table 4). An average number of 41 species was recorded per sample plot of which 7.2% exotic species. Exotic plants included species such as *Tagetes minuta* (Species Group L, Table 3), *Verbena officinalis* (Species Group S, Table 3), *Conyza bonariensis*, *Achyranthes aspera*, *Bidens bipinnata*, *Gomphrena celosioides*, *Lepidium bonariensis*, *Schkuhria pinnata*, *Solanum sisymbriifolium*, *Opuntia ficus - indica*, *Oxalis corniculata* and *Zinnia peruviana* (Species Group V, Table 3).

Bredenkamp *et al.* (1988) described a similar community (*Acacia karroo* Woodland) in the Potchefstroom-Fochville-Parrys area with *Ziziphus zeyheriana* abundantly occurring on severely degraded areas. Bezuidenhout & Bredenkamp (1991) also described an *Acacia karroo* community with a similar floristic species composition such as *Asparagus larycinus*, *Acacia karroo*, *Pavonia burchellii* and *Teucrium trifidum*. This community also corresponds to the Thornveld described by Louw (1951).

## 8. *Cymbopogon pospischilii* - *Themeda triandra* Grassland

The *Cymbopogon pospischilii* - *Themeda triandra* Grassland was associated with the midslopes of the rocky quartzite outcrops. This community was characterized by a relatively shallow soils (> 0.2 m) of the Hutton and Glenrosa soil forms with a low clay content (>10%) and a good drainage regime.

The differential species in this community were found in species group O (Table 3). *Cymbopogon pospischilii* (species group Q, Table 3) and *Themeda triandra* (species group U, Table 3) were the dominant species in this community. Other co-dominant species in this community included species such as *Hermannia depressa* (species group P, Table 3), *Ziziphus zeyheriana* (species group Q, Table 3), *Berkheya radula* (species group R, Table 3), *Hyparrhenia hirta* (species group R, Table 3), *Setaria incrassata* (species group R, Table 3), *Helichrysum nudifolium* var. *nudifolium* (species group R, Table 3), *Acacia karroo* (species group S, Table 3) and *Conyza podocephala* ((species group S, Table 3). The average height of the tree stratum was 5.4 m with a canopy cover of 9.8%. The average height of the shrub stratum was 1.2 m with a canopy cover of 8.2%. The average height of the herbaceous stratum was 0.9 m with a high canopy cover of 77%. An average number of 31 species was recorded per sample plot of which 6.3% was exotic species. Exotic plants included species such as *Tagetes minuta* (Species Group L, Table 3), *Verbena officinalis* (Species Group S, Table 3), *Conyza bonariensis*, *Achyranthes aspera*, *Avena fatua*, *Bidens bipinnata*, *Gomphrena celosioides*, *Physalis angulata*, *Oenothera rosea*, *Oenothera tetraptera* and *Cirsium vulgare* (Species Group V, Table 3).

Bredenkamp *et al.* (1989) described a closely related community (*Themeda triandra* – *Elionurus muticus* Grassland) similar to the *Themeda triandra* – *Heteropogon contortus* variant described by Bredenkamp & Bezuidenhout (1989), with an absolute dominance of *Themeda triandra*. The *Cymbopogon pospischilii* - *Themeda triandra* Grassland also shows similar floristic

characteristics with the *Themeda triandra* variant described by Bezuidenhout & Bredenkamp (1991) in the Bc-land type. The dominant grass species in these communities are *Eragrostis plana*, *Cymbopogon pospischilii* and *Themeda triandra* with *Berkheya radula* as the prominent forb.

### **9. *Setaria incrassata* – *Hyparrhenia hirta* Grassland**

The *Setaria incrassata* – *Hyparrhenia hirta* Grassland was mostly a wetland community restricted to the valley bottomlands and floodplains in or along drainage lines. The geology comprises mostly of alluvial deposited from the upper slopes. The relatively high clay content (> 25 %) causes soil to swell and shrink on wetting and drying. This habitat was fairly unstable due to seasonal flooding and drying. Hutton and Swartland were the dominating soil forms found in this community.

No differential species were identified in this community. *Setaria incrassata* (species group R, Table 3) and *Hyparrhenia hirta* (species group R, Table 3) were the dominant species in this community. The average height of the herbaceous shrub stratum was 0.9 m with a high canopy cover of 69% (Table 4). Other co-dominant species found in this community included *Berkheya radula* (species group R, Table 3), *Eragrostis plana* (species group R, Table 3), *Conyza podocephala* (species group S, Table 3), *Acacia karroo* (species group S, Table 3), *Asparagus laricinus* (species group S, Table 3) and *Cynodon dactylon* (species group S, Table 3). The average height of the shrub stratum was 0.8 m with a poor canopy cover of 1.3 % (Table 4). The average height of the tree stratum was 3 m with a canopy cover of 6% (Table 4). An average number of 24 species was recorded per sample plot of which 12% was exotic species. Exotic plants included species such as *Verbena officinalis* (Species Group S, Table 3), *Paspalum dilatatum*, *Conyza bonariensis*, *Ciclospermum leptophyllum*, *Persicaria lapathifolia*, *Oenothera rosea* and *Oenothera tetraptera* (Species Group V, Table 3).

Several studies have been done on similar wetland grassland communities by different researchers. Bredenkamp *et al.* (1989) described an *Aristida bipartita* – *Eragrostis plana* – *Setaria sphacelata* Grassland in the Potchefstroom-Fochville-Parys area; Bezuidenhout & Bredenkamp (1991) described an *Eragrostis plana* Grassland in the vegetation of the Bc-land type in the western Transvaal; Bredenkamp *et al.* (1994) described a *Hyparrhenia hirta* Grassland in the Boskop Dam Nature reserve; Bezuidenhout *et al.* (1994c) described a *Hyparrhenia hirta* – *Eragrostis plana* Grassland in the Fb-land type in the old western Transvaal; and Cilliers *et al.* (1998) described a *Hyparrhenia hirta* Grassland in the Potchefstroom municipal area. The similarity found in all these communities is that their habitats are fairly unstable due to seasonal flooding and drying which, together with the frequent overgrazing of these sites, caused an advanced state of degradation of the vegetation.

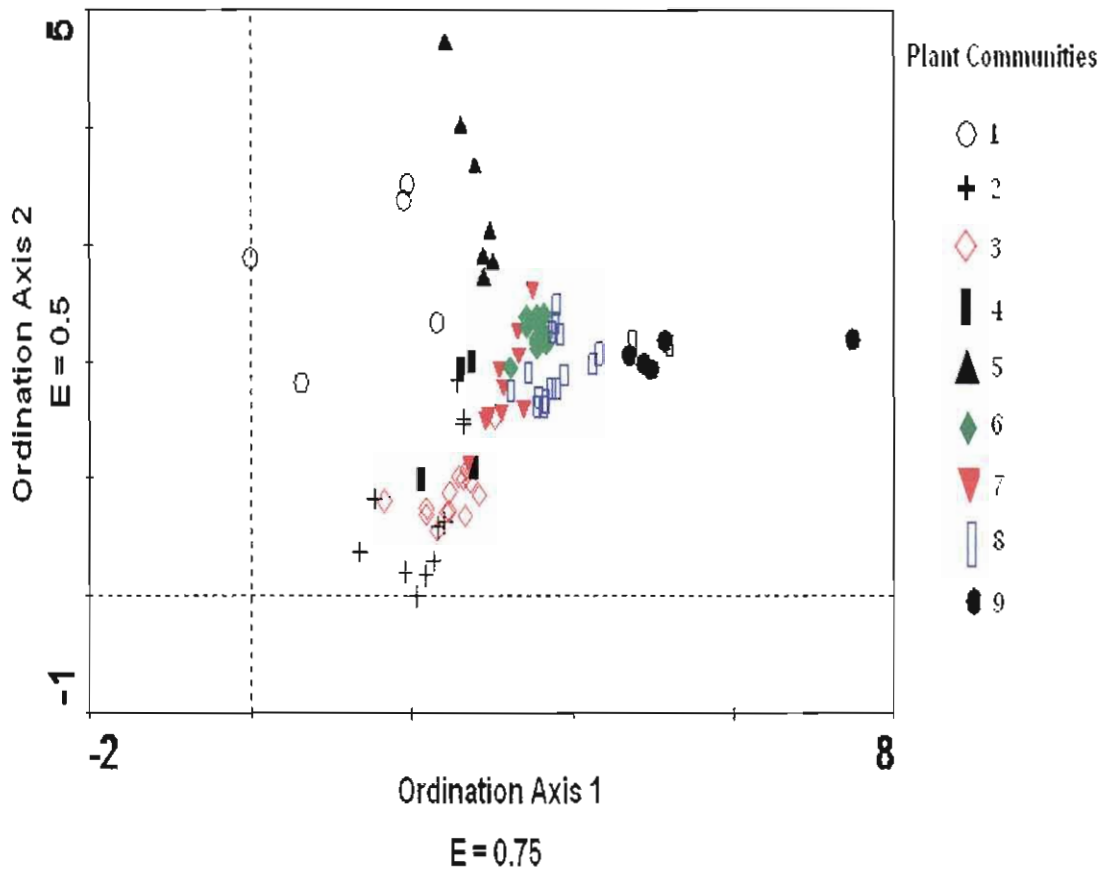
### 3.5 ORDINATION

A Detrended Correspondence Analysis (DCA) ordination algorithm was applied to the data set to confirm the existence of the different plant communities and to determine whether the gradients in plant communities along different ordination axes could be explained by gradients in specific environmental characteristics. It will be an indirect gradient, as few quantitative environmental characteristics were studied and therefore impossible to study direct gradients using Canonical correspondence analysis (CCA).

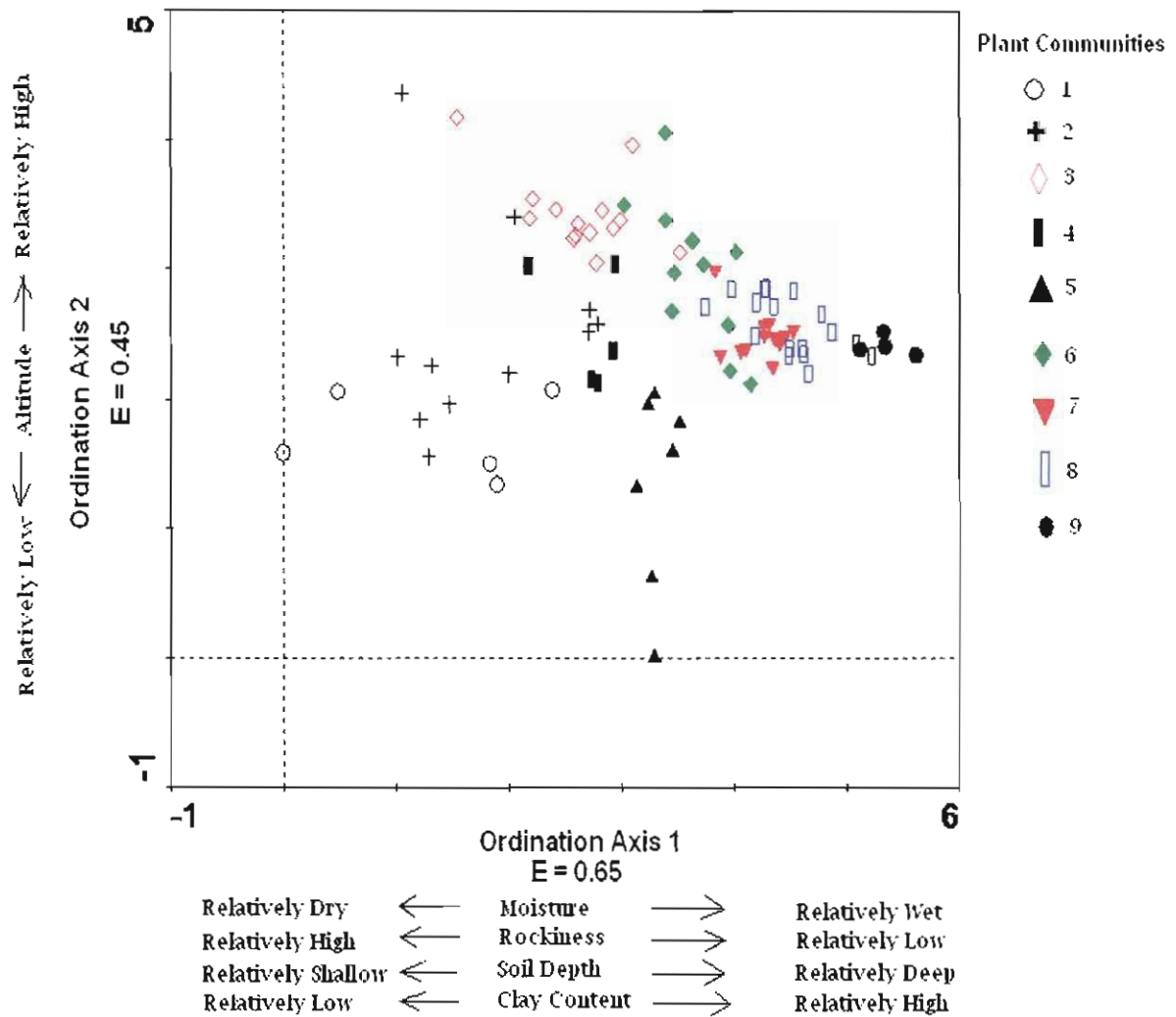
The stepwise ordination approach followed by Mucina & van Tongeren (1989) was adopted to cope with the heterogeneity of the data set and therefore, two different ordinations were completed (Figures 4 and 5). The scatter diagram in Figure 4 shows the DCA ordination with all relevés of the entire HNP. The relative positions of points on the second axis are clustered and the different plant communities cannot be clearly distinguished from each other (Figure 4).

The scatter diagram in Figure 5 shows a second DCA ordination after the removal of an outlier relevé 80. There is a significant change in the distribution of points on the second axis and the plant communities 1, 2, 3, 4 and 5 show some dissimilarity with the other communities (Figure 5). The gradient along ordination axis 1 ( $E = 0.65$ ) could be explained by environmental characteristics such as moisture, surface rockiness, soil depth and soil clay content (Figure 5). Plant communities to the left side of the scatter diagram are characterized by a relatively dry habitat, high percentage of surface rockiness, shallow soil and relatively low clay content, while those on the right are characterized by a relatively wet habitat, low percentage of surface rockiness, deeper soil and relatively high clay content (Figure 5). The gradient along ordination axis 2 ( $E = 0.45$ ) could be explained by altitude.

Plant communities at the top of the scatter diagram (Figure 5) are mainly limited to the upper slopes, rocky quartzite hills and ridges, crests and dolomitic areas in the HNP. These are mainly woodlands and shrublands communities found in high altitudes. Plant communities found at the bottom of the scatter diagram (Figure 5) are associated with low altitudes and occur mainly in the footslopes and bottomlands in the HNP.



**Figure 4. First Detrended Correspondence Analysis ordination with all relevés in the Highveld National Park (Plant community 1 = *Mystroxylon aethiopicum* - *Pavetta zeyheri* Shrubland; 2 = *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland; 3 = *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland; 4 = *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland; 5 = *Rhus pyroides* - *Acacia erioloba* Woodland; 6 = *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland; 7 = *Ziziphus zeyheriana* - *Acacia karroo* Woodland; 8 = *Cymbopogon pospischilii* - *Themeda triandra* Grassland; 9 = *Setaria incrassata* - *Hyparrhenia hirta* Grassland).**



**Figure 5. Second Detrended Correspondence Analysis ordination with 87 relevés in the Highveld National Park (Plant community 1 = *Mystroxydon aethiopicum* - *Pavetta zeyheri* Shrubland; 2 = *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland; 3 = *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland; 4 = *Schizachyrium sanguineum* - *Cymbopogon excavatus* Grassland; 5 = *Rhus pyroides* - *Acacia erioloba* Woodland; 6 = *Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland; 7 = *Ziziphus zeyheriana* - *Acacia karroo* Woodland; 8 = *Cymbopogon pospischilii* - *Themeda triandra* Grassland; 9 = *Setaria incrassata* - *Hyparrhenia hirta* Grassland).**

### 3.6 CONCLUSION

Three structural vegetation units, namely woodland, shrubland and grassland were identified in the HNP. The DCA-ordination also confirmed the relationship between the plant communities and the environmental gradients in the HNP. Many of the communities showed some floristic similarity to previously described plant communities for the Bc- (Bezuidenhout & Bredenkamp, 1991), Fa- (Bezuidenhout *et al.*, 1994b) and Fb-land types (Bezuidenhout *et al.*, 1994c). Similar communities were also described by Cilliers *et al.* (1998, 1999) in the phytosociological studies of the urban spaces in Potchefstroom. Differences in floristic composition were also found between plant communities of the HNP and those previously described in the grassland of the former western Transvaal. The differences are probably due to the effect of numerous disturbances such as uncontrolled fires and other accompanying factors such as overgrazing and trampling, which result in soil compaction. The habitat and floristic composition of the plant communities of the rocky hills and ridges and shallow soils in the undulating landscape indicated that these communities represent Bankenveld rather than *Cymbopogon - Themeda* Veld of Acocks (1988). The description of the plant communities in the HNP also showed floristic similarities to the broader Grassland Bioregion Unit (Gh 12, Gh 13, Gh 15 and Gm 11) and the Central Bushveld Bioregion Unit (SVcb 11) described by Mucina & Rutherford (2006). The current classification, together with the description and ecological interpretations of the vegetation and associated habitats should form a basis for all vegetation-related management and conservation planning in the region.

## CHAPTER 4

### CLASSIFICATION AND DESCRIPTION OF VEGETATION IN THE DEGRADED SPITSKOP AREA

#### 4.1 INTRODUCTION

The relationship between vegetation and soil erosion deserves attention due to its scientific importance and practical applications (Guerrero-Campo & Montserrat-Marti, 2000). Vegetation reduces soil erosion and, as a consequence, many studies have been devoted to understanding the interaction between vegetation and erosion (Morgan & Rickson, 1995). However, the effect of soil erosion on vegetation is still poorly understood, especially with regard to the ecological aspects. Phytosociological studies of vegetation from eroded areas are also rare, but could be quite useful in providing vegetation and habitat information of degraded areas (Morgan & Rickson, 1995). This scarcity is possibly due to the characteristicly poor species composition of such degraded communities in comparison to those of the better conserved neighbouring areas (Guerrero-Campo & Montserrat-Marti, 2000). From an ecological viewpoint it is considered that the erosion process provokes high levels of stress and disturbance on plant species of the affected communities (Guerrero-Campo & Montserrat-Marti, 2000).

The Spitskop area in the HNP is characterized by pronounced soil degradation and therefore necessitates a detailed survey in order to determine plant communities and different types of soil erosion in the area. The objective of this chapter was therefore to classify, describe and map the plant communities occurring in the degraded sites of the Spitskop area. The geology of the area, soil forms, terrain units, and rockiness of the surface area were used in describing the plant communities. The types of erosion associated with the plant communities are briefly mentioned in this chapter but a detailed description will follow in Chapter 5. The percentages of exotic species in different communities

are also indicated to show the extent of their invasion and the need for management intervention. A comparison (where applicable) was made between the plant communities of the degraded areas and those described for the HNP (Chapter 3) and previously described communities in the grassland of the former western Transvaal.

## 4.2 CLASSIFICATION

The vegetation analyses are given in a phytosociological table (Table 5) and resulted in the formulation of a vegetation map (Figure 6) and the recognition of three major plant communities and three sub-communities. The hierarchical classification of these communities was as follows:

1. *Seriphium plumosum*- *Acacia caffra* Woodland
  - 1.1 *Melinis repens* - *Acacia robusta* Woodland
  - 1.2 *Eragrostis racemosa* - *Mundulea sericea* Shrubland
  - 1.3 *Asparagus suaveolens* - *Acacia karroo* Shrubland
2. *Setaria sphacelata* var. *torta* - *Eragrostis curvula* Grassland
3. *Cymbopogon pospischilii* - *Elionurus muticus* Grassland

## 4.3 BRIEF DESCRIPTION OF PLANT COMMUNITIES

1. The *Seriphium plumosum* - *Acacia caffra* Woodland was situated on the rocky quartzite midslopes of the Spitskop hill.

1.1. The *Melinis repens* - *Acacia robusta* Woodland was limited to the north-eastern gradual midslope of the quartzite Spitskop hill.

1.2. The *Eragrostis racemosa* - *Mundulea sericea* Shrubland was limited to the north-eastern steeper midslope of the rocky quartzite Spitskop hill.

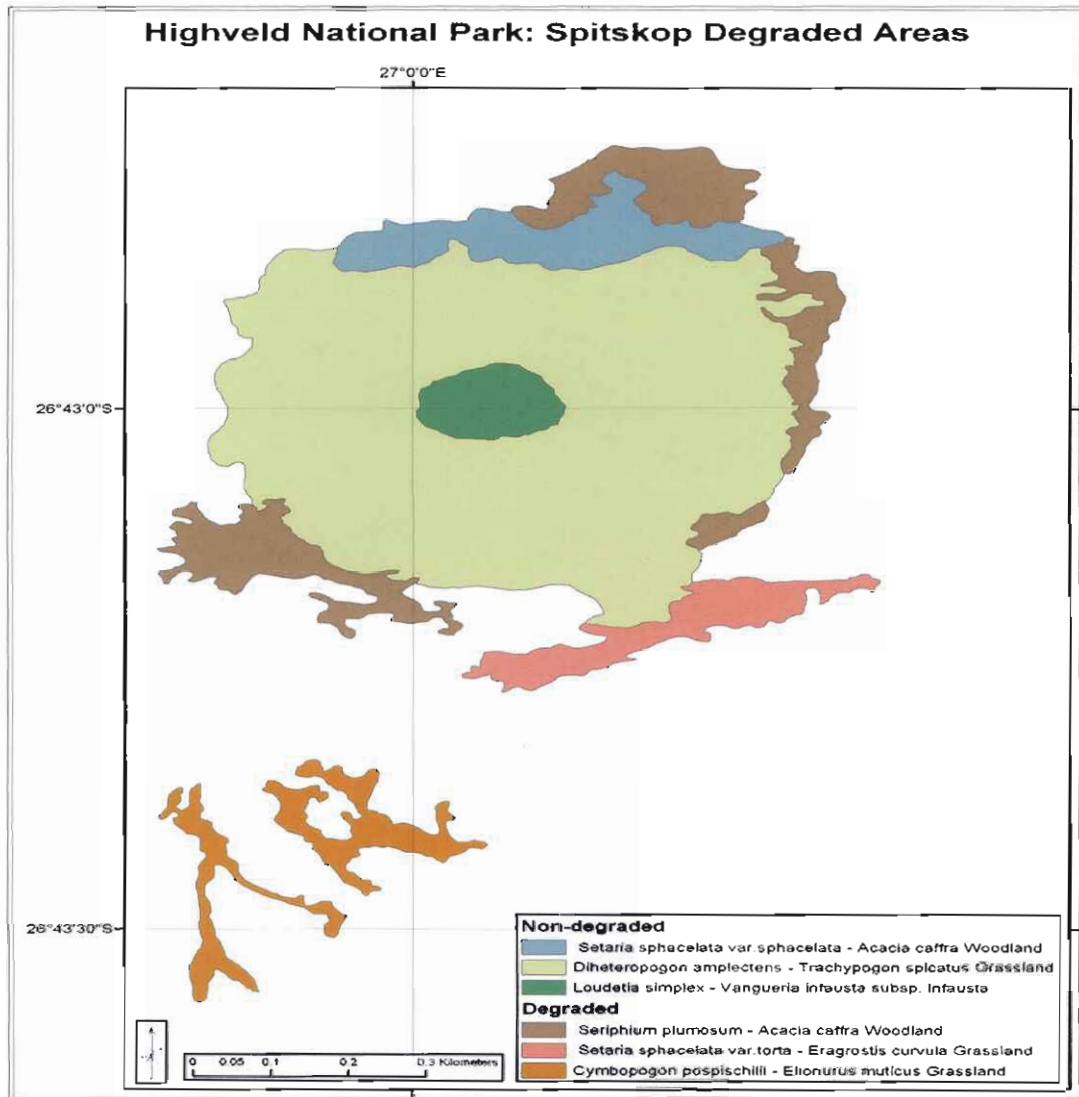
- 1.3. The *Asparagus suaveolens* - *Acacia karroo* Shrubland generally occurred on gradual footslopes in the south-western areas of the quartzite Spitskop hill.
2. The *Setaria sphacelata* var. *torta* - *Eragrostis curvula* Grassland occurred on the footslopes of the quartzite Spitskop hill.
3. The *Cymbopogon pospischilii* - *Elionurus muticus* Grassland occurred in the valley bottomland and floodplains along the drainage lines.

#### 4.4 DETAILED DESCRIPTION OF PLANT COMMUNITIES

##### 1. *Seriphium plumosum*- *Acacia caffra* Woodland

The *Seriphium plumosum* - *Acacia caffra* Woodland occurred on the rocky quartzite midslopes of the Spitskop hill. This community was characterized by the presence of sheet gully and rill erosion (Table 6). The habitat was relatively dry and characterized by well-drained, relatively shallow soil (< 0.2 m), with a relatively low clay content (< 10%). Glenrosa was the dominant soil form in this community. The percentage of surface rocks was high (> 10%).

The differential species of this community were found in species group A (Table 5) and included species such as *Acacia caffra*, *Seriphium plumosum*, *Gomphocarpus fruticosus* subsp. *fruticosus*, *Aristida bipartita* and *Convolvulus sagittatus*. The abundance of karroid shrubs such as *Seriphium plumosum* (species group A, Table 5) may become dominant in degraded and overgrazed areas (Acocks, 1988; O'Connor & Bredenkamp, 2003). Other dominant species found in this community included the forb *Convolvulus sagittatus*, the grasses *Aristida bipartita* (species group A, Table 5), *Eragrostis racemosa*, *Urochloa panicoides* (species group H, Table 5) and the two shrubs *Rhus pyroides* and *Euclea undulata* (species group H, Table 5). Species of general occurrence were found in species group M (Table 5).



**Figure 6. Vegetation map of the Spitskop area in the Highveld National Park.**

Table 5. A phytosociological table of the Spitskop degraded area in the Highveld National Park.

| Number of relevés                                       | 1   | 2 | 3 | 7 | 13 | 4   | 5 | 6 | 8   | 9 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|---|-----|---|---|---|----|-----|---|---|-----|---|----|----|----|----|----|----|----|----|----|----|--|
| Plant Community   | 1   |   |   |   |    |     |   |   |     |   |    |    | 2  |    |    | 3  |    |    |    |    |  |
| Sub-Community   | 1.1 |   |   |   |    | 1.2 |   |   | 1.3 |   |    |    |    |    |    |    |    |    |    |    |  |
| <b>SPECIES GROUP A</b>                                  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Acacia caffra</i>                                    | +   | + | 1 | 1 | +  | 1   | B | 1 |     | R | B  | R  | +  |    | +  |    |    | R  |    |    |  |
| <i>Seriphium plumosum</i>                               | R   |   | + | 1 | R  |     | R | R | A   | 1 | +  | R  | +  |    |    | 1  |    |    |    |    |  |
| <i>Gomphocarpus fruticosus</i> subsp. <i>fruticosus</i> | R   | R | + | R |    | +   | + | 1 | +   |   | R  |    |    |    |    |    |    |    |    |    |  |
| <i>Aristida bipartite</i>                               |     |   | R | R |    |     | + | + |     | R | A  | R  | +  |    |    |    |    |    |    |    |  |
| <i>Convolvulus sagittatus</i>                           | R   |   | + | R | R  |     |   |   |     | + | 1  |    |    |    |    |    |    |    |    | R  |  |
| <b>SPECIES GROUP B</b>                                  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Panicum maximum</i>                                  |     | R |   | R |    |     |   |   | R   |   |    |    |    |    |    |    |    | R  |    |    |  |
| <i>Acacia robusta</i>                                   | 1   | R |   |   |    |     |   | R |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <b>SPECIES GROUP C</b>                                  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Indigofera</i> sp.                                   |     |   | + |   |    | R   | + | R | R   |   |    |    |    |    |    |    |    |    |    | R  |  |
| <b>SPECIES GROUP D</b>                                  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Diospyros lycioides</i> subsp. <i>lycioides</i>      | R   | + | + |   |    |     | + | + |     | + |    |    |    |    |    |    |    |    |    |    |  |
| <i>Clematis brachiata</i>                               |     |   | R |   | R  | +   | 1 |   | +   |   |    |    |    |    |    | +  |    | R  |    |    |  |
| <b>SPECIES GROUP E</b>                                  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Senecio</i> sp.                                      |     |   |   |   |    |     |   |   | +   | + | R  |    |    |    |    | +  |    | R  |    |    |  |
| <i>Atriplex</i> sp.                                     |     |   |   |   |    |     |   |   | 1   | R |    |    |    | R  |    |    |    |    |    |    |  |
| <i>Lantana rugosa</i>                                   |     |   |   |   |    |     |   |   | R   | R |    |    |    |    |    | R  | R  |    |    |    |  |

| Number of relevés                               | 1   | 2 | 3 | 7 | 13 | 4   | 5 | 6 | 8   | 9 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|---|-----|---|---|---|----|-----|---|---|-----|---|----|----|----|----|----|----|----|----|----|----|--|
| Plant Community                                 | 1   |   |   |   |    |     |   |   |     |   |    |    | 2  |    |    | 3  |    |    |    |    |  |
| Sub-Community                                   | 1.1 |   |   |   |    | 1.2 |   |   | 1.3 |   |    |    |    |    |    |    |    |    |    |    |  |
| <b>SPECIES GROUP F</b>                          |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Mundulea sericea</i>                         |     |   | + |   |    | R   | A | 1 | R   |   | R  | R  | +  |    |    |    |    |    |    |    |  |
| <b>SPECIES GROUP G</b>                          |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Eragrostis curvula</i>                       |     |   |   |   |    |     |   |   |     |   |    |    |    | +  | 1  | 1  |    |    |    |    |  |
| <i>Digitaria eriantha</i>                       | R   |   | R |   | R  |     | + |   |     |   |    |    | +  | R  | A  | 1  |    |    |    |    |  |
| <i>Setaria sphacelata</i> var. <i>torta</i>     |     |   |   | + |    |     |   |   |     |   |    |    |    | +  | A  | 1  |    |    |    |    |  |
| <i>Asparagus laricinus</i>                      |     |   |   |   |    |     |   |   |     |   |    |    | +  |    | +  | +  |    |    |    | R  |  |
| <i>Grewia flava</i>                             |     |   |   |   |    |     |   |   |     |   |    |    | +  | R  | R  |    |    |    | R  |    |  |
| <i>Solanum lichtensteinii</i>                   |     |   |   |   |    |     |   |   | R   |   |    |    |    | R  |    | +  |    | R  |    |    |  |
| <b>SPECIES GROUP H</b>                          |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Eragrostis racemosa</i>                      | +   |   | + | + |    | +   | A | + | B   | 1 | B  | +  | 1  | +  | +  |    |    |    |    |    |  |
| <i>Rhus pyroides</i>                            | R   | R | + |   |    | +   |   | R | +   | + | R  |    | +  |    | +  | +  |    |    |    |    |  |
| <i>Urochloa panicoides</i>                      |     |   | + | + |    |     | R |   | 1   |   | 1  | R  | +  | R  | R  | +  |    | R  |    |    |  |
| <i>Euclea undulata</i>                          |     | + | R |   |    | +   |   |   | R   |   |    |    |    |    | R  | +  |    |    |    |    |  |
| <b>SPECIES GROUP I</b>                          |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Elionurus muticus</i>                        |     |   |   |   |    |     |   |   |     |   |    | R  |    |    |    |    | R  | R  | R  |    |  |
| <i>Gomphrenia celosioides</i> *                 |     |   | R |   |    |     |   |   | R   |   |    |    |    | R  |    |    |    | R  |    |    |  |
| <i>Sida alba</i>                                |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    | R  |    |    |  |
| <i>Eustachys paspaloides</i>                    |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    | R  |    | R  |  |
| <i>Aristida congesta</i> subsp. <i>congesta</i> |     | R |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    | R  |    |    |  |
| <i>Vernonia oligocephala</i>                    |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    | +  |    | R  |  |
| <b>SPECIES GROUP J</b>                          |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Cymbopogon pospischilii</i>                  |     |   | R |   |    |     |   |   |     |   |    |    |    | R  | R  |    | R  | R  | R  |    |  |

| Number of relevés                                 | 1   | 2 | 3 | 7 | 13 | 4   | 5 | 6 | 8   | 9 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|---|-----|---|---|---|----|-----|---|---|-----|---|----|----|----|----|----|----|----|----|----|----|--|
| <b>Plant Community</b>                            | 1   |   |   |   |    |     |   |   |     |   |    |    | 2  |    |    | 3  |    |    |    |    |  |
| <b>Sub-Community</b>                              | 1.1 |   |   |   |    | 1.2 |   |   | 1.3 |   |    |    |    |    |    |    |    |    |    |    |  |
| <b>SPECIES GROUP K</b>                            |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Chrysocoma ciliata</i>                         |     |   |   |   |    |     |   |   |     | + |    |    | +  | R  |    | 1  | R  |    |    | R  |  |
| <i>Eragrostis lehmanniana</i>                     |     |   |   |   |    |     |   |   |     | + | 1  |    |    |    |    | 1  | 1  | +  |    | R  |  |
| <b>SPECIES GROUP L</b>                            |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Acacia karroo</i>                              |     |   |   |   |    | R   |   | R | 3   | B | B  | 1  | B  | +  | A  | B  | R  |    | R  | +  |  |
| <i>Setaria sphacelata</i> var. <i>sphacelata</i>  |     |   | + |   |    |     |   | 1 | B   | + | +  | R  | 1  |    |    |    | +  | +  | R  | +  |  |
| <i>Ziziphus zeyheriana</i>                        |     |   |   |   | R  | R   | R |   |     | 1 | 1  | R  | 1  |    |    |    | +  | +  |    | +  |  |
| <b>SPECIES GROUP M</b>                            |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Melinis repens</i>                             | 1   | + | 1 | A | 1  | +   | 1 | 1 | A   | + | +  | +  | 1  | +  | +  | +  | +  | 1  | R  | R  |  |
| <i>Aloe greatheadii</i> var. <i>davyana</i>       | R   | R | + | + | R  | +   | 1 | + | A   | A | 1  | R  | +  | R  | 1  | +  | R  | +  | R  | R  |  |
| <i>Cynodon dactylon</i>                           | R   | R | + | + | +  | +   | + | + | A   | A |    |    | +  |    | +  | 1  | +  | +  |    | R  |  |
| <i>Themeda triandra</i>                           | R   | R | 1 | + | +  |     | 1 | 1 | A   | A |    | +  | +  | +  | 1  |    |    | +  |    | R  |  |
| <i>Hyparrhenia hirta</i>                          |     | R |   | + |    | +   | 1 | 1 |     | 1 | A  | +  |    |    | A  | A  | R  | +  |    |    |  |
| <i>Asparagus suaveolens</i>                       |     | + | + | + |    | R   | + | R | 1   | 1 | +  | R  | +  | R  | +  | 1  | +  |    |    | R  |  |
| <b>SPECIES GROUP N</b>                            |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Cucumis zeyheri</i>                            |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    | R  |    |    |    |  |
| <i>Helichrysum rugulosum</i>                      |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    | R  |    |    |    |  |
| <i>Hermannia lancifolia</i>                       |     |   |   |   |    |     |   |   |     |   |    |    |    | R  |    |    |    |    |    |    |  |
| <i>Tripteris aghillana</i>                        |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Plantago lanceolata</i> *                      |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Pollichia campestris</i>                       |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Setaria pallide-fusca</i>                      |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    | 1  |    |    |    |    |  |
| <i>Sida rhombifolia</i> subsp. <i>rhombifolia</i> |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Sida spinosa</i> var. <i>spinosa</i>           |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    | 1  |    |    |    |    |  |

| Number of relevés             | 1   | 2 | 3 | 7 | 13 | 4   | 5 | 6 | 8   | 9 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |  |
|-------------------------------|-----|---|---|---|----|-----|---|---|-----|---|----|----|----|----|----|----|----|----|----|----|--|
| Plant Community               | 1   |   |   |   |    |     |   |   |     |   |    |    | 2  |    |    | 3  |    |    |    |    |  |
| Sub-Community                 | 1.1 |   |   |   |    | 1.2 |   |   | 1.3 |   |    |    |    |    |    |    |    |    |    |    |  |
| SPECIES GROUP N               |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Sporobolus fimbriatus</i>  |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    | +  |    |    |    |    |  |
| <i>Acacia hebeclada</i>       |     |   |   |   |    |     |   |   |     |   | R  |    |    |    |    |    |    |    |    |    |  |
| <i>Rhus lancea</i>            |     |   |   |   |    |     |   |   |     |   |    |    | +  |    |    |    |    |    |    |    |  |
| <i>Berkheya sp.</i>           |     |   | R |   |    |     |   |   |     | R |    |    |    |    |    |    |    |    |    |    |  |
| <i>Opuntia ficus-indica*</i>  |     |   |   |   | R  |     |   |   | R   |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Pentarrhinum inspidum</i>  |     |   |   |   | R  |     |   |   | R   |   |    |    |    |    | R  |    |    |    |    |    |  |
| <i>Solanum eleagnifolium*</i> |     |   | R |   |    |     |   |   |     |   |    |    |    |    |    | R  |    |    |    |    |  |
| <i>Enneapogon scoparius</i>   | +   |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    |    |  |
| <i>Ehretia rigida</i>         |     | R |   |   |    |     |   | R | R   |   |    |    |    |    |    | R  |    |    |    | R  |  |
| <i>Rhus leptydactyla</i>      |     |   |   |   |    | R   |   |   | R   |   |    |    |    |    | R  |    |    |    |    |    |  |
| <i>Oxalis corniculata*</i>    |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    | R  |    |    | R  |    |  |
| <i>Teucrium trifidum</i>      |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    | R  | R  |    |    |    |  |
| <i>Eragrostis gummiflua</i>   |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    | R  |    |    |  |
| <i>Hermannia depressa</i>     |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    | R  |  |
| <i>Sonchus nana</i>           |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    | R  |  |
| <i>Tephrosia capensis</i>     |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    | R  |  |
| <i>Felicia filifolia</i>      |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    | R  |    |  |
| <i>Felicia hirsute</i>        |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    | R  |    |  |
| <i>Gnidia capitata</i>        |     |   |   |   |    |     |   |   |     |   |    |    |    |    |    |    |    |    |    | R  |  |

**Table 6. Summary of soil degradation types affecting plant communities in the Spitskop area in the Highveld National Park.**

| Plant community  | Degradation type | Severity class             |
|--|------------------|----------------------------|
| 1. <i>Seriphium plumosum</i> – <i>Acacia caffra</i><br>Woodland                      | Sheet            | High - Severe              |
|  | Rill             | Severe                     |
|  | Gully            | Slight                     |
| 1.1 <i>Melinis repens</i> – <i>Acacia robusta</i><br>Wodland                         | Sheet            | Severe                     |
|  | Gully            | Slight                     |
| 1.2 <i>Eragrostis racemosa</i> – <i>Mundulea sericea</i> Shrubland                   | Rill             | Severe                     |
|  | Sheet            | High - Severe              |
| 1.3 <i>Asparagus suaveolens</i> – <i>Acacia karroo</i> Shrubland                     | Sheet            | Slight – Moderate - Severe |
|  | Rill             | Severe                     |
|  | Gully            | Slight                     |
| 2. <i>Setaria sphacelata</i> var. <i>torta</i> - <i>Eragrostis curvula</i> Grassland | Sheet            | High –Severe               |
|  | Rill             | High – Severe              |
|  | Gully            | Slight                     |
| 3. <i>Cymbopogon pospischilli</i> – <i>Elionurus mutichus</i> Grassland              | Compact soil     | Severe                     |

The average height of the tree stratum was 1.6 m with a canopy cover of 10.5% (Table 7). The average height of the shrub stratum was 0.5 m with a canopy cover of 5.7% (Table 7). The average height of the herbaceous layer was 0.2 m with a canopy cover of 3.1% (Table 7). An average number of 18 species was recorded per sample plot of which 2.1% was exotic species. Exotic plants included species such as *Gomphrena celosioides* (Species Group I, Table 5), *Solanum elaeagnifolium* and *Opuntia ficus-indica* (Species Group N, Table 5).

The *Seriphium plumosum* - *Acacia caffra* Woodland was related to the *Setaria sphacelata* var. *sphacelata* – *Acacia caffra* Woodland described in chapter 3, but the *Seriphium plumosum* - *Acacia caffra* Woodland was mainly restricted to the

degraded areas at Spitskop hill. Wood harvesting also contributed to degradation of this community. Bezuidenhout *et al.* (1994c) also stated that the reason for differences in floristic composition might be due to the fact that the vegetation is often subjected to overgrazing, resulting in degradation and subsequent presence of many pioneer species and exotic species. Bezuidenhout *et al.* (1994c) and Cilliers *et al.* (1999) described a similar, but less degraded community (*Rhus leptodictya* – *Acacia caffra* Woodland) in the Potchefstroom area.

The *Seriphium plumosum* - *Acacia caffra* community was divided into three subcommunities, which are discussed below.

### **1.1 *Melinis repens* - *Acacia robusta* Woodland**

The *Melinis repens* - *Acacia robusta* Woodland was limited to the gradual north-eastern midslope of the quartzite Spitskop hill. This community was severely affected by sheet erosion (Table 6) and was characterized by well-drained, relatively shallow soil (< 0.2 m) with a relatively low clay content (< 10%). Glenrosa was the dominant soil form in this community.

The differential species of this community were found in species group B (Table 5) and included the grass *Panicum maximum* and the tree *Acacia robusta*. Dominant shrubs in this community included species such as *Diospyros lycioides* subsp. *lycioides* (species group D, Table 5) and *Euclea undulata* (species group H, Table 5). The average height of the herbaceous stratum was 0.2 m with a low canopy cover of 1.0% (Table 7). The average height of the tree stratum was 1.3 m with a canopy cover of 5.2% (Table 7). The average height of the shrub stratum was 0.5 m with canopy cover of 1.8 % (Table 7). An average number of 16 species was recorded per sample plot of which 3.7% was exotic species. Exotic plants included species such as *Gomphrena celosioides*, *Solanum elaeagnifolium* and *Opuntia ficus-indica* (species group N, Table 5).

## 1.2 *Eragrostis racemosa* - *Mundulea sericea* Shrubland

The *Eragrostis racemosa* – *Mundulea sericea* Shrubland was limited to the gradual north-eastern midslope of the rocky quartzite Spitskop hill. This community was affected by sheet and rill erosion (Table 6). The soil was relatively shallow (< 0.2 m), well-drained and characterized by a relatively low clay content (< 10%) and a relatively high percentage of surface rocks (> 10%). The dominant soil form was Glenrosa.

The differential species in this community was found in species group C (Table 5) consisting of only one species, *Indigofera* sp. and the community was characterized by the absence of species group B (Table 5). Dominant species in this community were *Eragrostis racemosa* (species group H, table 5) and *Mundulea sericea* (species group F, Table 5). Other co-dominant species found in this community included trees such as *Acacia caffra* (species group A, Table 5), *Acacia karroo* (species group L, Table 5), the shrubs *Diospyros lycioides* subsp. *lycioides* (species group D, Table 5), *Rhus pyroides* (species group H, table 5) and the grasses *Eragrostis lehmanniana* (species group K, Table 5), *Urochloa panicoides* (species group H, Table 5) and *Setaria sphacelata* var. *sphacelata* (species group L, Table 5). The average height of the herbaceous layer was 0.1 m with a canopy cover of 2.3 % (Table 7). The average height of the tree stratum was 1.5 m with a canopy cover of 9.3 % (Table 7). The average height of the shrub stratum was 0.5 m with a canopy cover of 5.3 % (Table 7). An average number of 17 species was recorded per sample plot and no exotic species were recorded.

**Table 7. Average height and cover values of the trees, shrubs and herbaceous layers of the different plant communities in the Spitskop area in the Highveld National Park.**

| Community  | Stratum            |                   |                    |                   |                    |                   |
|--|--------------------|-------------------|--------------------|-------------------|--------------------|-------------------|
|  | Trees              |                   | Shrubs             |                   | Herbaceous         |                   |
|  | Average Height (m) | Average Cover (%) | Average Height (m) | Average Cover (%) | Average Height (m) | Average Cover (%) |
| 1. <i>Seriphium plumosum</i> – <i>Acacia caffra</i> Woodland                         | 1.6                | 10.5              | 0.5                | 5.7               | 0.2                | 3.1               |
| 1.1 <i>Melinis repens</i> – <i>Acacia robusta</i> Woodland                           | 1.3                | 5.2               | 0.5                | 1.8               | 0.2                | 1.0               |
| 1.2 <i>Asparagus suaveolens</i> – <i>Acacia karroo</i> Shrubland                     | 1.5                | 9.3               | 0.5                | 5.3               | 0.1                | 2.3               |
| 1.3 <i>Asparagus suaveolens</i> – <i>Acacia karroo</i> Shrubland                     | 2.1                | 17.0              | 0.6                | 10.0              | 0.2                | 6.0               |
| 2. <i>Setaria sphacelata</i> var. <i>torta</i> - <i>Eragrostis curvula</i> Grassland | 1.2                | 11.2              | 0.3                | 6.8               | 0.2                | 5.4               |
| 3. <i>Cymbopogon pospischilli</i> – <i>Elionurus mutichus</i> Grassland              | 1.0                | 0.5               | 0.6                | 1.0               | 0.4                | 2.9               |

### 1.3 *Asparagus suaveolens* - *Acacia karroo* Shrubland

This sub-community occurred in the south-western footslopes of the quartzite Spitskop hill and can be regarded as a transition from *Acacia caffra* to *Acacia karroo* Woodland. This community was affected by sheet, rill and gully erosion (Table 6). The soil was moderately deep (0.2 – 0.5 m) with less than 10% surface rocks. Hutton and Glenrosa were the dominating soil forms in this sub-community.

The differential species in this community were found in species group E (Table 5) and included species such as *Senecio* sp., *Atriplex* sp. and *Lantana rugosa*. *Acacia karroo* (species group L, Table 5) and *Acacia caffra* (species group A, Table 5) were the dominant trees in this community. The average height of the tree stratum was 2.1 m with a canopy cover of 17% (Table 7). Dominating shrubs included species such as *Asparagus suaveolens* (species group M, Table 5), *Seriphium plumosum* (species group A, Table 5), *Rhus pyroides* (species group H, Table 5) and *Ziziphus zeyheriana* (species group L, Table 5). The average height of the shrub stratum was 0.6 m with a canopy cover of 10% (Table 7). Dominating grasses included species such as *Aristida bipartita* (species group A, Table 5), *Eragrostis racemosa* (species group H, Table 5), *Urochloa panicoides* (species group H, Table 5) and *Setaria sphacelata* var. *sphacelata* (species group L, Table 5). The average height of the herbaceous stratum was 0.2 m with a canopy cover of 6.0% (Table 7). An average number of 21 species was recorded per sample plot of which 1.9% was exotic species. Exotic plants included species such as *Gomphrena celosioides* and *Opuntia ficus-indica* (Species Group N, Table 5).

This community is related to the *Ziziphus zeyheriana* – *Acacia karroo* Woodland described in Chapter 3. The difference between the two communities is the dominance of *Ziziphus zeyheriana* (species group Q, Table 3) in the *Ziziphus zeyheriana* – *Acacia karroo* Woodland and *Asparagus suaveolens* (species

group M, Table 5) in the *Asparagus suaveolens* - *Acacia karroo* Woodland. This degraded community was characterized by a low average number of indigenous species and a high percentage of exotic species in comparison to the *Ziziphus zeyheriana* – *Acacia karroo* Woodland described in Chapter 3. A similar community (*Acacia karroo* Woodland) was described by Breidenkamp *et al.* (1988) in the Potchefstroom-Fochville-Parys area. A similar community was also described by Bezuidenhout & Breidenkamp (1991) for the footslope and bottomlands of the Bc-land type in the Potchefstroom area. Cilliers & Breidenkamp (1998) described another similar community in the vegetation analysis of railway reserves in Potchefstroom area. The *Asparagus suaveolens* - *Acacia karroo* Shrubland also corresponded to the Thornveld described by Louw (1951).

## **2. *Setaria sphacelata* var. *torta* - *Eragrostis curvula* Grassland**

The *Setaria sphacelata* var. *torta* – *Eragrostis curvula* community occurred on the footslopes of the quartzite Spitskop hill and was also affected by sheet, rill and gully erosion (Table 6). The soils were relatively deep (> 0.5 m) and had a relatively high clay content (> 25%). The soil forms that were present in this community were Hutton and Mispah. This community represented a transitional zone between woodland and grassland.

The differential species in this community were found in species group G (Table 5). These species included grasses such as *Eragrostis curvula*, *Digitaria eriantha* and *Setaria sphacelata* var. *torta*, the shrubs *Grewia flava* and *Asparagus laricinus* and the forb *Solanum lichtensteinii*. Other dominating species included *Acacia karroo* (species group L, Table 5), *Rhus pyroides* (species group H, Table 5) and *Chrysocoma ciliata* (species group K). The average height of the tree stratum was 1.2 m with a canopy cover of 11.2% (Table 7). The average height of the herbaceous layer was 0.2 m with a canopy cover of 5.4 % (Table 7). Species such as *Aloe greatheadii* var. *davyana* occurred abundantly and its

cover seemed to increase under conditions of severe degradation. The average height of the shrub stratum was 0.3 m with a canopy cover of 6.8 % (Table 7). An average number of 23 species was recorded per sample plot of which 4.2% was exotic species. Exotic plants found in this community included species such as *Gomphrena celosioides*, *Plantago lanceolata*, *Oxalis corniculata* and *Solanum elaeagnifolium* (Species Group N, Table 5).

This community was encroached by *Acacia karroo* and disturbed areas were enhanced by changes in the competitive balance between grasses and bush, brought about by changes in grazing and/or fire regimes in the management of the grasslands (Friedel, 1987). Related communities were described by Bezuidenhout *et al.* (1994) for the Ba-land type in the former western Transvaal, Bezuidenhout & Bredenkamp (1991) for the Bc-land type and Bredenkamp *et al.* (1989) in the Potchefstroom-Fochville-Parys area.

### **3. *Cymbopogon pospischilii* - *Elionurus muticus* Grassland**

The *Cymbopogon pospischilii* - *Elionurus muticus* Grassland occurred in the valley bottomland and floodplains along drainage lines. The geology of this landscape mostly comprised of alluvial deposits from the upper slopes. This community was also characterized by bare patches of compacted soil resulting from overgrazing and trampling (Bezuidenhout *et al.*, 1994). Mispah and Hutton were the dominant soil forms in this community.

The differential species for this community were found in species group I (Table 5). These species included grasses such as *Elionurus muticus*, *Eustachys paspaloides* and *Aristida congesta* subsp. *congesta*, the dwarf shrub *Sida alba*, the forb *Vernonia oligocephala* and the exotic plant *Gomphrena celosioides*. Dominant plants in this community included the grasses *Cymbopogon pospischilii* (species group J) and *Elionurus muticus* (species group I, Table 5). Other co-dominant species included *Setaria sphacelata* var. *sphacelata*, the tree *Acacia*

*karroo* and the shrub *Ziziphus zeyheriana* (species group L, Table 5). The average height of the tree stratum was 1.0 m with a canopy cover of 0.5% (Table 7). The average height of the shrub stratum was 0.6 m with a canopy cover of 1.0% (Table 7). The average height of the herbaceous layer was 0.4 m with a canopy cover of 2.9 % (Table 7). An average number of 17 species was recorded per sample plot of which 4.4% was exotic species. Exotic plants included species such as *Gomphrena celosioides* and *Oxalis corniculata* (Species Group N, Table 5).

A Similar community (*Elionurio mutici* – *Cymbopogonnetum plurinodis* ass. nov.) was described by Bezuidenhout *et al.* (1994) for the Ba-land type in the former western Transvaal grassland. Another related community (*Elionurus muticus* – *Acacia karroo* Woodland) for the Bc-land type in the former western Transvaal grassland was described by Bezuidenhout & Bredenkamp (1991).

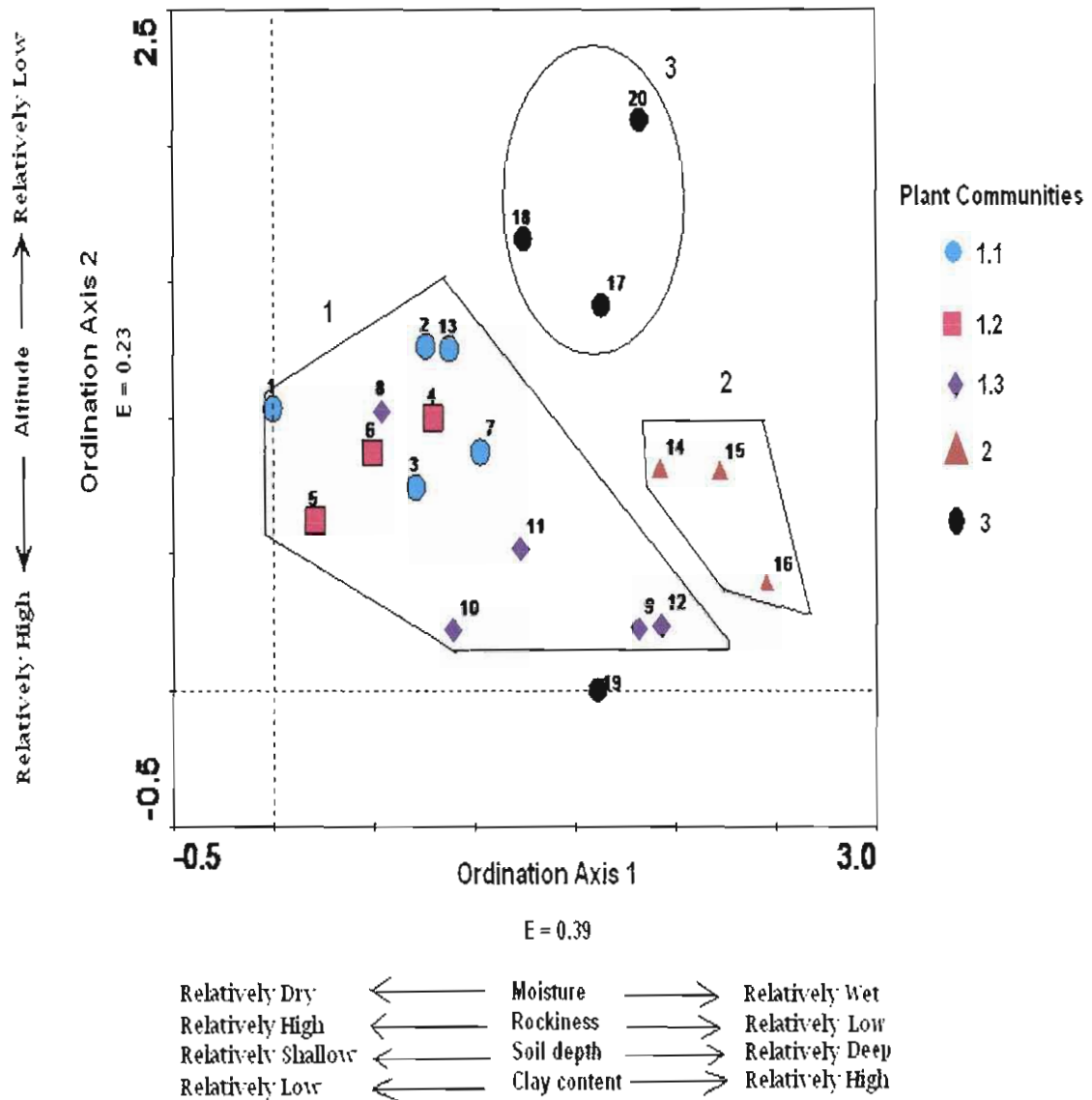
#### 4.5 ORDINATION

A DCA ordination algorithm was applied to the data set to confirm the existence of the different plant communities and to determine whether the gradients in plant communities along different ordination axes could be explained by gradients in specific environmental characteristics. A scatter diagram was produced to show the relationship between the plant communities in the Spitskop area, HNP (Figure 7). Plant communities 1 and 2 and to a lesser extent plant community 3 form clear and separate groups. The three subcommunities of plant community 1 did not, however, show any clear dissimilarity. The gradient along ordination axis 1 ( $E = 0.39$ ) could be explained by soil depth, soil moisture, surface rockiness and clay content (Figure 7). The plant communities on the left of the scatter diagram are characterized by relatively shallow soil with relatively low clay content and dry habitat, while those on the right are characterized by relatively deep soil with relatively high clay content and wet habitat. The gradient along ordination axis 2 ( $E = 0.23$ ) could be explained by altitude. The grassland

communities at the top centre of the scatter diagram are more or less found at lower altitudes and shrubland and woodland communities at the bottom left of the scatter diagram are found at relatively high altitudes (Figure 7).

For the environmental gradient analysis, the direct ordination (Canonical Correspondence Analysis – CCA) was employed to determine the correlation between plant communities and soil erosion gradients (quantitative environmental variables). This was done using the CANOCO software programme (Ter Braak, 1986). The environmental gradients and the relative importance and intercorrelation of the environmental variables and the position of the relevés of the different plant communities in relation to the environmental gradient are shown in Figure 8. The length of an arrow is proportional to its importance and the angles between the arrows reflect the intercorrelations between the variables. The angle between an arrow and each axis is a representation of its degree of correlation with the axis.

Compacted soil (Com.) is most highly correlated with ordination axis 1 (figure 8) and the CANOCO results confirms this correlation as 0.82 (Table 8). Sheet erosion is most highly correlated with ordination axis 2 and the correlation coefficient is 0.65 (Table 8). In other words there is a soil compaction gradient along ordination axis 1 with higher percentage to the right and lower percentage to the left, and a sheet erosion gradient along ordination axis 2 with higher percentage at the top and lower percentage at the bottom.



**Figure 7. A Detrended Correspondence Analysis ordination with all relevés in the Spitskop area in the Highveld National Park (Plant community 1.1 = *Melinis repens* - *Acacia robusta* Woodland; 1.2 = *Eragrostis racemosa* - *Mundulea sericea* Shrubland; 1.3 = *Asparagus suaveolens* - *Acacia karroo* Shrubland; 2 = *Setaria sphacelata* var. *torta* - *Eragrostis curvula* Grassland; 3 = *Cymbopogon pospischilii* - *Elionurus muticus* Grassland).**

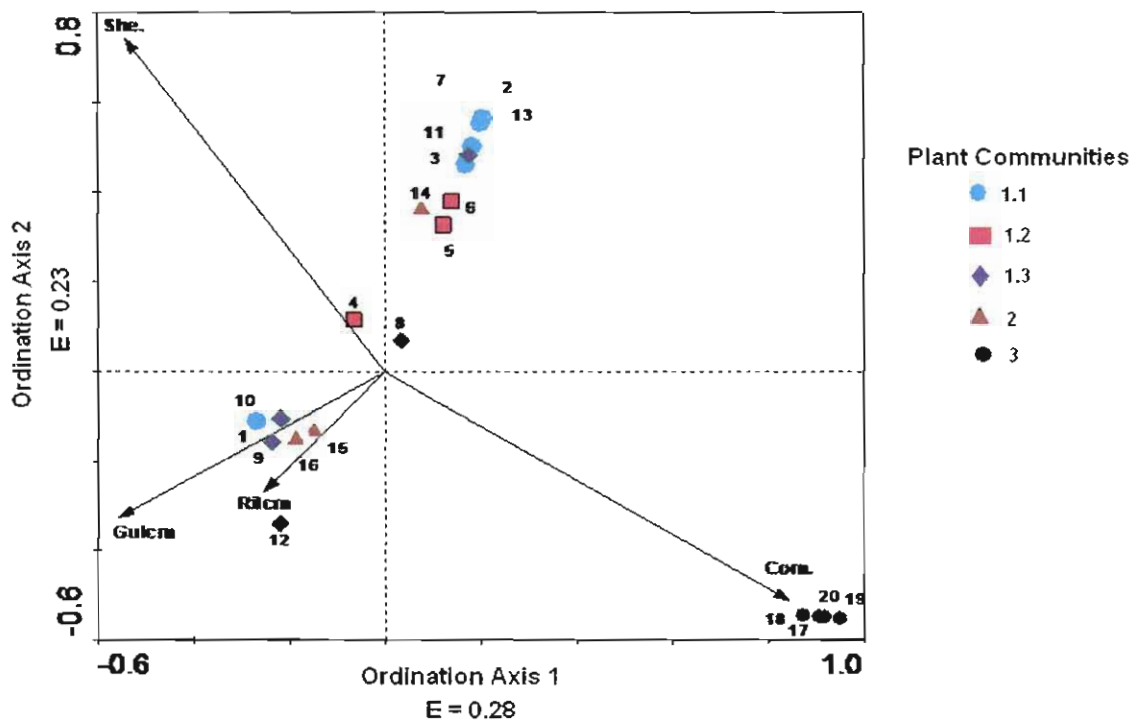


Figure 8. Canonical Correspondence Analysis showing correlation between plant communities and soil erosion gradients in the Spitskop area in the Highveld National Park (She. = Sheet erosion, Gulcm = Gully erosion, Rilcm = Rill erosion, Com. = Compacted soil. Plant community 1.1 = *Melinis repens* - *Acacia robusta* Woodland; 1.2 = *Eragrostis racemosa* - *Mundulea sericea* Shrubland; 1.3 = *Asparagus suaveolens* - *Acacia karroo* Shrubland; 2 = *Setaria sphacelata* var. *torta* - *Eragrostis curvula* Grassland; 3 = *Cymbopogon pospischilii* - *Elionurus muticus* Grassland).

**Table 8. Information used in a Canonical Correspondence Analysis of the Spitskop area in the Highveld National Park, showing correlation coefficients, eigen values and percentage variance of ordination axes 1 and 2.**

| <b>Factor</b>      | <b>Axis 1</b> | <b>Axis 2</b> |
|--------------------|---------------|---------------|
| Sheet              | -0.53         | 0.65          |
| Gully              | -0.54         | -0.28         |
| Rill               | -0.24         | -0.23         |
| Compacted Soil     | 0.82          | -0.45         |
| <b>Eigen value</b> | <b>0.28</b>   | <b>0.23</b>   |
| <b>% variance</b>  | <b>34.9</b>   | <b>63.5</b>   |

The Eigen value for ordination axis 1 of the plant community/environment biplot is 0.28 and the second axis is 0.23, representing 34.9 % and 63.5% of the total variance respectively (Table 8). Thus, the first two axes account for 28% of the variance in the plant community/environment data. Relevés of plant community 3 occur to the bottom right of Figure 8, and are associated with compacted soil. Sheet erosion is associated with plant community 1 (1.1, 1.2 and 1.3) and 2, and occur mostly to the top of the scatter diagram (Figure 8). Rill (Rilcm) and gully (Gulcm) erosion are shown to be of lesser significance in explaining the variation in plant communities, although in some of the relevés of plant communities 1.1, 1.3 and 2, gully and/or rill erosion was observed (Figure 8).

#### **4.6 CONCLUSION**

The descriptions and ecological interpretations of the plant communities described contribute significantly to the studies previously undertaken in the former western Transvaal grassland. Of special interest was the comparison of the degraded communities described in this chapter with other previously described communities in the area (Bredenkamp *et al.*, 1988; Bezuidenhout &

Bredenkamp, 1991; Bredenkamp *et al.*, 1994; Bezuidenhout *et al.*, 1994 and Cilliers & Bredenkamp, 1998). The vegetation was divided into woodland, shrubland and grassland communities. Woodland communities were mostly composed of trees such as *Acacia caffra*, *Acacia karroo* and *Acacia robusta*. Shrubs such as *Seriphium plumosum*, *Mundulea sericea* and *Asparagus suaveolens* grew in abundance and indicated the state of degradation.

The plant communities in the degraded areas of Spitskop were associated with big patches of bare ground characterized by different types of erosion which possibly resulted from overgrazing and trampling by livestock. The presence of exotic species also reflected the status of degradation in these communities. Uncontrolled fires, gathering of firewood and accompanying disturbances such as trampling and soil compaction are the most important threats to these communities (Cilliers & Bredenkamp, 1998). The current demands on woodlands, especially for fuel wood, exceed the supply to a significant degree and the estimation is that parts of South Africa may be totally denuded of their natural woodlands within the next 25 years (Hoffman *et al.*, 1999). Taking vegetation degradation in its entirety, the degree, extent and rate of veld deterioration in South Africa is markedly higher in communal districts (Hoffman *et al.*, 1999). The proclamation of the HNP is therefore anticipated to contribute towards the conservation of these plant communities in the grassland biome.

## CHAPTER 5

### SOIL EROSION IN THE SPITSKOP AREA, HNP

#### 5.1 INTRODUCTION

Land degradation is considered to be a collective degradation of different components of the land such as water, biotic and soil resources (Hennemann, 2001; Visser *et al.*, 2007). Soil erosion is one component of land degradation and is defined as a naturally occurring process on land and may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of topsoil (Wall *et al.*, 1987). From Chapter 4 it was clear that different types of erosion could be observed around the Spitskop area of the HNP. Factors controlling the rate and magnitude of soil erosion by water include rainfall intensity, water runoff; soil erodibility, slope gradient, slope length, and vegetation cover (Wall *et al.*, 1987). Loss of vegetation cover and change in species composition are probably the first visible forms of degradation, although it remains difficult to separate changes in veld condition due to environmental factors (such as fluctuations in mean annual precipitation) from those changes which are a result of mismanagement (Hoffman & Meadows, 2002). Despite this, the conclusion of most historical reviews and official investigations in South Africa in the past has been that it is people and their land use practices and not climate that should be blamed for the current state of the environment (Hoffman & Todd, 2000). For example, human alterations to the environment include fragmentation which, among other things, increases habitat isolation and changes the disturbance regime (Östman *et al.*, 2006).

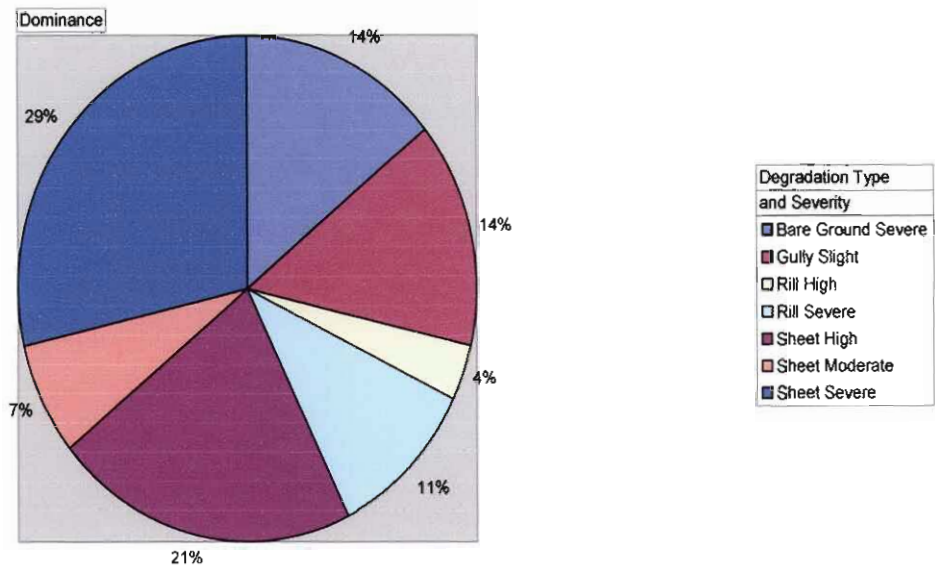
In summary it can be said that a multitude of environmental and historical factors simultaneously interact in causing land degradation (Östman *et al.*, 2006). This chapter focuses on soil erosion as one component of land degradation and the aim is therefore to identify and classify the types of soil erosion occurring in the

Spitskop area. Other causes of soil erosion, such as overgrazing, trampling by livestock, frequent fires and wood harvesting, are also briefly discussed in this chapter.

## 5.2 RESULTS

In the Spitskop area, vegetation cover was strongly and negatively associated with the degree of soil erosion. Sheet erosion was prominent in areas where there was less vegetation cover and the extent of severity ranged from slight to severe, affecting 57% of the total area sampled (Figure 9). The number of indigenous species per relevé was generally low in the degraded Spitskop areas (Chapter 4) when compared to non degraded areas (Chapter 3). Table 6 in Chapter 4 showed a summary of the Spitskop area classified according to the soil degradation types and classes associated with the plant communities. Sheet erosion was found to occur in most of the vegetation communities in the Spitskop locality except in the *Cymbopogon pospischilii* - *Elionurus muticus* Grassland (Chapter 4). The *Cymbopogon pospischilii* - *Elionurus muticus* community was also not affected by rill and gully erosion, but showed a severe stage of degradation indicated by large areas of bare, compacted soil. This severe stage of degradation in the area is possibly due to overgrazing and trampling as described by Breidenkamp *et al.* (1989) and constituted 14% of the area sampled (Figure 9).

Rill erosion affected 15% of the total area sampled (Figure 9) and formed integrated drainage networks leading to formation of gullies in most cases. The *Seriphium plumosum* – *Acacia caffra* Woodland and the *Melinis repens* – *Acacia robusta* Woodland were severely affected by rill erosion (Table 6). Gully erosion was not so severe in all affected plant communities and covered 14% of the total area sampled (Figure 9).



**Figure 9. A pie chart showing the dominance of erosion types and severity classes in the Spitskop area in the Highveld National Park.**

### 5.3 DISCUSSION

Sheet erosion leads to the formation of rill erosion and gully erosion (Figure 10) on lower slopes due to the inability of the water to infiltrate the compacted soil and therefore reaching the lower slopes with intense velocity (Valentin *et al.*, 2005). Cattle tracks were also observed to cause the formation of waterways in the form of rills or gullies where a concentration of water runoff can occur. Manyatsi (1998) found that cattle grazing around active gullies can also increase the dimension of gullies. The increase in the dimension of gullies results from the falling in of the gully walls. Rill and sheet erosion have always been measured together and the results could not be separated (Hoffman *et al.*, 1999). However, Kakembo's (1997) sequential aerial photographic study of the Pedi district in the Eastern Cape showed that the area of land affected by both rill and sheet erosion

had increased by some 12 -13% of the total area between 1938 and 1988. Morgan (1995) quoted studies from Belgium in which rills accounted for 20 – 70% of soil movement on hillsides. The soil affected by sheet erosion in the Spitskop area was prone to crusting and vegetation re-establishment in these affected areas was almost impossible except in areas where there was brush packing after wood harvesting or rare occurrences where seedlings were growing in cattle dung.



(a)



(b)



(c)



(d)

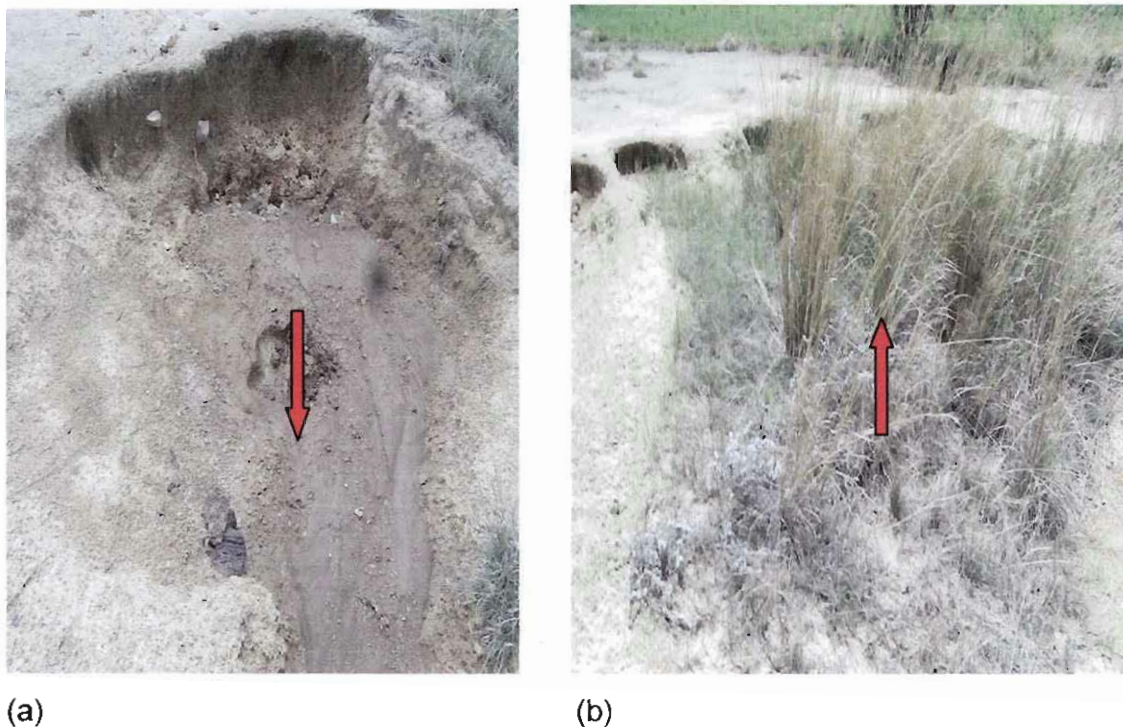
**Figure 10. Sheet (a - b) and rill (c - d) erosion in the Spitskop area in the Highveld National Park.**

Several studies on soil erosion revealed that, where gully systems form integrated drainage networks with eroding or highly eroded channels, further deterioration could occur due the absence of monitoring and rehabilitation (Hanvey *et al.*, 1991; Brady, 1993). This was evident in the study by Brady (1993) where the volume of gullies increased by 1348 m<sup>2</sup> in the seven years between 1984 and 1991 due to irresponsible land use. Gully formation processes in South Africa do not vary significantly from those in other parts of the world (Hoffman *et al.*, 1999). Hanvey *et al.* (1991) and Brady (1993) all considered sidewall erosion and collapse to be a major active gulying process.

Deepening of gullies is not mentioned anywhere in literature and some authors are of the opinion that the gullies they studied are either stable in depth or filling up due to sediment deposition. It is important to note that, in the long term, gully erosion can be a cycling phenomenon, with identifiable periods of erosion and infilling, although different areas may reach different stages at different times (Hoffman *et al.*, 1999). Sediments are sometimes deposited within the rill or gully and when those sediments are deposited for a variable period of time, they result in infilling and establishment of vegetation (Figure 11). These small infilling depressions also accumulate and hold water and provide a useful seedbed for plants.

The destruction of the protective vegetation cover by overgrazing, wood harvesting, fire and trampling (Figure 12) accelerates soil erosion and the resultant impoverished hydrological status of the soil is the ultimate cause of soil degradation (Tyson, 1986). The combination of factors such as overgrazing and trampling indirectly enhance the aridity of the area because of the reduction in vegetation cover (Beckerling, 1989). The study by Scott (1981) on veld and pasture management in South Africa revealed that excessive soil loss is due to burning practices whereby frequent fires strip canopy and basal vegetation cover, leaving an unprotected soil surface prone to erosion. Sherry (1959) also observed massive soil losses due to burning of trash after wattle harvesting in

Kwazulu Natal. Brady (1993) considered vegetation burning and the indiscriminate veld burning policy to be an influential factor in rapid gully expansion. On the contrary, Watson's (1981) study in experimental catchments at Cathedral Peak indicated no increases in sediment yield after burning. Garland's (1987) experimental plots at Kamberg and the Drakensberg showed that soil losses caused by burning alone were insignificant, although erosion from footpaths in burned grassland was much greater than that from tracks in unburned areas.



**Figure 11. Gully formation (a) and infilling of a gully (b) in the Spitskop area in the Highveld National Park.**

Several studies also revealed that the frequency of fires might affect the direction of change in woody plant density (Thomas & Pratt, 1967; Sabiti & Wein, 1987; Walters *et al.*, 2004). Some studies reported that a decrease in grass cover favours the establishment of woody seedlings due to reduced competition (Schultz *et al.*, 1955; Kanz, 2001) whereas other researchers challenged these

findings (O'Connor, 1995; Brown & Archer, 1999). There have been limited attempts in African savannas and grassland to quantitatively measure the intensity of fires and to relate fire intensity to the response of herbaceous and woody plants in terms of mortality and changes in physical structure (Trollope, 2001). Such research appears to be limited to studies conducted in the savanna areas of South Africa (Trollope, 1993). The contradictory results from literature concerning the effect of fire on vegetation and soil erosion necessitates further research, as it seems that continuous use of incorrect burning practices may have disastrous consequences on both vegetation composition and structure and soil (Walters *et al.*, 2004).

Specific human activities such as deforestation have been empirically examined and found to have an influence on biodiversity (Forester & Machlis, 1996). The effect of wood harvesting on land degradation cannot be underestimated as the removal of trees, shrubs and their litter exposes the surface soil to moving water and encourages the concentration of flowing water (Showers, 1989). There has also been a marked decline in the woodland resources, a decline that seems to be accelerating (Du Toit *et al.*, 2003) with the majority of South Africa's rural population remaining dependent upon fuel wood for their primary source of domestic energy (Griffin *et al.*, 1993; Shackelton, 1994). Observations in the Spitskop degraded areas showed significant changes in the height structure class as compared to non degraded areas. Most woody plants in the Spitskop area were new recruits possibly as a result of wood harvesting or fire. The average heights of the tree and shrub strata in the Spitskop degraded areas were found to be low (Table 7) compared to the non degraded areas (Table 4). Shackelton *et al.* (1994) studied the vegetation community structure and woody plant species composition along a disturbance gradient in a communally managed South African savanna. Their work showed that wood harvesting and other impacts that are associated with communal area management have caused a significant reduction in woody plant species richness with increasing proximity to human settlements. Woody plant density is affected by management

practices, with some studies reporting a significant reduction in the number of woody plant stems in a communally managed area as opposed to a conservation area (Shackleton, 1993). The impact of natural resource harvesting on the woody plant height structure class has also been studied, with some studies reporting a significant difference between harvested and unharvested areas (Shackleton, 1993; Higgins *et al.*, 1999).



(a)



(b)



(c)

**Figure 12. The destruction of protective vegetation cover by overgrazing (a), fire impact (b) and wood harvesting (c) in the Highveld National Park.**

The *Acacia* woodland communities form an important part of the vegetation in the HNP, and these communities are adversely affected by unsustainable wood collection (Daemane & Bezuidenhout, 2005). The current demands on woodlands, especially for fuel wood, exceed the supply to a significant degree and some estimates suggest that parts of South Africa may be totally denuded of their natural woodlands within the next 25 years (Hoffman *et al.*, 1999). For example, Williams *et al.* (1996) suggested that woodlands in communal areas of South Africa yield less than 5 million tonnes of harvestable fuel wood annually, whereas the requirement under current population and levels of development is for rather more than double this amount. Taking vegetation degradation in its entirety, the degree, extent and rate of veld deterioration in South Africa is markedly higher in communal districts (Meadows & Hoffman, 2002).

The rate of soil erosion is also highly dependent on land use, slope and climatic factors (Garland, 1987). Observations in the HNP also reflected that the degree of slope attributes to accelerated erosion in the area. Even though experimental trials were not undertaken in this study to validate the effects of slope on erosion, rill and gullies were found to occur on the lower slopes of the Spitskop hill. Several studies on soil erosion all found rills and gullies rarely evident on gradients greater than 10°, typically on unconsolidated colluvial or alluvial materials (Snyman *et al.*, 1986; Liggitt, 1988; Cobban & Weaver, 1993). The influence of slope is strongly interrelated with factors such as soil type (Brady, 1993). The upper and mid-slopes of Spitskop were characterized by shallow rocky soil and a low percentage of clay content with a good drainage system. The lower slopes were composed of deeper soils that were less rocky and relatively wetter with a high clay content and a poor drainage system, making them susceptible to rill and gully erosion. This resulted in an accelerated velocity of water runoff reaching the lower slopes with great force, causing the soil to be washed away.

Rainfall also plays an important role in both soil erosion and forage availability (Barker, 1985; Garland, 1987). Coetzee (2005) stated that runoff may occur for two reasons. Firstly, if rain has a high intensity and falls too quickly for it to infiltrate the soil (infiltration exceeds runoff), and secondly, if the soil has already absorbed all the water it can hold. Rains with high intensity can therefore cause significant soil damage, as the amount of water received by the soil can exceed its absorption capacity (Liggit, 1988). Schulze (1997) and Hoffman's (1999) review of land degradation reflected the fact that topographic influence on rainfall pattern in South Africa is evident. A review of some of the most recent predictions suggested a 10-20% decrease in summer rainfall over the central interior, as well as an increase in the frequency and intensity of floods and drought (Joubert & Hewitson, 1997). It is also predicted that there will be a linear increase in temperature with rising carbon dioxide levels, becoming 1.5 – 2.5°C hotter than present by the year 2050, with an associated increased frequency of higher temperature episodes (Joubert & Hewitson, 1997).

#### **5.4 CONCLUSION**

Degradation in the HNP was mainly evident in the form of soil erosion, habitat destruction by overgrazing, frequent fires and wood harvesting. It can be deduced from this study that soil erosion has an effect on species composition as it stresses the plants by reducing the water retention and nutrient accumulation of the soil. Soil erosion is also associated with human or natural impacts that cause and maintain the erosion process such as grazing, trampling, fire, *etc.* (Guerrero-Campo & Montserrat-Marti, 2000). Even though experimental trials on overgrazing, fire effects and harvesting of wood were beyond the scope of this study, their effects could not be overlooked. The intensity of the erosion process was observed to depend on several factors such as slope, nature of substrata, plant cover *etc.* (Morel, 1998). The intensity of soil erosion also depends on several disturbance factors such as grazing, trampling, burning *etc.* (Morel, 1998). The interaction of this complex group of factors and the long time

required for monitoring make studies of soil and vegetation dynamics very difficult (Guerrero-Campo & Montserrat-Marti, 2000). In order to understand all the factors contributing to degradation, the influence of humans on the land should also never be under-estimated. It is widely accepted that human activities are responsible for the vast majority of current habitat loss and that human population density is correlated with habitat modification (Chown *et al.*, 2003). Understanding the relationship between human activity and biodiversity is therefore critical for reducing the rate at which degradation occurs.

Several studies established a positive link between population growth and habitat loss through deforestation (Rudel, 1989). Humans play an important role in vegetation–climate feedback by igniting the majority of fires in the savanna ecosystems (Hoffmann, 2002). However, it must be noted that climate largely determines fire frequencies even where most fires are caused by people (Barbosa *et al.*, 1999) because fuel drying determines the success of both intentional and accidental ignitions and the rate of fire spread (Chiney, 1981). Livestock grazing in the HNP was observed to have an extensive impact on the vegetation, especially around waterholes where habitat use is intensive. Freshly burnt grasslands were found to be very attractive to herbivores, possibly because of its increased protein concentration, thus resulting in concentrated grazing pressure as soon as sufficient growth has occurred (Van Oudtshoorn, 1999). It is expected that increases in grazing and trampling when plants are at an early stage of growth will result in increased mortality of some plants.

Discussions of ecosystem impacts and conservation implications of climate change have not been included in the institutional frameworks of the organizations responsible for the management of protected areas for a long time (Thomas, 2006). Protected areas offer limited resistance against problems posed by rapid environmental change and those protected areas need to be changed and adapted if they are to meet the challenges posed by global warming (Markham *et al.*, 1993; Scott, 2002; Van Jaarsveld *et al.*, 2003; Hannah

*et al.*, 2005). For instance, protected areas were proclaimed in the concept of permanence, but under climate change, species for which a particular protected area was established may no longer survive and protected areas could be faced with the massive task of having to shift to keep up with moving habitats and ecosystems (Markham *et al.*, 1993). More recently, shifting range boundaries as a result of contemporary climate change has been observed for a multiple of species, underscoring the potential for climate change effects on species composition at fixed geographical points such as protected areas (Hannah *et al.*, 2005). Increased drought and aridity could also lead to land degradation and huge losses of biodiversity (Turpie *et al.*, 2002).

It is evident that climate change will introduce new challenges that will require a different set of responses. These challenges imply that some threats that have been brought under control may re-emerge (i.e., invasive species, erosion, bush encroachment *etc.*) and in other cases completely new threats may be triggered by changes in climate, suggesting a need for intensified management of present threats (Hannah & Salm, 2003). Once fully effective management of present threats is in place, or as climate-related impacts become apparent, strategies specific to climate change may be put in place (Hannah & Salm, 2003). Clearly, protected areas managers need to consider degradation and climate change in their future plans and highlight these as imperative to management effectiveness. In conclusion, soil should be considered the most fundamental natural resource that sustains economic development and human well-being. This resource, however, is experiencing degradation at an unprecedented rate (Hoffman & Todd, 2000). Based on these predictions, it is evident that a subtle interaction exists between climate patterns and land use, highlighting the necessity for integrated studies looking at the impact of different land use practices under currently changing climatic conditions. It is therefore highly recommended that the future management of the HNP be aware of the threats of degradation to biodiversity and aim to control it.

## CHAPTER 6

### MANAGEMENT UNITS IN THE HNP

#### 6.1 INTRODUCTION

Ecological units such as association, population, community, or ecosystem, have been defined and delineated in great multitudes and for many different purposes (Jax *et al.*, 1998). For example, the concept of community is sometimes defined simply as a recurring combination of species (e.g. for the purpose of classifying vegetation), while in other cases the definition is based on interactions between the component organisms (e.g. for the understanding and prediction of succession). However, the different ways in which these units are defined and used have a substantial influence on the way in which their identity through time can be examined (Jax *et al.*, 1998). If ecological vegetation units prove to be an effective biodiversity management unit basis, the management efficiency could potentially increase (Mac Nally, 2002). If all ecological vegetation units are sufficiently well covered in a reserve or protected system, there would be high confidence that biodiversity would be adequately represented (Pressey & Nicholls, 1989; Margules & Pressey, 2000).

There has been growing interest in ecosystem-based management within protected areas as a result of the recognition that protected areas are subjected to many internal and external threats (Slocombe, 1993). This interest in ecosystem management has focused on internal ecosystem management in order to maintain integrity and ecosystem health. On broader approaches, ecosystem management seeks to recognize the need to manage an entire ecologically coherent region that usually extends well beyond the protected area boundaries to include the whole ecosystem (Slocombe, 1993). However, this is not the case in the HNP as there is urban development very close to one boundary of the park. Urban areas represent a threat to a potential National Park on a number of levels including noise pollution, visual pollution, loss of

wilderness ambiances, squatting and use of natural resources. The park will therefore need to develop a Conservation Development Framework (Spies, 2004) in order to provide an overarching spatial planning framework. This planning framework should have use zones, with management guidelines and broad conservation and tourism infrastructural requirements designated for each zone (Spies, 2004). The management units in the HNP will provide valuable information when drafting the Conservation Development Framework. The framework should also address issues such as urban development close to the park and future expansion of the park. Ascertaining whether an ecosystem, a community or any other ecological unit has completely changed, been destroyed or whether it remains the same is an important task that seeks the undertaking of ecological studies (Jax *et al.*, 1988). From an ecological perspective, it is essential to make a clear distinction between different plant communities occurring within a given area because of the ecological characteristics separating them from each other. It is therefore crucial to group these plant communities together in broad management units, which can be incorporated into a management plan (Van Wyk & Bredenkamp, 1986; Brown, 1997). Some of the criteria used to determine management units are plant communities, land types, broad soil patterns, geology, topography and land use (Brown, 1997).

The aim of this chapter is therefore to identify and describe the management units of the HNP. The compilation of management units is based on ecological principles whereby differences in several attributes such as vegetation, habitat, topography and soil characteristics are used. The suggested ecological management units for the HNP are not seen as units standing on their own, but rather as areas which show similarities towards vegetation, habitat, topography, soil characteristics *etc.* These ecological management units are therefore not confined to one area alone, but exist in different areas of the park which have the above-mentioned similarities and could therefore be similarly managed. A total of six different management units were identified and are indicated on two separate management unit maps of the park (Figures 13 and 14).

## 6.2. DESCRIPTION OF MANAGEMENT UNITS

### 6.2.1 Management Unit 1

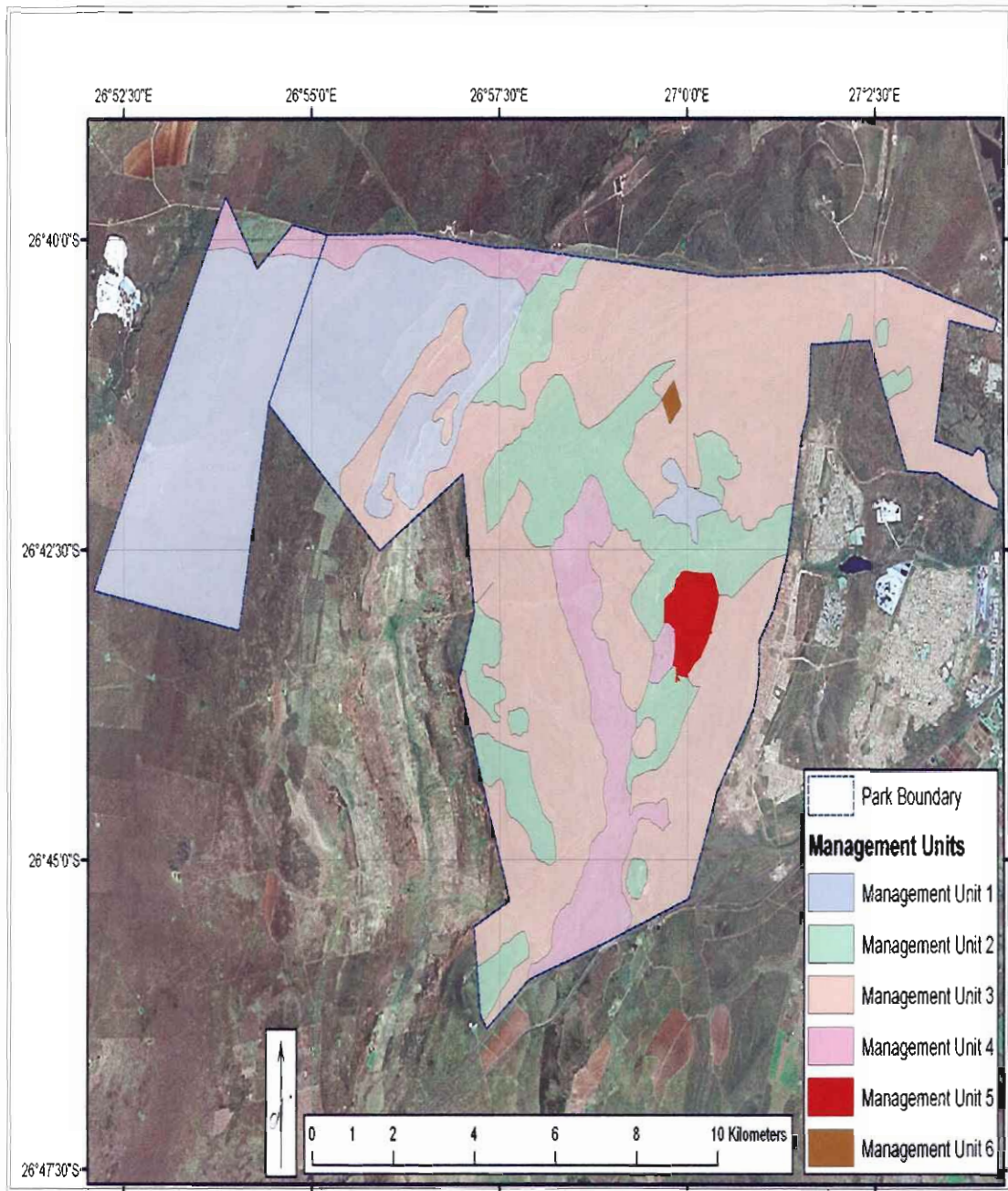
Management unit 1 (Figure 13) consisted mainly of areas associated with the midslopes and valley bottomlands of the dolomitic and rocky chert outcrops. Sinkholes were characteristically present in this unit which was underlain by dolomite. The soils of this unit were relatively shallow, well drained and with a relatively low clay content, except the sinkholes which were filled with deep sandy soil. The following plant communities occurred in management unit 1 of the HNP:

*Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland (Plant community 2 in the HNP)

*Schizachyrium sanguineum* – *Cymbopogon excavatus* Grassland (Plant community 4 in the HNP)

*Rhus pyroides* – *Acacia erioloba* Woodland (Plant community 5 in the HNP)

The tree species dominating this management unit included *Acacia erioloba*, *Celtis africana* and *Acacia caffra*. The dominant shrub species included *Rhus pyroides*, *Diospyros lycioides*, *Ehretia rigida* and *Vangueria infausta* subsp. *infausta*. The prominent grass species included *Schizachyrium sanguineum*, *Cymbopogon excavatus*, *Loudetia simplex*, *Trachypogon spicatus*, *Diheteropogon amplexus* and *Melinis nerviglumis*. Exotic plants found in this management unit included *Tagetes minuta*, *Verbena officinalis*, *Conyza bonariensis*, *Achyranthes aspera*, *Nicotiana longiflora*, *Bidens bipinnata* and *Solanum nigrum*. The floristic and habitat diversity of this management unit, especially the *Rhus pyroides* – *Acacia erioloba* community had a high conservation status and was similar to the Vaal Reefs Dolomite Sinkhole Woodland (Gh 12) described by Mucina & Rutherford (2006). The conservation status of the Vaal Reefs Dolomite Sinkhole Woodland is vulnerable and has a conservation target of 24%.



**Figure 13. Ecological management units of the Highveld National Park.**

## 6.2.2 Management Unit 2

Management unit 2 (Figure 13) was associated with the stony plains and midslopes of the rocky quartzite outcrops and hills. The soil in this unit was relatively shallow, well drained and characterized by a relatively low clay content. The following plant communities occurred in management unit 2 of the HNP:

*Mystroxyton aethiopicum* – *Pavetta zeyheri* Shrubland (Plant community 1 in the HNP)

*Diheteropogon amplexus* – *Trachypogon spicatus* Grassland (Plant community 3 in the HNP)

*Setaria sphacelata* var. *sphacelata* – *Acacia caffra* Woodland (Plant community 6 in the HNP)

Dominant trees found in this management unit included species such as *Acacia caffra*, *Acacia karroo*, *Olea europaea* subsp. *africana* and *Pappea capensis*. Dominant shrubs were represented by species such as *Pavetta zeyheri*, *Mystroxyton aethiopicum*, *Grewia occidentalis*, *Tapiphyllum parvifolium*, *Rhus pyroides*, *Ehretia rigida* and *Protasparagus suaveolens*. Dominant grasses included species such as *Panicum maximum*, *Melinis nerviglumis*, *Themeda triandra*, *Elionurus muticus*, *Diheteropogon amplexus*, *Trachypogon spicatus*, and *Cymbopogon excavatus*. Forbs such as *Helichrysum rotundatum*, *Senecio venosus*, *Vernonia oligocephala*, *Dicoma anomala* and *Aloe greatheadii* var. *davyana* were also associated with the rocky habitat of this management unit. This management unit had a high number of exotic species (18). These included species such as *Tagetes minuta*, *Verbena officinalis*, *Paspalum dilatatum*, *Conyza bonariensis*, *Achyranthes aspera*, *Bidens bipinnata*, *Gomphrena celosioides*, *Schkuhria pinnata*, *Verbena bonariensis*, *Gulleminea densa*, *Plantago lanceolata*, *Solanum sisymbriifolium*, *Chenopodium album*, *Opuntia ficus-indica*, *Oxalis corniculata*, *Zinnia peruviana*, *Oenothera tetraptera* and *Cirsium vulgare*.

### 6.2.3 Management Unit 3

Management unit 3 (Figure 13) was found on the footslopes, bottomlands and midslopes of the rocky quartzite hills. The unit was characterized by generally medium to deep soil with a relatively high clay content and a poor drainage regime. The following plant communities occurred in management unit 3 of the HNP:

*Ziziphus zeyheriana* – *Acacia karroo* Woodland (Plant community 7 in the HNP)

*Cymbopogon pospischilii* - *Themeda triandra* Grassland (Plant community 8 in the HNP)

Dominant trees found in this management unit included species such as *Acacia karroo* and *Acacia caffra*. *Acacia karroo* encroaches into the floodplains as a result of overgrazing or other forms of disturbance of the vegetation. Shrubs such as *Rhus pyroides*, *Ehretia rigida*, *Ziziphus zeyheriana*, *Asparagus suaveolens*, *Maytenus heterophylla* and *Asparagus laricinus* were evenly distributed. *Clematis brachiata* was also associated with this unit as a climber amongst the trees and shrubs. Grasses associated with this unit included *Cymbopogon pospischilii*, *Themeda triandra*, *Elionurus muticus*, *Setaria sphacelata* var. *sphacelata*, and *Eragrostis curvula*. Forbs such as *Verbena officinalis*, *Teucrium trifidum*, *Delosperma herbeum*, *Aloe greatheadii* var. *davyana*, *Sida spinosa* and *Pavonia burchellii* were prominent in this community. This unit was characterized by pioneer species such as *Conyza podocephala*, *Teucrium trifidum* and *Berkheya radula*. This management unit had the highest number of exotic species (19). These included species such as *Tagetes minuta*, *Verbena officinalis*, *Conyza bonariensis*, *Achyranthes aspera*, *Avena fatua*, *Bidens bipinnata*, *Gomphrena celosioides*, *Physalis angulata*, *Oenothera rosea*, *Oenothera tetraptera*, *Cirsium vulgare*, *Lepidium bonariensis*, *Schkuhria pinnata*, *Solanum sisymbriifolium*, *Opuntia ficus - indica*, *Oxalis corniculata* and *Zinnia peruviana*.

#### 6.2.4 Management Unit 4

Management unit 4 (Figure 13) occurred on the valley floors and in most wetland areas present at local depressions. The following plant community occurred in this management unit:

*Eragrostis plana* – *Hyparrhenia hirta* Grassland (Plant community 9 in the HNP)

This management unit was generally fairly unstable, possibly due to seasonal flooding and subsequent desiccation which, together with overgrazing, accelerate an advanced state of degradation such as compacted, bare soil and loss of vegetation cover. The soil surfaces closer to the artificial watering points exhibited large bare patches with compacted soil. These areas were an indication of overgrazing and trampling by livestock in the past and had a lower vegetation cover.

Trees were absent in this management unit and a few shrubs such as *Asparagus suaveolens* and *Asparagus laricinus* were very pronounced and seemed to increase with degradation. Prominent grass species in this unit were *Eragrostis plana*, *Hyparrhenia hirta*, *Cymbopogon pospischilii*, *Elionurus muticus*, *Eragrostis chloromelas* and *Setaria sphacelata* var. *sphacelata*. This unit was characterized by pioneer species such as *Verbena officinalis*, *Conyza podocephala* and *Berkeya radula*. Exotic plants found in this management unit included species such as *Verbena officinalis*, *Paspalum dilatatum*, *Conyza bonariensis*, *Ciclospermum leptophyllum*, *Persicaria lapathifolia*, *Oenothera rosea* and *Oenothera tetraptera*.

## 6.2.5 Management Unit 5

### Spitskop

Management unit 5 (Figure 14) was associated with the valley bottomlands, footslopes, midslopes and crest of the quartzite Spitskop hill. Two plant communities, *Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland and *Diheteropogon amplexans* - *Trachypogon spicatus* Grassland were included in management unit 2, but excluding the Spitskop area (Figure 9). These two plant communities also occurred in the Spitskop area and shared a similar habitat with the degraded plant communities found in this area. All plant communities occurring in the Spitskop areas were therefore grouped under management unit 5, consisting of four sub-units.

#### Management Unit 5: Sub-unit 1

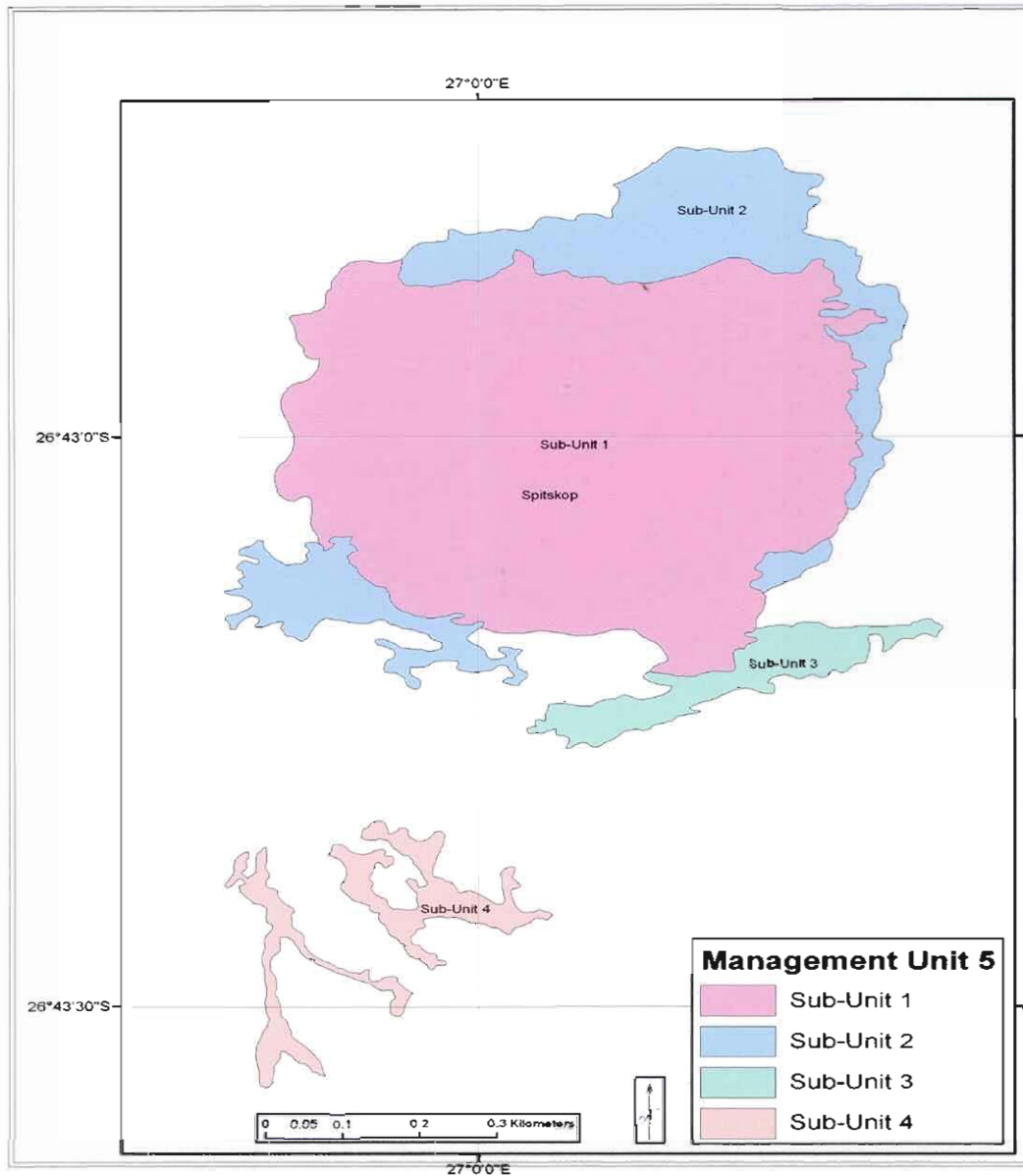
Sub-unit 1 (Figure 14) occurred on the crest and midslopes of the rocky quartzite Spitskop hill and was characterized by shallow soil not affected by erosion. The following plant communities occurred in this sub-unit:

*Loudetia simplex* - *Vangueria infausta* subsp. *infausta* Shrubland (Plant community 2 in the HNP)

*Diheteropogon amplexans* - *Trachypogon spicatus* Grassland (Plant community 3 in the HNP).

Dominant species found in this community included grasses such as *Loudetia simplex*, *Diheteropogon amplexans* and *Trachypogon spicatus*. These species were typically characteristic for the relatively dry habitat and shallow rocky soils. Shrubs in this sub-unit included species such as *Vangueria infausta* subsp. *infausta*, *Mundulea sericea* and *Zanthoxylum capense*. *Acacia caffra* represented the tree stratum in this management sub-unit. Exotic plants found in this sub-unit

included species such as *Tagetes minuta*, *Verbena officinalis*, *Conyza bonariensis*, *Achyranthes aspera* and *Nicotiana longiflora*.



**Figure 14. Four sub-units found in management unit 5 of the Spitskop area in the Highveld National Park.**

## Management Unit 5: Sub-unit 2

Sub-unit (Figure 14) occurred on the rocky quartzite midslopes of the Spitskop hill and was generally characterized by pronounced sheet, rill and gully erosion. Wood harvesting was also evident in this subunit. The following plant communities were found in this sub-unit:

*Setaria sphacelata* var. *sphacelata* - *Acacia caffra* Woodland (Plant Community 6 in the HNP).

*Seriphium plumosum*- *Acacia caffra* Woodland (Plant Community 1 in the Spitskop area).

*Acacia caffra* was the dominant tree in this sub-unit and the abundance of *Seriphium plumosum* was a clear indication of degradation in this sub-unit. *Setaria sphacelata* var. *sphacelata*, *Eragrostis racemosa*, *Aristida bipartita*, *Eragrostis rigidior* are the dominant grasses in this sub-unit. Shrubs present included species such as *Ziziphus zeyheriana*, *Rhus pyroides* and *Euclea undulata*. This sub-unit had a high number of exotic species (18). These included plants such as *Verbena officinalis*, *Paspalum dilatatum*, *Conyza bonariensis*, *Achyranthes aspera*, *Bidens bipinnata*, *Schkuhria pinnata*, *Verbena bonariensis*, *Gulleminea densa*, *Plantago lanceolata*, *Solanum sisymbriifolium*, *Chenopodium album*, *Oxalis corniculata*, *Zinnia peruviana*, *Oenothera tetraptera*, *Cirsium vulgare*, *Gomphrena celosioides*, *Solanum elaeagnifolium* and *Opuntia ficus-indica*.

### Management Unit 5: Sub-unit 3

Sub-unit 3 (Figure 14) occurred on the footslopes of the quartzite Spitskop hill and was affected by sheet, rill and gully erosion. This sub-unit was encroached by *Acacia karroo* due to changes in the grazing and/or fire regime in the management of this grassland. The following plant community was found in this sub-unit:

*Setaria sphacelata* var. *torta* – *Eragrostis curvula* Grassland (Plant community 2 of the Spitskop area).

Dominant grasses in this sub-unit included species such as *Setaria sphacelata* var. *torta*, *Eragrostis curvula* and *Digitaria eriantha*. Shrubs included species such as *Grewia flava* and *Asparagus laricinus*. Species such as *Aloe greatheadii* var. *davyana* were abundant in this sub-unit and their cover seemed to increase under severe conditions of degradation. Exotic plants found in this sub-unit included species such as *Gomphrena celosioides*, *Plantago lanceolata*, *Oxalis corniculata* and *Solanum elaeagnifolium*.

### Management Unit 5: Sub-unit 4

Sub-unit 4 (Figure 14) occurred on the valley bottomlands and floodplains and was characterized by bare patches of compacted soil resulting from overgrazing and trampling. The following plant community was found in this sub-unit:

*Cymbopogon pospischilii* – *Elionurus muticus* Grassland (Plant community 3 in the Spitskop area).

Dominant grass species found in this sub-unit included species such as *Cymbopogon pospischilii*, *Elionurus muticus*, *Eustachys paspaloides* and *Aristida congesta* subsp. *congesta*. Other dominant species included the dwarf shrub *Sida alba*, the forb *Vernonia oligocephala*, the tree *Acacia karroo* and exotic species such as *Gomphrena celosioides* and *Oxalis corniculata*.

## 6.2.6 Management Unit 6

### DUMPING SITE

The existence of an official dumping site of the Potchefstroom Municipality (Figure 13) within the protected area is one unique scenario that should be taken into consideration in the HNP. The management of this area is exclusively undertaken by a contracted private company (Millenium Utility Company). It must be ensured that the highest standards are maintained to comply with the second addition of the Minimum Requirements for Waste Disposal by Landfill (released by the Department of Water Affairs and Forestry during 1998).

Proper management control in the dumping site is crucial and presently includes the following (Millenium Utility Company, 2003):

- Gate control
- Record keeping (different waste stream)
- Ensuring maximum compaction (air space control)
- Daily cover
- Methane monitoring
- Nuisance control (flies, odours *etc.*)

Small quantities of hazardous waste are allowed from the residents of the communities that the site serves and a container built for this purpose was supplied for these wastes to be disposed. The container is emptied on a regular basis at a permitted Landfill Facility (Millennium Utility Company, 2003). The proper management of any landfill cannot be overemphasized since this solely determines the long-term success of a landfill (Millennium Utility Company, 2003).

### 6.3 CONCLUSION

The description of the plant communities together with the vegetation map assisted in the formulation of management units for the HNP. The formulation of management units based on ecological principles serves as the basic foundation forming an integral part of future strategic management plans. The management units make it possible to manage the different sections of the park in collected and identical units and not as broken and unmanageable areas.

Management unit 1 was associated with the *Rhus pyroides* – *Acacia erioloba* community occurring in the dolomitic and rocky chert outcrops, and had a high conservation status. The *Rhus pyroides* – *Acacia erioloba* community was similar to the Vaal Reefs Dolomite Sinkhole Woodland (Gh 12) described by Mucina & Rutherford (2006). The conservation status of the Vaal Reefs Dolomite Sinkhole Woodland is vulnerable and has a conservation target of 24%. A study on the historical background of the area may provide some answers concerning the current state of degradation in certain areas of the park such as Spitskop. The cause of degradation differs and includes factors such as wood harvesting, overgrazing by livestock, soil erosion and frequent fires. Subunit 4 in management unit 5 was characterized by areas of bare compacted soils indicating overgrazing and trampling by livestock in the past and had less vegetation cover. Of special interest were the exotic plant species found in these management units and their association with degradation. Subunit 3 in management unit 5 in the Spitskop area was adversely affected by sheet, rill and gully erosion. Wood harvesting was also evident in this management unit. This observation re-emphasizes the necessity for an alien eradication and rehabilitation program in the park. Special attention must be given to management units 2, 3 and 5 as they had a high number of exotic plant species. Future park management should also ensure that biodiversity objectives are not compromised by the existence of waste disposal sites within the HNP. Management recommendations are provided in Chapter 7.

## **CHAPTER 7**

### **MANAGEMENT RECOMMENDATIONS FOR THE HNP**

#### **7.1 INTRODUCTION**

The focus of degradation in this study was mainly limited to the Spitskop area due to the pronounced impact on the surrounding area. It was observed that the main cause of degradation in this area was soil erosion by water run-off from the steep slopes of Spitskop. Other factors such as overgrazing, fire and trampling by livestock contributed to the reduction of resource potential on land. Different types of erosion were identified and some of the factors influencing erosion were discussed in Chapter 5. Alien species also deteriorated the physical, chemical, biological and economic properties of soil. They also had an effect on the hydrological status and compete with the indigenous flora over the long-term. Alien species occurring in the HNP were mentioned in Chapters 3, 4 and 6, and the management of these species will be briefly discussed in this chapter. A rehabilitation plan will be required in order to attain the recovery of ecosystem processes, productivity and services.

Definitions of rehabilitation and restoration in this thesis follow that of Coetzee (2005). According to Coetzee (2005) rehabilitation emphasize the recovery of ecosystem process, productivity and services. It returns some of the functions of the original pre-disturbance ecosystem and the historical or pre-existing ecosystem. Restoration shares with rehabilitation the reparation of ecosystem processes to as close to the original structure and function as possible, but differs in that it also includes the re-establishment of the pre-existing biotic species composition and community structure (Coetzee, 2005). Restoration generally requires more post-rehabilitation after-care and it takes much longer to achieve the desired result (Coetzee, 2005).

The aim of this chapter is therefore to recommend a rehabilitation plan that seeks to achieve the following:

- reduction of the speed of water run-off in order to reduce the erosive force of water on unprotected soil surfaces,
- retaining of soil, plant debris, and seed that may be carried away by water run-off,
- improving the vegetation cover of the degraded areas,
- upholding and increasing the biodiversity of the land, and
- eradication of all alien species found in the park

## 7.2 SOIL EROSION CONTROL MEASURES

The proposed strategies for soil conservation are based on covering the soil for protection from raindrop impact; increasing the infiltration capacity of the soil to reduce impact; increasing the infiltration capacity of the soil to reduce runoff; improving the aggregate stability of the soil; and increasing surface roughness to reduce the velocity of runoff (Wall *et al.*, 1987). The reduction of water runoff velocity could increase the chance of vegetation re-establishment and thus minimize the erosion problem. Control measures regarding sheet, rill and gully erosion must also aim at slowing concentrated runoff water flow to reduce its velocity and also to capture sediments (Valentin *et al.*, 2005). The soil on sheet erosion patches and other meagerly vegetated areas develop a hard surface crust due to long exposure to sun, wind and raindrop impact (Figure 15), inhibiting penetration of water into the soil. An appropriate organic substrate is required to facilitate seed germination in hard surfaces such as in areas impacted by sheet erosion. For example, small seedlings of *Chenopodium album* were found growing on cattle dung in some of the areas affected by sheet erosion (Figure 16). Other methods such as mechanical soil cultivation were found to be effective in combating sheet erosion (Van der Merwe & Kellner, 1999). Subsoil cultivation with a ripper is recommended in areas affected by sheet erosion and the rip furrows must be at least 200 mm deep to ensure the best effect (Van der

Merwe & Kellner, 1999). Mechanical soil cultivation facilitates better water infiltration into the soil and also creates a favourable micro-habitat for the optimal propagation of seedlings (Wight & White, 1974; Van der Merwe & Kellner, 1999).



**Figure 15. Exposed soil with eroded stones and rock particles in the Spitskop area in the Highveld National Park.**



**Figure 16. Cattle dung providing a good growth medium in an area affected by sheet erosion in the Spitskop area in the Highveld National Park.**

Two methods, namely stone packing and brush packing worked effectively in areas that were previously affected by erosion in the HNP. Stone packing diverts and reduces the speed and force of runoff water and traps water-carried soil particles and organic matter (Figure 17). Stone packing also traps valuable plant litter and keeps it in place over the soil, protecting and enriching the soil and the important detritivores that live in it (Coetzee, 2005). Rows of stones can be stacked along the contours to obstruct the runoff of water, thereby improving the moisture status of the soil. Plants, especially grasses, can be established above the rows of stones (Van Oudtshoorn, 1999).

Brush packing is also an effective and renewable resource if sensitively harvested. Branches of trees can be packed over the bare patches (Figure 18a). Brush packing, even at a very low scale (Figure 18 b-c), plays an important part in capturing sediments. A very small amount of sediments can capture seeds and ultimately result in the establishment of vegetation. Brush packing is effective in protecting bare patches against the wind, sun and also probably new seedlings against early grazing and other natural factors (Van Oudtshoorn, 1999). Brush-packing also provides cover for a large number of animals including reptiles, rodents, hares, small carnivores and hosts of invertebrates (Coetzee, 2005). These animals also leave their droppings and remnants of their meals, which decompose and help to build up the organic components of the topsoil. Many of these animals also burrow into the soil, which assists with infiltration of water (Coetzee, 2005).

According to Coetzee (2005), the most effective method to reclaim gully erosion is to stack stones in gabions (wire baskets) so as to catch sediments but allow the water to pass through with a reduced velocity. Gabion constructions should immediately be followed by seeding or planting for the establishment of vegetation cover. Branches can also be piled in gullies to capture sediments (Van Oudtshoorn, 1999). Research has shown that an increase in root density of grass and other plants results in an exponential decrease of concentrated flow

erosion rates (Gyssels & Poesen, 2003). Care must be taken to ensure that the removal of stones does not become the cause of a new erosion problem at the source of the material (Coetzee, 2005). It is crucial to treat gullies in the early stages of formation rather than to try to repair the damage once a deep gully has formed (Coetzee, 2005). Small rills that are starting to open can be easily controlled by filling them with brush or stones.



**Figure 17. The soil erosion control measure using stone packing in the Spitskop area in the Highveld National Park.**



(a)



(b)



(c)



(d)

**Figure 18. The soil erosion control measure using brush packing in the Spitskop area in the HNP.**

The recovery progress of the rehabilitated areas needs to be monitored at regular intervals to evaluate the effectiveness of the methods employed (Table 9). A class score (1 – 4) is given for each level of erosion (soil movement, surface litter, flow pattern, sheet erosion, flow patterns, rills, gullies) at four different erosion severity classes (Table 9). For example, erosion severity class 1 has a total score of 6 points (1 x 6), class 2 has a total score of 12 points (2 x 6) etc. The presence of soil movement, surface litter and flow patterns indicate the availability of transport of resources from upslope sources in the landscape and imply some soil instability (Coetzee, 2005; Savory, 1990). Little evidence of flow patterns indicates slight erosion whereas numerous flow patterns indicate severe erosion. A score of 6 points or less in Class 1 indicates conditions of stable soil surface whereas a score of 24 points in Class 4 will be an indication of severe soil erosion (Table 9). These guidelines can be used together with Table 2 whereby the severity of different types of soil erosion can be measured and monitored over time. The rehabilitation of degraded areas in Spitskop can be monitored by observing the condition of soil movement, surface litter, flow patterns and also measuring the severity of sheet, rill and gully erosion in all affected plant communities in each management unit.

This guide should be used together with vegetation monitoring methods, including the fixed-point photographic method (Coetzee, 2005). Vegetation monitoring in rehabilitated areas will provide information about the subtle changes in species composition. Photographs at fixed points and directions should be taken when undertaking the floristic composition survey, enabling the comparison of different sets of photographs taken at different dates. The individual photographs must be numbered reflecting the date that the photographs were taken. By applying this guideline as a monitoring tool, the distinction will be made between areas where erosion is likely to occur and areas where erosion is becoming severe. The monitoring interval should be three to six months but this will depend on rainfall and the rate of vegetation recovery in the area.

**Table 9. Approaches in monitoring degradation status in the Highveld National Park (Adapted & modified from Savory, 1990).**

| Class                        | 1   | 2   | 3   | 4  |
|------------------------------|---|---|---|--|
| Soil movement                | Little evidence of movement of soil particles.  | Moderate movement is visible and recent<br>Slight terracing evident.                              | Soil movement with each event deposited against obstacles.                                  | Sub-soil exposed over much of the area.  |
| Surface litter               | Litter accumulating and incorporated into soil. Rapid breakdown   | Little movement by wind and water evident. Slow breakdown.  | Extreme movement, large deposits against obstacles  | Litter removed by animals, wind and water.   |
| Flow patterns                | Little evidence of particle movement  | Well-defined, small & intermittent.   | Flow patterns evident with deposition of soil & litter                                      | Patterns numerous and noticeable. Large barren fan deposits  |
| Sheet                        | No evidence of sheet erosion.   | Low percentage of small scattered rocks (< 10%).  | High percentage of small scattered rocks (> 10%).   | Exposed sub-soil surface developing into hard crust with less vegetation.  |
| Rill erosion                 | Small rills absent or at infrequent intervals. Vegetation present in depressions. Rills < 3 cm in depth | Rills 2.5 – 20 cm wide occurring in exposed areas, at frequent intervals, greater than 3 m apart. | Rills occur frequently and quickly, cutting sides, often exposing roots.                    | Rills joining at short intervals and denuding large areas. Wider braided rills 15 – 20 cm                            |
| Gully erosion                | May be present in stable condition. Slopes and channels generally stable and vegetated.                 | Gullies present but with falling sides from animal impact, vegetation becoming established.       | Gullies numerous and well-developed. Active erosion evident along 25 – 50% of their length. | Sharply inclined gullies with little vegetation over large areas; gullies actively eroding over 50% of their length. |
| Score                        | 6   | 12  | 18  | 24   |
| Explanation of rating scores | Soil Surface conditions are stable. No action required.   | Conditions indicate some active erosion. Consider management intervention                         | Condition deteriorating. Implement erosion control programme                                | Situation is severe. Intensive erosion control required.   |

### 7.3 ERADICATION OF ALIEN VEGETATION

The percentage of alien vegetation found in the degraded areas and the park as a whole is very low in comparison to that of the natural vegetation (Table 3 & 5). The following alien species were identified in different plant communities in the HNP (Chapter 3 & 4):

*Achyranthes aspera*, *Bidens bipinnata*, *Cirsium vulgare*, *Conyza bonariensis*, *Gomphrena celosiodes*, *Lepidium bonariensis*, *Nicotiana longiflora*, *Oenothera rosea*, *Oenothera tetraptera*, *Opuntia ficus-indica*, *Oxalis corniculata*, *Physalis angulata*, *Plantago lanceolata*, *Solanum elaeagnifolium*, *Solanum nigrum*, *Solanum sisymbriifolium*, *Zinnia peruviana*. Additional species such as *Eucalyptus camaldulensis* were also identified in the HNP.

The Conservation of Agricultural Resources Act (CARA, Act No 43 of 1983, amended, 2001) previously classified problem plants in two groups – declared weeds and plant invaders (Henderson, 2001). The amended regulation makes provision for four groups – declared weeds (Category 1 plants), plant invaders (Category 2 & Category 3 plants) and indicators of bush encroachment. The following species in the list above fall under Category 1 weeds:

*Achyranthes aspera*, *Cirsium vulgare*, *Opuntia ficus-indica*, *Solanum elaeagnifolium* and *Solanum sisymbriifolium*.

These are prohibited plants that should not be tolerated as they are able to invade undisturbed environments and transform or degrade natural plant communities. They also use more water than the plant communities they replace or can be particularly difficult to control (Henderson, 2001). Most of the plants in this category produce copious numbers of seeds, are wind or bird dispersed or have highly efficient means of vegetation reproduction.

*Eucalyptus camaldulensis* falls under Category 2 plants. This plant has proven potential of becoming invasive, but nevertheless has certain beneficial properties

that warrant its continued presence in certain circumstances (Henderson, 2001). CARA makes provision for Category 2 plants to be retained in special areas demarcated for that purpose, but those occurring outside demarcated areas have to be controlled. The exception is that Category 2 plants may also be retained or cultivated in biological control reserves, where the plants will serve as host plants for the breeding of biological control agents (Henderson, 2001).

The presence of these alien invasive plants may jeopardize the existence of other species by adversely affecting preferred habitats (USDA, 1999). Areas invaded by these alien plants need to be classified according to the degree of infestation. Although each species acts differently in the environment and in its interaction with other species, eradication of all alien vegetation within the boundaries of the HNP and surrounding areas should be considered a high priority.

Monitoring of these species should aim at the long-term reduction in density and abundance of an invasive species to below a pre-set acceptable threshold. The damage caused by the species below this threshold is considered acceptable with regard to damage to biodiversity (Foxcroft, 2003a). In order to evaluate the success or failure of management efforts, the populations of invasive species, the condition of the area under control and the changes in species composition and dominance should be monitored. Targets for success may be the removal of the invasive species if the option chosen is eradication, but if it is control, then the criteria for success may be a measure of some other feature such as the return of a plant. Plant control may involve manual methods (e.g. hand pulling, cutting, mowing, *etc.*); herbicides or chemical methods, the release of biological control agents, controlled use of browsing or grazing animals; prescribed fires; and other land management practices (Foxcroft, 2003b). The use of chemical control might have an adverse impact on the surrounding ecosystem and careful consideration must be taken before application. However, it must be noted that the complete eradication of alien plants is unrealistic (Coetzee, 2005) and it is

therefore crucial to rather prevent the further spread of alien plants into uninfected areas and isolate the dense infestations within a landscape that is maintained free of alien plants.

#### **7.4 BURNING REGIME**

Fire managers seeking to maintain biodiversity may have multiple objectives to meet even in conservation areas (Gill, 2001). The protection of human life and property is often paramount; aesthetics, cultural protection and smoke management may also be of concern (Gill, 2001). Application of any fire policy creates fire regimes that have implications for biodiversity and socio-economic conditions (Gill, 2001). The basic role of protected areas was to separate elements of biodiversity from processes that threaten their existence by establishing them in remote areas (Margules & Pressey, 2000). A more systematic approach to locating and designing protected areas has been evolving and this approach will need to be implemented if a large proportion of today's biodiversity is to exist in a future of increasing numbers of people and their demands on natural resources (Margules & Pressey, 2000).

The challenge in the HNP is the presence of recent urban developments very close to the N12 boundary. The HNP management will need an ecologically sound and socially responsible fire regime policy and a monitoring and evaluation system in order to reach amicable solutions with the community. The objectives need to reconcile considerations of biodiversity conservation with fire security. It is proposed that neighbouring communities should be approached with a view to forming a Fire Protection Association in terms of Act 101 of 1998. Firebreaks should be applied on the boundary between the park and any adjoining lands and also in the park around fixed property, infrastructure improvements, movable property, fauna and flora to limit and reduce the damage and losses caused by fires to life.

Fire is ecologically used to remove moribund and or unacceptable accumulated grass material in order to maintain the natural habitat of the area (Trollope & Potgieter, 1986; Trollope & Trollope, 2004). It is also used to create or maintain an optimum relationship between herbaceous and woody vegetation where necessary, and to encourage wildlife to move to less preferred areas in order to minimize the overuse of preferred areas (Trollope & Trollope, 2004). A variety of fire regimes incorporating different frequencies, intensities, seasons and types of fire were described by Trollope & Trollope (2004) and can be applied in the HNP. The total area to be burnt can be determined as a function of the estimated standing grass fuel load at the end of the growing season. This is determined by using a disc pasture meter (Bransby & Tainton, 1977; Trollope & Potgieter, 1986). The prescribed burns are applied when the grass sward is dormant to avoid any detrimental effects on the re-growth and basal cover (Trollope & Trollope, 2004).

The frequency of burning varies as a function of the stocking rate of grazing animals and the amount of rainfall the park receives. When burning to remove moribund material, the frequency of burning depends on the rate at which the grass sward becomes moribund, i.e. accumulated grass fuel load greater than 4000 kg/ha (Trollope & Trollope, 2004). An increased burning frequency results in an increased number of pioneer grass species due to nutritional attractiveness of the burned areas and therefore heavy grazing by herbivores (Trollope and Potgieter, 1985). Fire intensity varies according to the reason for burning (Trollope & Trollope, 2004). When burning to remove moribund material, a cool fire of < 1000 kJ/s/m is recommended. This is achieved by burning when the air temperature is <20°C and the relative humidity >50 %. When burning to maintain the balance between herbaceous and woody vegetation, an intense fire of >2000 kJ/s/m is required (Trollope & Trollope, 2004). This is achieved when the grass fuel load is >4000 kg/ha, air temperature is >25°C and the relative humidity is <30 %. This results in significant top-kill of stems and branches of trees and

shrubs up to a height of 3 m, making the vegetation more available for shorter browsing animal species (Trollope & Trollope, 2004).

Limits are set to the area burnt to help ensure adequate supplies of forage for herbivorous wildlife. It is recommended that no more than 50% of the area be burnt in the grassland ecosystems (>700 mm rainfall per year). The application of patch burns during the burning season has the effect of attracting grazing animals to a different, newly burnt area after each fire (Brockett *et al.*, 2001). This minimizes the possible deleterious impact of heavy, continuous grazing in any one area after burning (Brockett *et al.*, 2001)

## **7.5 CONCLUSION**

Over the past two decades, the science of ecology has undergone many significant shifts in emphasis and perspectives, which have important implications for how we manage ecosystems and species (Wallington *et al.*, 2005). Degradation (both natural and human induced), climate change and the heterogeneous nature of vegetation communities are concepts that dominate current ecological thinking (Wallington *et al.*, 2005). Worldwide, loss of habitat is regarded as the foremost cause of loss of biodiversity, and South Africa is no exception (Mucina & Rutherford, 2006). Management of protected areas needs to focus not only on species and threats but also on land degradation in general (Rutherford *et al.*, 1999a; Rutherford *et al.*, 1999b; Lovejoy, 2006).

Protected areas are the most important and effective components of current conservation strategies, and they are the central elements of climate change (Bruner *et al.*, 2001). This means that protected areas may not provide adequate future safeguards for the continued survival of existing ecosystems and species in a changing world (Bruner *et al.*, 2001). As climate changes, the role of protected areas will certainly expand with associated shifts in species ranges and new management strategies will be required (Hannah & Salm, 2003). Priority

needs to be given to threats that are most likely to be affected by, or interact with, variation in climate (Hannah & Salm, 2003). Examples are fire management, flood regimes and invasive species. For example, combating erosion at much earlier stages or eliminating an invasive species may be possible at a much lower level of management resources prior to climate change, and be more expensive or impossible once climate change is evident (Hannah & Salm, 2003). Such steps to control current threats, while not tailored specifically for climate change, are good initial investments in climate change management (Hannah & Salm, 2003; IUCN, 1993; IPCC, 2002).

## CHAPTER 8

### CONCLUDING REMARKS

The proposal to establish the HNP as one of the protected areas in the Grassland Biome was a great initiative towards biodiversity conservation. Grassland, which forms the major vegetation type in the natural and semi-natural areas in the Potchefstroom area of the North West Province in South Africa, is not included in the eight conservation "hot-spots" of plant diversity and endemism in southern Africa, described by Cowling & Hilton-Taylor (1994). The term 'hot-spots' describes areas that are characterized by high species richness, a high concentration of endemic species and which are experiencing high rates of habitat modification or loss. It is therefore imperative to determine the location and extent of the major vegetation types within the Grassland Biome. Over the past years, significant information was gathered on the grassland of the former western Transvaal (Bezuidenhout *et al.* (1994a, b, c, d and e). The vegetation of heavily disturbed areas in and around urban environments in Potchefstroom was also studied by Cilliers and Bredenkamp (1998); Cilliers *et al.* (1998), Cilliers & Bredenkamp (1998) and Cilliers *et al.* (1999).

The objectives of the present study to obtain data on the floristic composition and structure of the plant communities in the HNP were achieved. The plant communities in the HNP were identified, described and ecologically interpreted, resulting in a total of 12 plant communities and 3 subcommunities. Identification of these plant communities resulted in detailed vegetation and management unit maps. The Braun-Blanquet approach proved to be an accurate and effective way to identify and classify plant communities based on their floristic composition. Indirect and direct gradient analyses were successfully used to confirm and refine the classification and to determine any possible environmental gradients. Different types of soil erosion were also identified and categorized according to their severity classes. Future management recommendations on soil erosion, eradication of alien vegetation, burning regime and monitoring were also made.

The achievement of all these objectives serves as a basis to develop the management plan for the HNP to ensure the sustainable utilisation and conservation of the vegetation of the area. This study will serve as a tool to give decision-makers on local, provincial and national level enough information to continue to protect and develop this Grassland National Park in a sound and ecologically sustainable manner.

At the beginning of 2007 when this study was at the completion phase, the fence surrounding the park was constructed, and the main entrance gate to the park was about to be finished. However, problems such as fence cutting, harvesting of trees for firewood, uncontrolled fire and livestock grazing were still evident in the park. This signifies the importance of conservation to the economy and to people's lives as it is evident that the rural and urban poor are those worst affected because they depend directly on the environment for their livelihood (Mucina & Rutherford, 2006). The HNP is threatened by increasing urbanization and it is of the utmost importance to recognize the causes of loss of biodiversity, and implement measures to reduce these pressures and impact. There is a need for regular and open communication between conservation bodies and affected communities living adjacent to the park. Low levels of conflict are associated with open and regular communication; while the absence of communication or the selective giving of information is associated with high conflict (Fabricius *et al.*, 2001). Many of the past conflicts arose from differences in knowledge and understanding between communities and conservationists. It is therefore clear that problems arising from the HNP are not only confined to those that are measured scientifically, but also include a multitude of social ones as the park exist in a social as well as an ecological matrix. Few studies on relationships between human activity, species richness, and conservation requirements have, to date, been undertaken (Chown *et al.*, 2003; Forester & Machlis, 1996) and it is therefore necessary to identify the major social and economic forces that are currently driving the loss of functional diversity (Folke *et al.* 1996).

Due to the scope of the study, all other relevant questions arising during the period of the study could not be addressed. For example, biodiversity loss includes not just the extinction of species, but any change in species and ecosystems that results from human activity and therefore compromising the structuring processes upon which the survival of human beings depends (Perrings *et al.*, 1992). Therefore, the potential driving forces of environmental degradation and biodiversity loss, including human population growth, economic development and policies need further studies (Meffe *et al.* 1993). This approach to biodiversity conservation supports a strategy that refocuses biodiversity research and policy away from genetic information and conservation of species for tourism and recreation in nature reserves and national parks, and towards conservation for protection of ecosystem function and resilience (Perrings *et al.*, 1992). Social ecology studies looking at sustainable utilization of natural resources will also be of the utmost importance to the management of the park.

Degradation within and outside protected areas is also becoming a serious concern and therefore there is a need for research linking degradation with recent threats such as climate change. Changes in climate will require adjustments to management, both to maximize the effectiveness of existing protected areas (which may not have been selected for their biodiversity or with climate change in mind) and to ensure that change is managed in a coordinated fashion throughout the protected areas in a given system (Hannah & Salm, 2003). A new synthesis of biogeography and conservation biology is necessary to respond to the challenges posed by climate change to the conservation of biological diversity (Hannah *et al.*, 2002). Biogeography has developed increasingly detailed understanding of past and future biotic responses to climate change, but the application of these results in reserves design, selection and management has been limited (Hannah *et al.*, 2002). New collaboration between these disciplines is urgently needed if the impending impacts of anthropogenic climate change are to be addressed in the strategies for conserving biodiversity.

There is also a need to monitor soil erosion and the effect of fire in the HNP. Further research will enable a greater understanding of the complexities of the fire and soil erosion relationship. The floristic composition of the HNP grassland can be investigated further in an attempt to identify how the species composition reacts to the frequency and timing of burns, as well as the continued monitoring of the vegetation cover in response to different burn treatments. The contribution of overgrazing and fire to erosion in comparison to natural erosion also requires further study. Other negative impacts in the HNP include alien and invasive species. Five alien species (*Achyranthes aspera*, *Cirsium vulgare*, *Opuntia ficus-indica*, *Solanum elaeagnifolium* and *Solanum sisymbriifolium*) of Category 1 declared weeds were identified in the HNP. These are prohibited plants that should not be tolerated as they are able to invade undisturbed environments and transform or degrade natural plant communities (Henderson, 2001). One species, *Eucalyptus camaldulensis*, a Category 2 plant, also occurs in the HNP. This category includes plant species with proven potential of becoming invasive, but which nevertheless have certain beneficial properties that warrant their continued presence in certain circumstances (Henderson, 2001).

The analysis of potential herbivore carrying capacity as well as the ability to support stable carnivore populations was also beyond the scope of this study and need further detailed research. Vegetation in the HNP is already subjected to overgrazing, resulting in degradation and the subsequent presence of many pioneer species and exotic species as discussed in this thesis. The potential to support stable predator populations within the park will be extremely limited (Holness, 2003). For example, a single pride of 10 lions require around 45 000 ha and this suggests that an introduction of larger predators would be impossible in the park (Holness, 2003). Further research is also required after introduction of game in the park in order to monitor their effects on vegetation.

The future success of the HNP depends not only on the different stakeholders (Potchefstroom City Council, South African Defence Force, Barolong Local Community and South African National Parks) involved, but also requires the undivided support of the community at large.

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