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# VEGETATION STUDIES IN THE MANAGEMENT OF UNGULATES ON THE BYNESPOORT GAME PARK, CULLINAN

by
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**Submitted in partial fulfilment of the degree Magister Scientiae**

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Any omissions are sincerely regretted

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## ABSTRACT

A Braun-Blanquet vegetation survey was done for Bynespoort Game Park. Ten plant communities, and sub-communities within these, were identified and described. For each of the communities identified, the veld condition, woody vegetation structure, browsing capacity, and grazing capacity were determined. Hereafter decisions were made regarding the management of the ungulates found on the Game Park, also taking into consideration the selection of habitat by the ungulates.

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The veld condition was mostly satisfactory. After determining the grazing and browsing capacity, it was found that the Park was slightly overstocked with grazers, and that some adjustments were necessary to correct this.

The ratio of different types of feeders (selective/ non-selective/ browsers) also needed some correcting, and it would be important to introduce more bulk-grazers.

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# Chapter 1. Introduction

Wildlife management is, according to Gilbert & Dodds (1992), an unprecise science if it is compared to classical pure science such as physics and chemistry (Pauw, 1989). It is therefore rather looked upon as a skill, which Bailey (1984) describes as the art of making the land produce populations of wildlife for harvest or other value. These values include eco-tourism, scientific studies and protection of endangered species.

South Africa's natural resources are coming under increasing threat as a result of the inevitable utilisation thereof, and a competition for space (Bothma, 1986), which is the net result of the increasing human population of the world. Game farms that are managed efficiently and correctly, play an important role in wildlife conservation in South Africa, and provides an alternative resource that can be utilised. To manage a game farm effectively ecological limits and principles have to be taken into account (Bothma, 1986).

The concept of plant communities is an important facet of the management of a game farm. A plant community can be defined as a group of plant species that constantly occur together in a specific environment. Each plant community has a specific plant species composition which exists under specific environmental conditions (climate, geology, topography, soil,

drainage, herbivory) (Bredenkamp & Van Rooyen, 1994), and can therefore be regarded as an ecosystem. Each plant community has its own production and utilisation potential, and provides its own unique set of niches. Each plant community also reacts differently to environmental disturbances such as grazing and browsing, or burning (Bothma, 1986). As a result of this, particular communities could be damaged or degraded more easily than others. Specific herbivores also show distinct preferences for certain plant communities within a specific region, spending most of their time and energy utilising these areas (Dankwerts, 1989). This leads to the over-utilisation of these more preferred areas, and to the under-utilisation of the less preferred areas. Plant communities and their associated habitats therefore form the basis of scientific veld management, and therefore this aspect formed the basis of this study.

The Bynespoort Game Park consists of various distinctly different plant communities (Bredenkamp & van Rooyen, 1994), which offer a variety of habitats for the ungulate species on the Game Park, resulting in a high diversity of life occupying the area. These ungulates mainly utilise their resources by:

- Grazing - Where grass is the primary source of food, and
- Browsing - Where leaves and twigs of trees and shrubs are eaten.

As utilisation preferences of the ungulate species are known, stocking rates can be manipulated according to the type of plant communities present, the condition of the veld and the resulting carrying capacity of the veld under a

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specific rainfall regime. By applying this knowledge in a wildlife management plan, a Game Park such as Bynespoort Game Park can be managed efficiently to be as self sustainable as possible by producing optimal numbers of game without degradation of the vegetation as primary natural resource.

Coetzee (1993) did phytosociological studies in the area and identified similar communities to this study. In this study the woodland communities: *Acacia caffra - Euclea crispa* woodland, *Burkea africana - Faurea saligna* closed woodland, and *Burkea africana - Englerophytum magalismontanum* open woodland were very similar to some found in this study of Bynespoort Game Park. There were various other similarities with the study of Coetzee (1993), for example the presence of the *Themeda triandra - Setaria sphacelata* grassland community within the grassland area, and the *Leersia hexandra - Phragmites australis* wetland areas.

Bynespoort Game Park is the property of Premier Mine, a diamond mine owned by De Beers Consolidated Diamond Company.

Because of the large scale destruction that mining brings about, especially open cast mining, mining companies have become aware of their effects on the environment(Hacking & Nicholls, 1995), and they have consequently become actively involved in the protection of the natural environment by applying environmental management to their mining operations. This reduced the destructive effects to a certain extent. By declaring a Game Park, where the natural environment of the specific area can be conserved,

mining companies contribute to the conservation of the natural environment. The creation of these islands of natural environment surrounded by human developments necessitated the development of specialised wildlife and environmental management plans to ensure maintenance of the natural ecosystems, combined with optimal and environmentally viable utilisation.

The specific aims of the study are the following:

1. To conduct a vegetation survey of the Bynespoort Game Park, and identify the different plant communities on the Game Park;
2. To conduct a structural analysis of the woody plant layer of the Bynespoort Game Park;
3. To determine the grazing and browsing capacity of the different plant communities of the Byespoort Game Park;
4. To use all of the assembled information to recommend a stocking rate of ugulates for the Bynespoort Game Park, which will be able to sustain itself without placing stress on the environment.

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# Chapter 2. Characteristics of the Study Area

## 2.1. Introduction

The Bynespoort Game Park is approximately 1 780 ha in size. It is situated approximately 7 km to the west of Cullinan, in Eastern Gauteng. The altitude varies between 1280 m and 1423 m above sea level. The topography comprises of a combination of rocky hills, plains and drainage wetlands. A network of roads criss-crosses the Park, and infrastructure includes a Camping Site with a lapa, boma, and slaughter-house, three dams and a rural school (Fig.1).

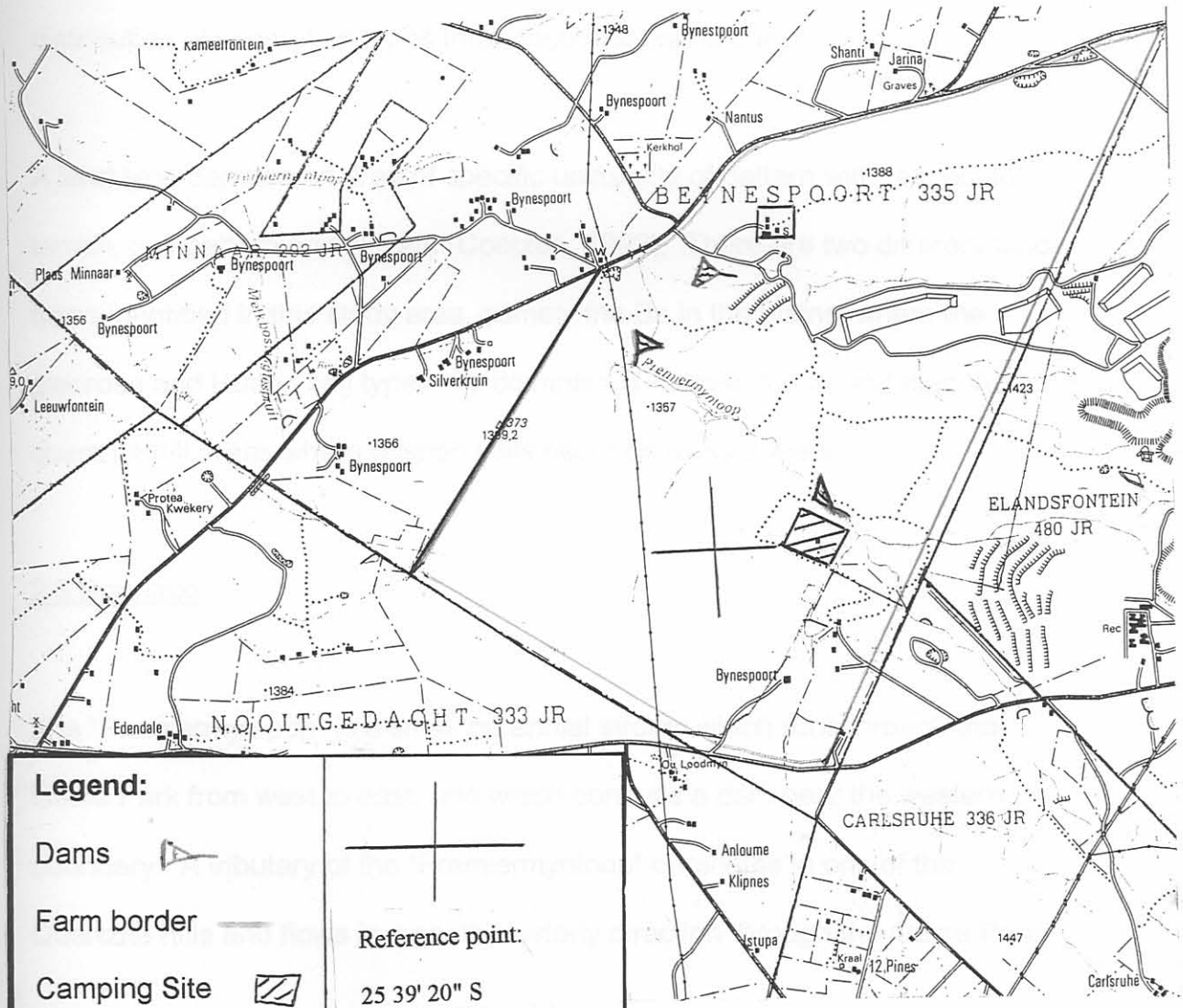



Fig 1: 1 : 50 000 Topographical map of the Bynespoort Game Park

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## 2.2.Geology and Land types

The geology of the Game Park basically consists of four substrate types (Fig. 2) namely quartzite, gabbro, diabase, alluvium and other recent deposits.

The Rayton formation of the Pretoria supergroup contains the quartzite and the diabase and alluvium are contained in the bushveld complex.

The geology has a strong influence on the topography, soil types and distribution of vegetation types throughout the Game park.

A land type denotes an area of specific uniformity of pattern with respect to terrain, soil pattern and climate (Coetzee, 1993). There are two different land types identified in this study area, namely the Ba in the plains, where the glenrosa and Hutton soil types are dominant (Coetzee, 1993),and Ib in the quartzite hill areas where Mispah soils occur on rocky sheets.

## 2.3.Drainage

The "Premiermynloop" is a small perennial stream which runs through the Game Park from west to east, and which contains a dam near the western boundary. A tributary of the "Premiermynloop" originates in one of the Quartzite hills and flows in a south-easterly direction through the Game Park,

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and this stream contains two dams, one near the campsite and another was recently built near the source. Two disused slimes dams occur in the central and eastern sections of the park, and seepage occurs into the "Premiermynloop" during the wet season.

## 2.4.Climate

The climate of the Game Park and surrounding areas is given in Figure 3. The annual rainfall is on average 678 mm (Bredenkamp & Van Rooyen, 1994). The wet season is usually between October and April with December and January being the wettest months. The rainfall is a primary driving force for the productivity of the veld (Dankwerts, 1989). Therefore, the rainfall in an average rainfall year (600 mm), a below average rainfall year (400 mm) and an above average rainfall year (851 mm as in 1996) was used to determine the carrying capacity of the veld.

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# Geology of the Bynespoort Game Park

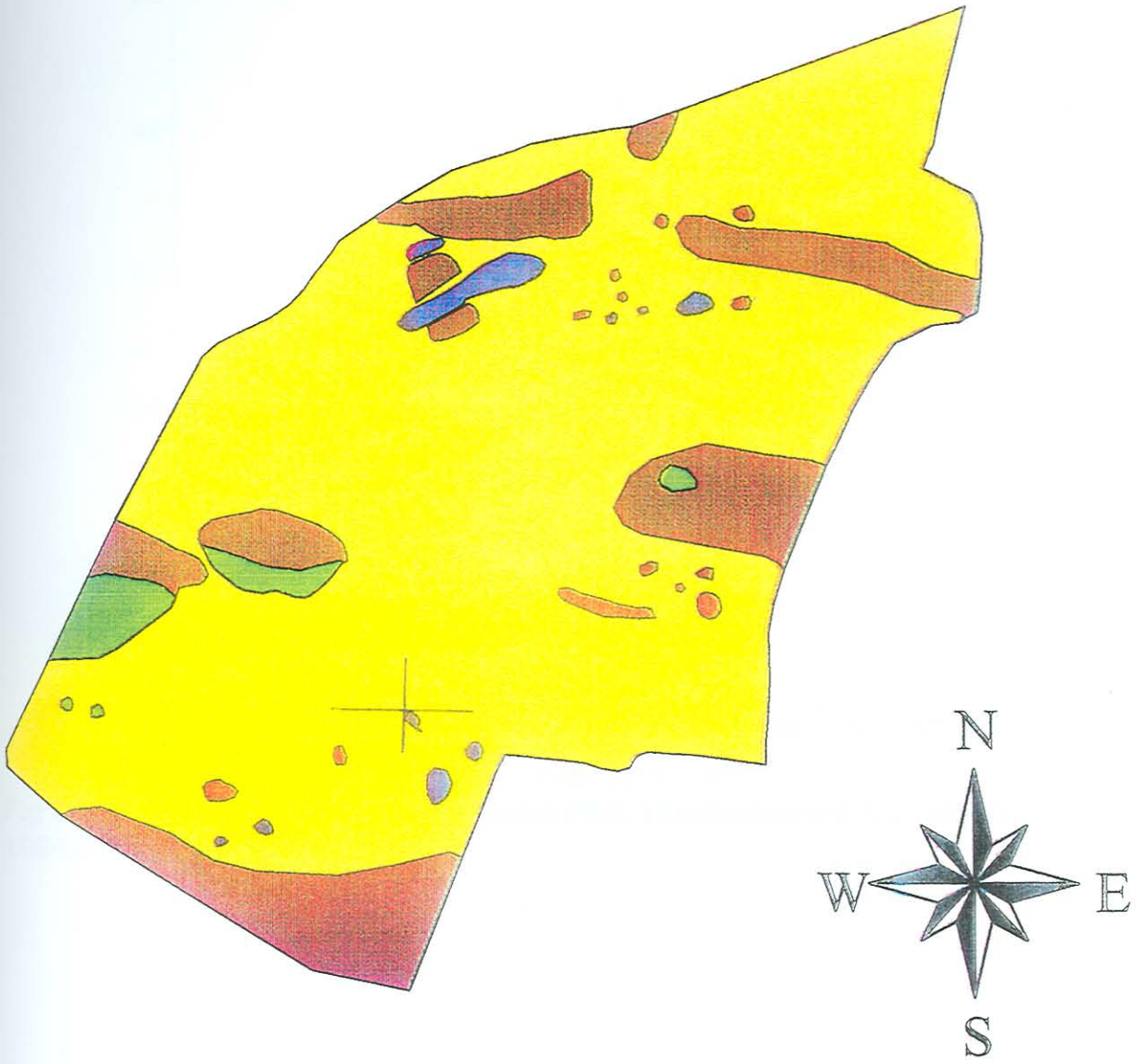



Fig 2: Geology of Bynespoort Game Park

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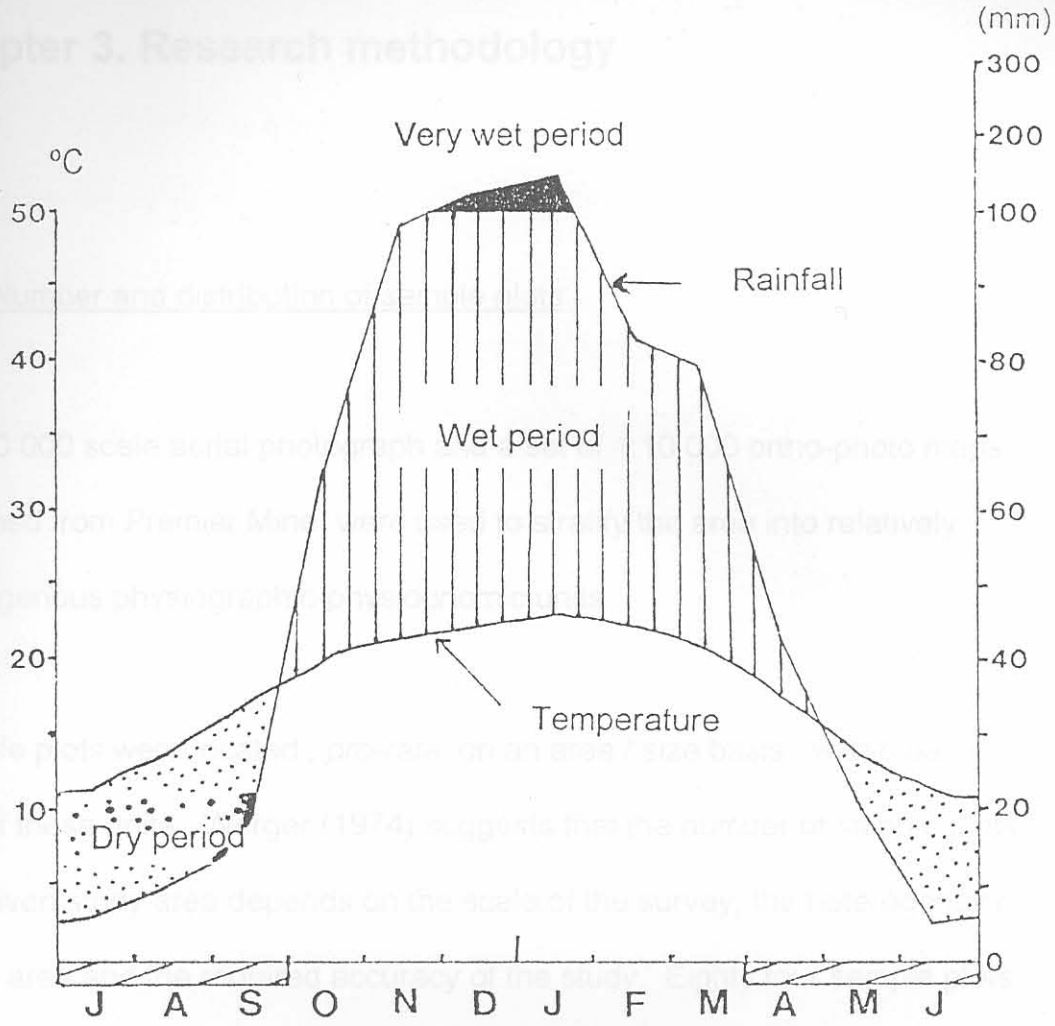



Fig 3: Climatograph of Bynespoort Game Park (Bredenkamp & Van Rooyen, 1994).

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# Chapter 3. Research methodology

## 3.1. Number and distribution of sample plots

A 1:20 000 scale aerial photograph and a set of 1:10 000 ortho-photo maps obtained from Premier Mine were used to stratify the area into relatively homogenous physiographic-physiognomic units.

Sample plots were located , *pro-rata*, on an area / size basis, within each one of these units. Werger (1974) suggests that the number of sample plots in a given study area depends on the scale of the survey, the heterogeneity of the area and the required accuracy of the study. Eighty four sample plots were found to sufficiently cover the area concerned both in floristic composition and vegetation structure. At each of these sample plots vegetation and habitat surveys were conducted.

## 3.2. Vegetation survey and classification

The method of the Zurich-Montpellier (Braun-Blanquet) school of vegetation classification was used (Werger,1974; Westhoff & van der Maarel, 1980). The method is widely used in South Africa to describe and classify vegetation (Bredenkamp & van Rooyen, 1994), and is applied with great success in

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classifying vegetation in game reserves and conservation areas (Pauw, 1988). It has proved to be an efficient and reliable method for vegetation survey and classification in most countries (Werger, 1974). The Braun-Blanquet approach takes a practical, intermediate position that recognises the heterogeneity of species distributions but emphasises the interactions between plants in the community (Westhoff & van der Maarel, 1980).

The method was considered as exceptionally suitable for studying the vegetation of the Bynespoort Game Park, as it is based on the principles that;

- plant communities can be recognised by their floristic composition which reflects the best relationship between plants and their environment;
- that some plant species are more sensitive indicators of environmental gradients than others, and can be used as diagnostic species for a plant community; and
- that plant communities can be organised into hierarchical classes based on diagnostic species (Werger, 1974).

Data for the Braun-Blanquet survey were collected as follows:

In each sample plot all plant species and percentage cover were noted according to the Braun-Blanquet cover abundance scale (Werger, 1974)

Additionally the average height (in meters) of each stratum (tree, shrub, herbaceous) was noted.

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Habitat data such as topography, aspect (true bearing), slope (degrees), soil depth (centimeters), % clay, erosion (present or absent) and utilisation (presence or absence) were also noted.

The data were analysed using the Turboveg software package (Hennekens, 1996). This is a software package designed for input, processing and presentation of phytosociological data (Hennekens, 1996). The package consists of routines to store, select, export and analyse vegetation data, and to present the results as tables.

The relevé data were captured into the program and a matrix of sample plots against plant species was obtained. This matrix was then subjects to a **T**wo **W**ay **In**dicator **Sp**ecies **An**alysis (TWINSPAN) (Hill, 1979), which is based on similarity indices, and where species with a similar distribution in the relevés and sample plots with the most similar species composition are grouped together. This is considered a first approximation of vegetation communities.

The Braun-Blanquet principles were then applied to the matrix in the software package MEGATAB (Hennekens, 1996). This program facilitates the manual rearranging of the matrix. The matrix is further refined into nodes of species with similar distribution and sample plots with similar species contribution (Bredenkamp *et.al,* 1989; Kent & Coker, 1996). The releve nodes represent plant communities, and the species nodes represent diagnostic species of the

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various plant communities. Species, which show a restriction to a community, are known as diagnostic species for the community concerned and are used to characterise the community (Westhoff & van der Maarel, 1980).

## 3.3 . Grazing Capacity and Veld Condition Assessment

### 3.3.1 Veld Condition

An assessment of the veld condition by studying the grass layer can provide valuable information on the utilisation potential of the veld.

The Ecological Index method (Van Oudtshoorn, 1994, Foran *et.al,* 1978, Verster, 1982) was used to classify grass species into Ecological Status Groups in relation to their reaction to grazing, tastiness, and preference by herbivores.

According to all these criteria all grass species can be classified into one of 9 groups

The groups are described as follows (Van Oudtshoorn, 1994):

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| | |
|---|---|
| Decreaser | A species which is abundant in a good veld, but decreases when the veld is mismanaged |
| Increaser I | A species which is abundant in a poorly managed veld, and increases with under-utilisation or selective grazing |
| Increaser Ia | A species which increases as a result of mild under-utilisation or selective grazing |
| Increaser Ib | A species which increases under conditions of extreme under-utilisation or selective grazing |
| Increaser II | A species which is abundant in a poor veld, and increases with over-utilisation |
| Increaser IIa | A species which increases as a result of light overgrazing |
| Increaser IIb | A species which increases as a result of mild over-utilisation |
| Increaser IIc | A species which increases as a result of heavy over-utilisation |
| Invader | A species not indigenous to an area |

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### 3.3.2 Sample Method

The same 84 sites of the sample plots used for the Braun-Blanquet vegetation survey, were also used for the assessment of the grazing capacity. In each of these plots a 100 point step-point analysis was undertaken. This acts as a descending point from which the sample is taken (Mentis, 1981). At each point the closest grass species was noted. According to Mentis (1981) this method is adequate for rapid assessment and also saves manpower and equipment. Point data of the sample plots representing each plant community (determined by the classification) were pooled and veld condition was then calculated for each plant community (Vorster, 1982; Zieger, 1994).

### 3.3.3 Grazing capacity

The percentage contribution of each ecological class is multiplied by its respective forage values to give the veld condition index score as a percentage for each plant community (Zieger, 1994). The forage values according to Vorster (1982) are as follows:

Decreaser - 10

Increaser I - 7

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Increaser II a and b - 4

Increaser II c - 1

The grazing capacity of a specific area of veld can be described as a specific production unit (ha) that has the potential to maintain one large stock unit (L.S.U.). This was calculated for each plant community by using the formula of Dankwerts (1989):

$$GC = -0.03 + 0.00289x_1 + [(x_2 - 419.7) \times 0.000633]$$

where:

G.C = grazing capacity

$x_1$ = % ecological index

$x_2$ = mean annual rainfall

The grazing capacities for each of the plant communities are then added to calculate a total grazing capacity for the entire Game Park.

The grazing capacity was calculated for three different scenarios, firstly for an average rainfall year (600 mm), secondly for a poor rainfall year (400 mm), and thirdly for an above average rainfall year (851 mm), which was recorded during 1996.



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The size of each plant community was calculated in hectares from a scaled map. From the calculated grazing capacity (ha/L.S.U.) the number of L.S.U. that can be supported by each plant community was calculated.

The present game stocking rate was evaluated against the calculated grazing capacity while recommended game stocking rates were estimated for optimal utilisation of the veld.

These analyses were done by using the computer program GRAZE (Bredenkamp, 1995). This program combines the Ecological Index Method with the grazing capacity calculations for an efficient assessment of the data, doing all conversions including those to calculate L.S.U. for the different game species, and includes calculations for stocking rates of the different game species for the Game Park.

### 3.4. Woody structure and browsing capacity

The BECVOL model (Smit, 1996) was used to estimate the available browsing on the game park. This is an effective method that can quantitatively describe the woody component of a plant community, and determine available browse. BECVOL, or Biomass Estimate from Canopy VOLume provides estimates of actual biomass of woody vegetation by estimates of the volume of the vegetation (Smit, 1996). According to Smit

(1996), there are three main factors to take into consideration from an agro-ecological point of view. These are:

1. Competition with herbaceous vegetation for soil, water and nutrients
2. Food for browsers
3. Creation of sub-habitats suitable for desirable grass species.

With the above factors taken into account, the following are the quantitative descriptive units that are used in this model:

ETTE - Evapotranspiration tree equivalent, which is equal to the leaf volume equivalent of a 1.5 m single-stemmed tree.

BTE - Browse tree equivalent - the leaf mass equivalent of a 1.5 m single stemmed tree

CSI - Canopied subhabitat index - the canopy area of trees which facilitate associations with grasses such as *Panicum maximum*, expressed as a percentage of the total transect area.

A transect of 100 m was laid in each of the plant communities, by using a rope and using all woody plants touching it. The measurements of these plants were taken as follows:

For the calculation of the spatial canopy volume:

1. Tree height (a)
2. Height of the maximum canopy diameter (b)
3. Height of the first leaves, or potentially leaf bearing stems (c)
4. Maximum canopy diameter (d)

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5. Diameter of the foliage at height c (e)

It is important to note that all measurements are based on live plant parts only. Because of the unsymmetrical dimensions of plants, the measurements are taken as an average of two perpendicular measurements.

From these measurements the spatial canopy volume is determined (Smit, 1996). It is done by using volume formulas for an ellipsoid, a right circular cone, a frustum of a right circular cone, or a circular cylinder. The formulas of any of these can be used singularly or in combination to determine the volume of the plants.

Once the canopy volume is determined the ETTE, BTE, and CSI can be calculated (Smit, 1996). The volume is multiplied by 1 000 000 to convert it to cm3. The spatial volume of the tree is substituted into the appropriate regression equation. From this regression a leaf volume (cm3) and leaf mass (g) can be read, and divided by 500 cm (1 ETTE) and 250 g (1 BTE).

The regressions were determined by harvesting at least 15 individuals of the most important South African savanna trees, drying and weighing them (Smit, 1996). The regression analyses were then applied.

The results of the BECVOL analysis are tabled, and compared between plant communities. From the BTE, and ETTE an available browse was determined, and the capacity was calculated for each community and the park as a whole.

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The canopy spread area (CSI) is calculated as a percentage of the total area of the transect, above a specific critical height.

3.5. Ungulate habitat Survey

To investigate whether certain ungulates preferred and selected certain habitats, a data sheet was compiled and linked to a map of the area. Sightings of game numbers and species were recorded along a fixed route, as well as their position on the map. During this survey, care was taken that similar time periods were spent in each area of the park, and all times of day were covered in the sampling. Therefore, as few external factors as possible could influence the sightings of ungulate species. The survey was however done in the winter season, and selection patterns may change with seasons. Done to the logistics of the project, it was impossible to spread the analysis over a full set of seasons.

The plant communities were then superimposed over the map and the sightings were allocated to communities. These numbers were converted into Large Stock Units (Meisner, 1982) combined for each community and divided by the area of the plant community. The unit obtained is then L.S.U/S/ha where:

L.S.U. = Large stock unit,

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S = sample,

ha = area of land (hectare)

This survey showed whether certain communities are utilised more than others, and this information could influence the management of the ungulates.

## 3.6. Geographic Information System Analysis

The Geographic Information System software packages of IDRISI and ARCVIEW were used for mapping and database purposes. Firstly the plant communities were mapped by tracing and digitising in the IDRISI package, this was done by using a 1 : 12 000 orthophoto map, and aerial photographs modified to the same scale. This was followed by a similar procedure for the Geology of the Game Park, as well as the road network. Hereafter information regarding the plant communities was tabled and incorporated into the program eg. Grazing capacity, area, habitat selection.

This program is then used to superimpose the different maps onto each other to identify any relationships . The program can now also be used as a database to monitor the conditions of the Game Park and predict any related problems. This database is also useful in collating information and making it available in a visual and easily understandable way. Information is stored in a uniform manner, that is easily shared between sources. Such accurately

digitised analyses can be placed further in perspective by using a Global Positioning System (G.P.S.), this gives accurate co-ordinates of latitude and longitude, and place the analysis in context in a global sense.

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# Chapter 4: Results

## 4.1 Plant Communities

The vegetation of the Bynespoort Game Park may be classified as Sourish Mixed Bushveld veld type in the Savanna biome (& Low & Rebelo, 1996; Acocks, 1988).

The diverse environmental conditions which are caused by the complex topography (hills, valleys, ridges), geology and utilisation by herbivores result in a heterogeneous vegetation. The Game Park houses 10 main plant communities with a number of variations within some of the communities.

The plant communities were recognised by the presence and/or cover-abundance of the diagnostic species, also taking into account habitat characteristics such as aspect, slope, geology and soil texture.

Identification of ecosystems at the plant community level of organisation is important when investigating habitat selection by game species, and planning veld management options. The veld condition of these plant communities is equally important because the cover of plants protects the soil against erosion, and also provides an estimate of the production potential (Bothma, 1986). The plant species composition of the communities also determines the acceptability of grazing, and therefore has a large influence on habitat

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selection. This could also have an effect on the potential grazing capacity of the entire Park (Bothma, 1986).

The plant communities identified in the Game Park are:

A. Sour mountain bushveld and grassland

1. *Harpochloa falx - Elionurus muticus* mountain grassland

1.1 *Harpochloa falx - Eragrostis chloromelas*

mountain grassland variation

2. *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland

3. *Terminalia sericea - Burkea africana* bushveld on sand

4. *Tristachya leucothrix - Trachypogon spicatus* mountain bushveld

4.1 *Protea caffra - Faurea saligna* mountain savanna variation

B. Sweet plains bushveld

5. *Cynodon dactylon - Acacia karroo* bushveld

5.1 *Ziziphus mucronata - Acacia karroo* bushveld variation

5.2 *Solanum panduniforme - Acacia karroo* disturbed bushveld variation

6. *Euclea crispa - Acacia karroo* bushveld on diabase

C. Sweet mountain bushveld

7. *Combretum apiculatum - Dombeya rotundifolia* bushveld of northern slopes

D. Anthropogenic vegetation

8. *Eucalyptus grandis* plantation

E. Wetlands

9. *Ischaemum fasciculatum - Phragmites australis* wetland

10. *Phragmites australis* slimes dams wetland

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# Plant communities of the Bynespoort Game Park

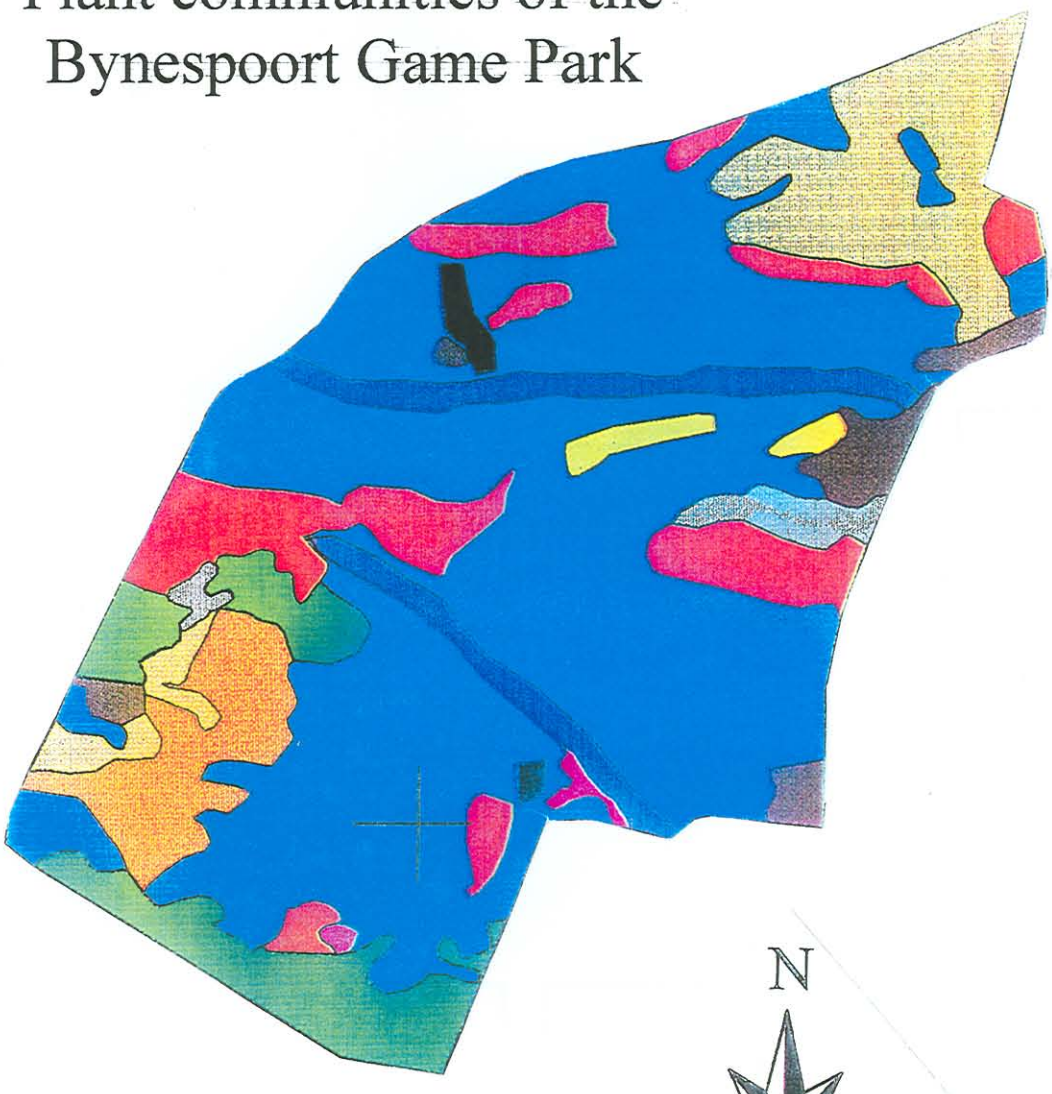
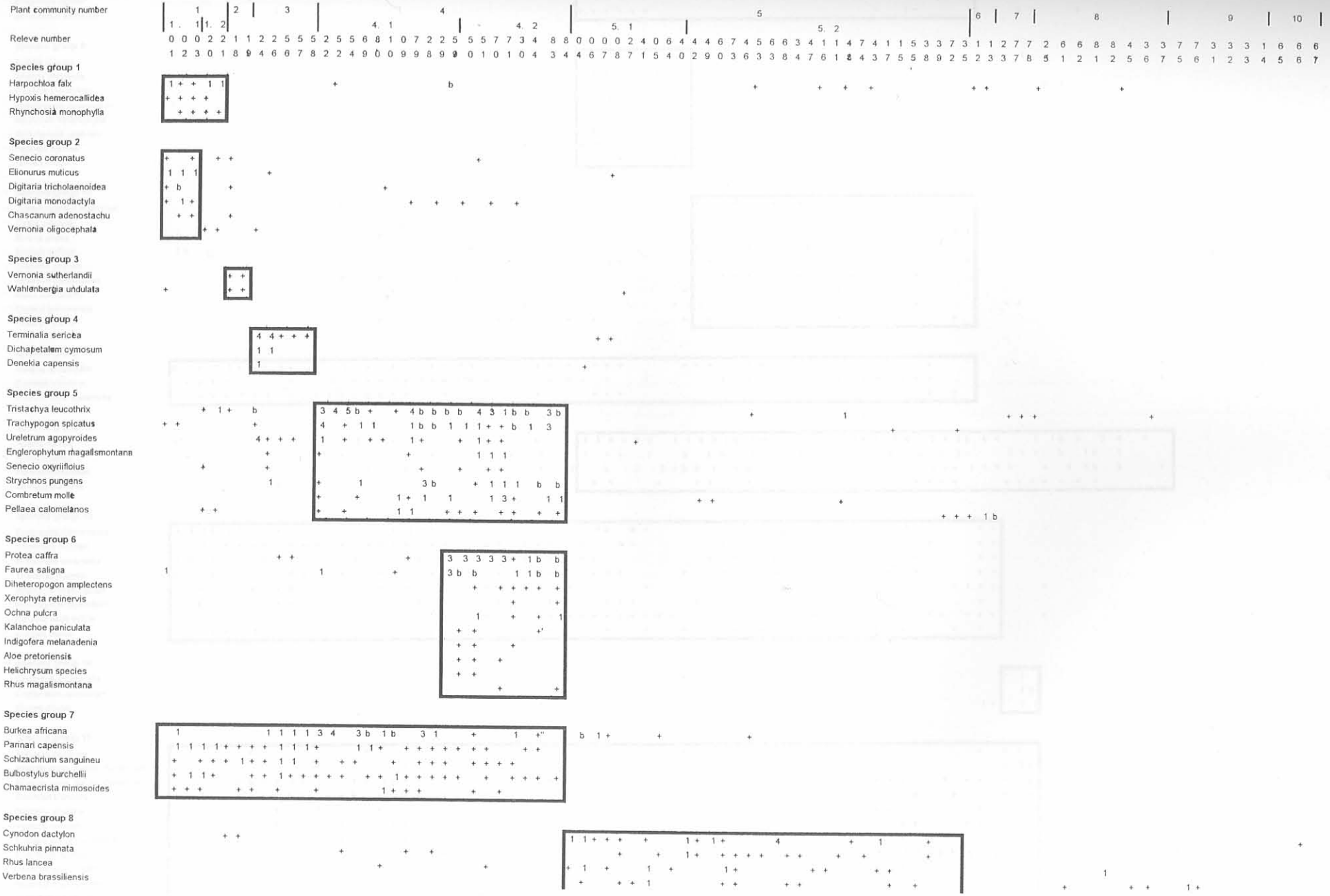


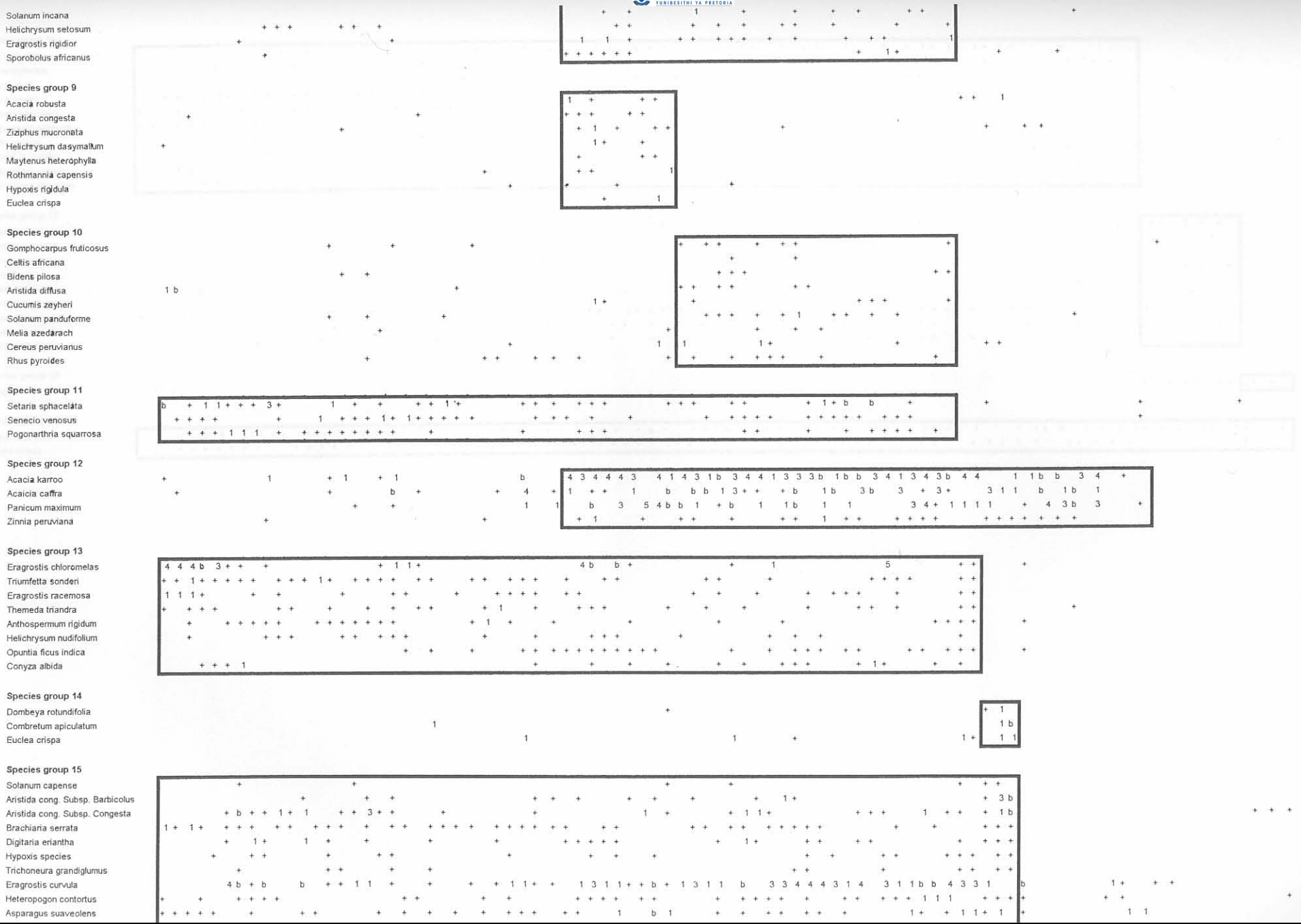

Fig a: Map of the plant communities of the Bynespoort Game Park

Table 1: A phytosociolgical table of the Bynespoort Game Park

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**Species group 16**

Rhus leptodictya
Bidens bipinnata
Rhys zeyheri
Melinis repens
Vernonia poskeana
Cymbopogon excavatus
Perotis patens
Eucalyptus grandis
Cymbopogon validus
Gomphrena celesoides

**Species group 17**

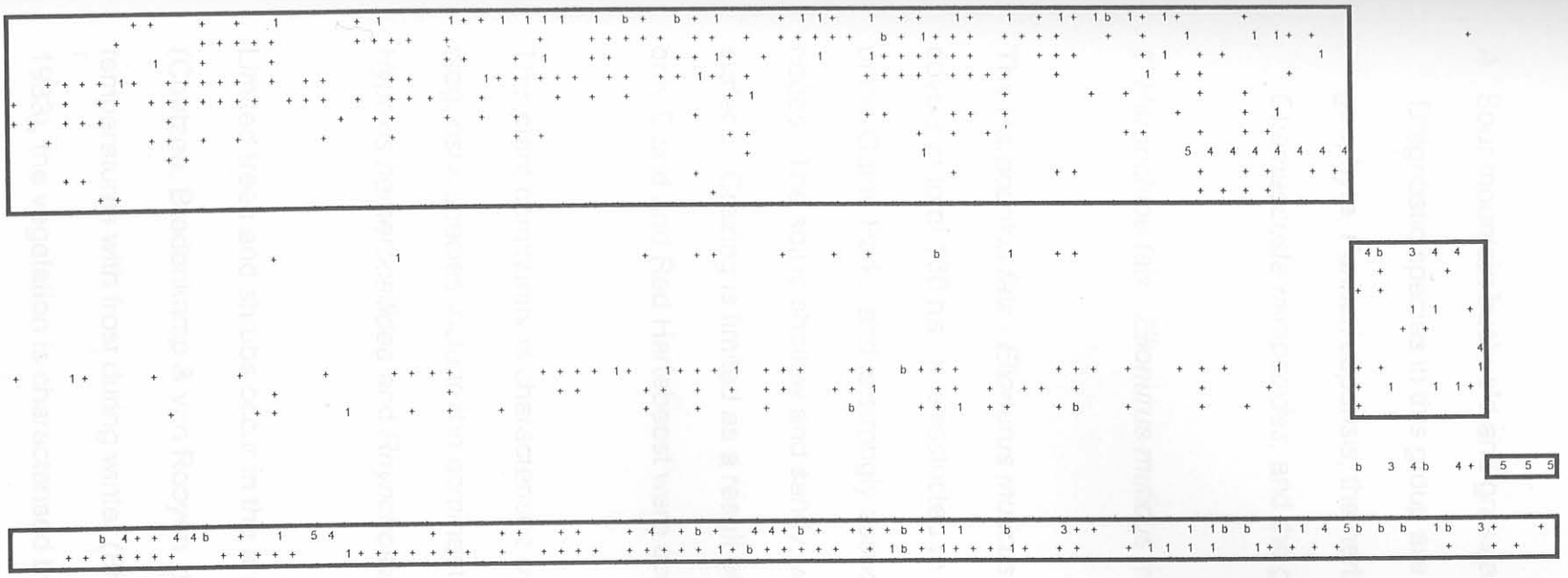
Ischaemum fasciculatum
Imperata cylindrica
Cyperus species
Acacia karroo
Gnidia capitata
Ischaemum afrum
Conyza bonariensis
Verbena bonariensis
Gnidia capitata

**Species group 18**

Phragmites australis

**Species group 19**

Hyparrhenia hirta
Tagetis minuta



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A. Sour mountain bushveld and grassland; characterised by species group 7. Diagnostic species in this group are the tree, *Burkea africana,* the geophyte, *Parinari capensis*, the herbs, *Bulbostylus burchellliii* and *Chamaecrista mimosoides,* and the grass, *Schizachrium sanguineu.*

1. *Harpochloa falx - Elionurus muticus* mountain grassland (Fig. 4)

The *Harpochloa falx - Elionurus muticus* mountain grassland community covers in total 130 ha. It is restricted to the southern and south-eastern parts of the Game Park, and is strongly associated with the high altitude quartzite ridges. The soil is shallow and sandy, with a high percentage of rocks on the surface. Grazing is limited as a result of the rockiness and steep slopes, and only Eland and Red Hartebeest were occasionally found in this community.

This plant community is characterised by species group 1 (Table 1), and the diagnostic species include the dominant grass *Harpochloa falx* and the forbs *Hypoxis hemerocallidea* and *Rhynchosia monophylla.*

Limited trees and shrubs occur in the area, possibly inhibited by its altitude (Coetzee, Bredenkamp & van Rooyen, 1995), and exposure to cold temperatures with frost during winter (Bredenkamp, Theron & van Vuuren, 1983), the vegetation is characterised by a diversity of grass species of up to

1 m, tall growing among the quartzite rocks, with the dominating species being *Harpochloa falx* and *Elionurus muticus*.

Small trees cover on average only 1% of the community and some species found are *Faurea saligna, Burkea africana, Acacia karroo and A. caffra*

Shrubs cover on average 3% of the community, including small individuals of some trees. Species found are: *Acacia karroo and Burkea africana*

Forbs cover on average 20% of the community and some of the more common species are *Rhynchosia monophylla, Hypoxis haemerocallidea, Wahlenbergia undulata, Senecio oxyriifolius, Parinari capensis, Bulbostylus burchelliii, Chamaecrista mimosoides, Helichrysum dasmymallum, Senecio venosus, Triumfetta sonderi* and *Anthospermum rigidum*

Grasses are the most important component of this community and even with the large percentage of surface rocks they cover 71% of the area. Species found are *Harpochloa falx, Elionurus muticus, Digitaria eriantha, D. monodactyla, Digitaria tricholenoides, Trachypogon spicatus, Schizachyrium sanguineum, Aristida diffusa, Setaria sphacelata, Eragrostis chloromelas, E. racemosa, Brachiaria serrata, Cymbopogon excavatus and Themeda triandra*

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1.1 *Harpochloa falx - Eragrostis chloromelas* mountain grassland variation

Locally within community 1, a variation is found where *Eragrostis chloromelas* is totally dominant with a canopy cover of 51-75 %.

The variation is furthermore characterised by species group 2 (Table 1), and the diagnostic species include the dominant grasses, *Elionurus muticus, Digitaria tricholaenoides*. and *D. monodactyla,* and also the forbs *Senecio coronatus, Chascanum adenostachyus* and *Vernonia oligocaphala.*

Trees cover on average only 1% of the area. The only species found is *Burkea africana*

Forbs cover on average 20% of the area. Species found are *Rhynchosia monophylla, Vernonia oligocephala, Pellaea calomelanos, Helichrysum spp., Parinari capensis, Bulbostylus burchellii, Chamaecrista mimosoides, Senecio venosus, Triumfetta sonderi, Conyza albida* and *Vernonia poskeana.*

Grasses cover on average 70% of the area. Species found are *Harpochloa falx, Tristachya leucothrix, T. rehmanii, Schizachyrium sanguineum, Setaria sphacelata, Pogonarthria squarrosa, Eragrostis chloromelas, Themeda triandra, Melinis repens, Cymbopogon excavatus* and *C. validus*

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2. *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland (Fig. 5)

This community covers an area of 80 ha. It is situated in the south- western part of the Game Park, in a flat lowland consisting of loamy soil and limited rocks, it has a history of disturbance, and was ploughed and cultivated in the past. It has however recovered, and is now totally dominated by the tall grass *Hyparrhenia hirta* which grows up to 1,8 m tall, overshadowing and outcompeting other species, and therefore overall plant diversity is low. Because of the lack of trees in this community, it is easily distinguished from the surrounding open woodland.

This plant community is characterised by species group 3 (Table 1). The diagnostic species are the forbs *Vernonia sutherlandii,* and *Wahlenbergia undulata*. These forbs are not abundant, but are nevertheless restricted to this species group.

Shrubs cover on average 3% of this area and species often encountered are *Acacia karoo* and the semi-woody weed *Asclepias fruticosa*. The presence of *Acacia karoo* shrubs indicates that woody plants are returning to this old field and that it will develop into a woodland in the future.

Herbs found scattered in this community cover on average 40% of the community. Species found include *Vernonia sutherlandi, Wahlenbergia undulata, Helichrysum* spp., *Parinari capensis, Triumfetta sonderi*

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*Anthospermum rigidum, Conyza albida, Vernonia poskeana, Tagetis minuta* and *Bidens bipinata*. Many of these species are weedy, indicating the secondary status of the vegetation.

Grasses cover on average 80% of the community, with the dominant *Hyparhenia hirta,* the following grass species may also be found:

*Diheteropogon amplectens, Schizachyrium sanguineum*

*Cynodon dactylon, Setaria sphacelata, Pogonarthria squarrosa, Eragrostis rigidior, E. chloromelas, Aristida congesta* sub sp. *congesta, Brachiaria serrata*

*Tricholeneura grandiglumis, Digitaria eriantha, Melinis repens, Cymbopogon excavatus, Eragrostis curvula* and *Heteropogon contortus*.

3. *Terminalia sericea - Burkea Africana* bushveld on sand (Fig. 6)

This community is found at three separate localities in the Game Park. The first is a large area in the north-eastern corner, and the other two are smaller patches situated in the south-west. In total these areas cover 136 ha. This community is exclusively found on the recent very sandy alluvial deposits where drainage is very good.

This plant community is characterised by species group 4 (Table 1), and diagnostic species include the woody tree *Terminalia sericea,* the poisonous

suffrutescent geoxylophyte *Dichapetalum cymosum* and *Denekia capensis*. These species show a distinct preference for well drained sandy soils.

The tree layer covers on average 33% of the community. It is characterised by dense stands of *Terminalia sericea* trees which are about 5 m tall, and few other species were encountered: *Protea caffra, Rhus leptodictya, R. zeyheri* and *Acacia karroo*.

Shrubs cover on average 5% of the community with only *Asparagus suaveolens and Acacia karroo* present in the shrub layer.

Herbs cover on average 20% of the community. Species found are *Denekia capensis, Senecio oxyriifolium, Bulbostylus burchellii, Chamaecrista mimosoides, Helichrysum setosum, Triumfetta sonderi, Anthospermum rigidum, Hypoxis* spp., *Perotis patens, Tagetis minuta* and *Bidens bipinata*.

It is interesting to note that the suffrutescent geoxylophyes *Dichapetalum cymosum* and *Parinari capensis* are abundantly present in these deep sandy soils.

Grass species such as *Ureletrum agropyroides* and *Trachypogon spicatus* dominate the grass stratum. Grasses cover on average 74% of the community and some other species found are, *Tristachya leucothrix, Schizachyrium sanguineum, Setaria sphacelata, Pogonarthria squarrosa,*

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*Eragrostis racemosa, E. curvula, Themeda triandra, Brachiaria serrata, Digitaria eriantha, Melinis repens, Heteropogon contortus* and *Hyparrhenia hirta*

*4. Tristachya leucothrix - Trachypogon spicatus* mountain bushveld (Fig 7)

This community covers 174 ha of the Game Park, covering the second largest area in the park. It occurs widespread throughout the park but is almost exclusively found on the quartzite ridges, mostly on the southerly and easterly facing slopes. The dominant grasses are *Tristachya leucothrix* and *Trachypogon spicatus*. This is an important habitat for the mountain loving mammals such as mountain reedbuck and kudu, and they are frequently seen there.

This plant community is characterised by species group 5 (Table 1). Diagnostic species for this community include the dominant grasses *Trachypogon spicatus, Tristachya leucothrix,* and *Ureletrum agropyroides*, the woody species *Strychnos pungens, Engelophytum magalismontana* and *Combretum molle,* and the forbs *Senecio oxyriifolius*, and *Pallaea calomelanos* , the xerophytic fern.

Trees cover on average 5% of the community.

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Shrubs cover on average 5% of the community and species commonly found are *Asparagus suaveolens,* and *Aloe greatheadii subsp. daveyana*

Herbs cover on average 25% of the community. Prominent species, other than the diagnostic species, found are:
*Kalanchoe paniculata, Indigofera melanadenia, Helichrysum spp., Bulbostylus buchelli* and *Chamaecrista mimosoides*

Grasses cover on average 74% of this community with the following species occurring: *Ureletrum agropyroides, Schizachyrium sanguineum, Setaria sphacelata, Pogonarthria squarrosa, Eragrostis chloromelas, E. racemosa, E. curvula, Themeda triandra* and *Heteropogon contortus.*

4.1 *Protea caffra - Faurea saligna m*ountain savanna variation

This variation of community 4 is found exclusively on the south facing slopes of the steepest quartzite ridges. In these areas trees are dominant, covering 50% of the area. The tree species which dominate the variation are *Protea caffra* and *Faurea saligna*, and this causes the structure of the variation to be distinctly different to the main community.

This variation is characterised by species group 6, and diagnostic species include the dominant woody *Protea caffra* , *Faurea saliga* and *Ochna pulcra,*

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the shrubs *Xerophyta retunervis* and *Rhus magalismotana* as well as the forbs *Indigofera melanadenia Aloe pretoriensis* and *Helichrysum spp.*.

Tree species found in this variation are *Protea caffra, Faurea saligna, Rhus leptodictya, R. magalismontana, Combretum molle, Strychnos pungens* and *Ochna pulcra*

Shrubs cover 3% of this community. Species found are *Xerophyta retinervis Asparagus suaveolens* and *Acacia karroo.*

Herbs cover on average 20 % of the variation. Species found are *Kalanchoe paniculata, Indigofera melanadenia, Helichrysum* spp., *Parinari capensis, Bulbostylus burchellii, Chamaecrista mimosoides, Schkuhria pinnata* and *Helichrysum setosum.*

Grasses cover on average 70% of the variation with prominent species *Diheteropogon amplectens, Schizachyrium sanguineum, Sporobolus africanum, Setaria sphacelata, Eragrostis racemosa* and *Themeda triandra*

B. Sweet plains bushveld, characterised by species group 12. Diagnostic species are: the trees *Acacia karroo* and *Acacia caffra,* the grass *Panicum maximum* and the forb *Zinnia peruviana.*

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5. *Cynodon dactylon - Acacia karroo* bushveld (Fig 8,Fig 9)

This is the most extensive plant community in the game park. It is spread throughout the park and is closely associated with the recent alluvial deposits. It covers 838 ha which is more than half of the total area of the Game Park.

The importance of this community for grazing cannot be overstated, as it provides the game with the most resources, and most of the game species frequent this community for grazing and shelter.

The community is characterised by the presence of *Acacia* species, and is described by some as being an open woodland.

This plant community is characterised by species group 8 (Table 1), and diagnostic species include the tree *Rhus lancea,* the grasses *Cynodon dactylon, Eragrostis rigidior* and *Sporobolus africanus.*, indicating that the area is heavily utilised, and the forbs *Schkuria pinnata, Verbena brassiliensis, solanum incana* and *Helichrysum setosum,* most of which are poorer weedy species, emphasising the fact that the area is heavily utilised.

The community consists of 2 variations, and each one will be discussed in detail.

*5.1 Ziziphus mucronata - Acacia karroo* bushveld variation

This is the woodland variation of the community. This reflects an historically more natural and undisturbed environment. Many species are abundant in this variation.

This variation is characterised by species group 9 (Table 1). Diagnostic species include the trees *Acacia robusta, Ziziphus mucronata, and Euclea crispa*, the grass *Aristida congesta,* and the forbs *Rothmannia capensis,* and *Hypoxis rigidula*.

Trees cover 60% of this variation and species, other than the diagnostic species, observed are *Acacia karroo, A. robusta, A. caffra, Celtis africana Rhus leptidictya, R. pyroides* and *R. zeyheri.*

The large diversity of trees, and especially nutritious trees, indicates a large browse potential, and emphasises the importance of this variation to the browsing ungulates.

Shrubs cover on average 15% of the area with six species common. These are *Maytenus heterophylla, Asparagus suaveolens, Rothmannia capensis* and *Aloe greatheadii susp. davyana. Cereus peruvianus* and *Opuntia ficus-indica* are also diagnostic of this variation and are regarded as a serious threat to the natural vegetation. These exotic invasive succulents have

invaded many sections of this variation, and could have a serious effect on the future vegetation species composition of the variation.

Herb species cover on average 30% of the variation with the following species found: *Hypoxis rigidior, Bidens pilosa, Cucumus zeyheri, Solanum panduniforme, Senecio venosus, Triumfetta sonderi, Anthospermum rigidum Conyza albida, Bidens bipinata, Vernonia poskeana, Zinnea peruviana* and *Tagetis minuta*

Grass species are abundant, covering 85% of the variation, and are well utilised by various herbivore species. Species found are *Setaria sphacelata, Pogonarthria squarrosa, Eragrostis chloromelas, Themeda triandra, Aristida congesta sub barbicollis, Hyparrhenia hirta, Heteropogon contortus* and *Sporobolus fimbriatus*.

*5.2 Solanum panduniforme - Acacia karroo* disturbed bushveld

This variation contains a number of plant species which indicate a disturbed environment. In areas where this variation is present there is either very heavy grazing and trampling by game, or has a history of disturbance through mining, building (ruins), or other human activity.

The invasive alien species *Melia azedarach and Cereus peruvianus,* unpalatable grass *Aristida diffusa,* the tree *Celtis africana,* the shrub *Solanum*

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*panduniforme* and the forbs *Gomphocarpus fruticosus, Bidens pilosa* and *Cucumis zeyheri* are diagnostic of this variation. The variation is characterised by species group 10 (Table 1).

Trees cover on average 50% of the variation with the following species, other than the diagnostic species, can be found: *Acacia karroo, A. robusta, Rhus leptodictya, R. pyroides, R. magalismontana*
*R. zeyheri* and *Euclea crispa.*

Shrubs cover on average 20% of the variation.
Species found are *Acacia caffra* and *Euclea crispa,* and *Cereus peruvianus* which is an exotic invader, and can become a serious problem where it grows in the shade of common bushveld trees.

Forbs cover on average 20 % of the variation. Species found are: *Bidens bipinata, Tagetis minuta, Senecio venosus, Anthospermum rigidum, Helichrysum nudifolium, Hypoxis spp. and Vernonia poskeana.*

Grasses cover on average 80% of the variation with the following species observed: *Cynodon dactylon, Sporobolus fimbriatus, Setaria sphacelata, Pogonarthria squarrosa, Eragrostis chloromelas, E. rigidior, E. curvula, E. racemosa, Aristida congesta* sub *barbicollis, Heteropogon contortus and Hyparrhenia hirta*

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6. *Euclea crispa - Acacia karroo* bushveld on diabase

This is a small community which covers only 7 hectares. It consists of two small patches in the south of the Game Park, and is easily spotted due to its very dense thickets of shrubs and trees. It is found on deep fertile soils of the Diabase rock.

This plant community is characterised by species group 13 (Table 1). Diagnostic species are the grasses *Eragrostis chloromelas, E. racemosa* and *Themeda triandra*, the forbs *Triumfetta sonderi, Anthospermum rigidum, Helichrysum nudifolium* and *Conyza albida,* and the alien invader *Opuntia ficus-indica.*

Trees are dense and cover 100% of the community with the following species prominent: *Euclea crispa, Rhus leptdictya, Acacia karroo, Acacia robusta* and *A. caffra. Melia azedrach* is an exotic tree which also occurs in this community, and is one of the most invasive alien trees in the savanna (Bromilon, 1995.)

Shrubs cover on average 15% of the community. Species found are: *Euclea crispa* and *Asparagus suaveolens.*

Forbs cover on average 10% of the community and those occurring are the diagnostic species already mentioned.

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As a result of the total cover of the trees in this community there are few grass species, and those that do occur are usually associated with the shade of trees.

Grasses do however cover 80% of the community with the following species present: *Pogonarthria squarrosa, Aristida congesta* subsp. *barbicollis, A. congesta* subsp. *congesta, Panicum maximum* and *Sporobolus africanum.*

C. Sweet mountain bushveld, characterised by species group 15 (Table 1). Diagnostic species in this group are the grasses *Aristida congesta* subsp. *barbicollis, A. congesta* subsp. *congesta, Brachiaria serrata, Digitaria eriantha, Eragrostis curvula, Heteropogon contortus* and *Sporobolus fimbriatus,* the forbs *Solanum capense, Hypoxis sp.* And *Asparagus suaveolens.*

*7. Combretum apiculatum - Dombeya rotundifolia* bushveld on northern slopes (Fig 10)

Because of the aspect the north facing slope of the quartzite ridges have a warmer micro-climate than the south facing slopes, and therefore the vegetation is distinctly different on these north slopes. This community covers approximately 25 ha and is found in two localities, one in the east and a smaller area in the west.

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Animal species are frequently found in this community and it is fairly heavily utilised by the ungulates.

This plant community is characterised by species group 14 (Table 1.). The The dominant trees *Dombeya rotundifolia Combretum apiculatum,* and *Euclea crispa* are diagnostic of the plant community. These trees require a warmer climate to exist, which this northern aspect provides. These are also valuable trees in terms of browse for the ungulates.

The trees cover 57% of the community and other species present are: *Rhus leptodictya, R. zeyheri* and *Acacia caffra.*

Shrubs cover approximately 5% of the community. Species present are: *Euclea crispa. Asparagus suaveolens* and *Acacia karroo*

There are not many herbs found in this community. Species found are: *Solanum capense, Hypoxis* sp., *Bidens bipinata, Vernonia poskeana, Gnidia capitata* and *Tagetis minuta*

Grasses cover on average 80% of the community. Species present are: *Aristida congesta* subsp. *barbicollis, A. congesta* subsp. *congesta, Brachiaria serrata, Digitaria eriantha, Panicum maximum, Heteropogon contortus,* and *Hyparrhenia hirta.* The presence of these grass species indicates that the

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community is over-utilised. This is possibly due to trampling by browsers to utilise the tree and shrub layers.

D. Anthropogenic vegetation, characterised by species group 19 (Table 1). The diagnostic species in this group are the grass *Hyparrhenia hirta* and the weed *Tagetis minuta*.

8. *Eucalyptus grandis* plantations (Fig 11)

This community consists mainly of dense stands of *Eucalyptus* trees of about 20 m tall. This occurs in areas where human settlements were involved in the past. This community covers 35 ha of the park and is totally covered with trees. The monotonous stands of alien plants can pose a problem as they lower the biodiversity and condition of the veld, and have the ability to invade natural veld. Because of this the plant diversity in this community is low. Game was also found to avoid this area to a great extent.

This plant community is characterised by species group 16 (Table 1). The diagnostic species is the dominant tree *Eucalyptus grandis*. This is an exotic which is an Australian native, and can become invasive (Bromilon, 1995). The forbs *Gomphrena celosioides, Perotis patens, Vernonia poskeana* and Bidens bipinnata, the trees *Rhus leptodictya* and *Rhus zeyheri* and the

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grasses *Melinis repens, Cymbopogon excavatus* and *Cmbopogon validus* are also diagnostic of this species group.

Trees cover 100% of the community. Other than the diagnostic species already mentioned, *Acacia Karroo* is also present.

Shrubs cover on average 3% of the community.

Species present include: *Acacia karroo* and *Asparagus suaveolens*

Herbs cover on average 8% of the community.

Species present include: *Conyza bonariensis, Tagetes minuta, Verbena bonariensis, Gnidia capitata* and *Solanum capense*.

Grasses cover on average 81% of the community.

Species present are: *Panicum maximum, Sporobolus fimbriatus, Hyparrhenia hirta* and *Heteropogon contortus*.

*9. Ischaemum fasciculatum - Phragmites australis* wetlands (Fig 12)

This community covers 70 ha, and is found surrounding the two waterways which flow through the Game Park. These are densely covered with reeds and grasses. This community is utilised by various ungulate species.

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This community is characterised by species group 17 (Table 1), and diagnostic species include the grasses *Ischaemum fasciculatum, Imperata cylindrica* and *Ischaemum afrum,* the forbs *Verbena bonariensis, Conyza bonariensis, Gnidia capitata, Cyperus sp.*and *Acacia karroo* in shrub form..

Trees do not occur in this community, but a number of shrub species do occur, and they cover 2% of the community. Species included are: *Acacia karroo* and *Asclepias fruticosus.*

Herbs are not abundant as a result of the dense grass cover, and they cover only 5% of the community. Species present are: *Verbena brassiliensis, V. bonariensis, Gnidia capitata, Tagetis minuta* and *Bulbostylus burchellii.*

Grasses and reeds cover 100% of the community.
Species found are all mentioned as diagnostic of the community.

*10. Phragmites australis* slimes dam wetlands (Fig 13)

This is a small community which consists of two unused slimes dams in the central part of the Game Park. These slimes dams are covered with dense stands of *Phragmites* reeds. Because of the conditions that the slimes dams pose, there are virtually no other plants occurring there.

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This plant community is characterised by species group 18 (Table 1). The diagnostic species is the dominant reed *Phragmites australis*.

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Fig 4: *Harpochloa falx - Elionurus muticus* mountain grassland



Fig: 5: *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland

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Fig 6: *Terminalia sericea - Burkea Africana* bushveld on sand



Fig 7: *Tristachya leucothrix - Trachypogon spicatus* mountain bushveld

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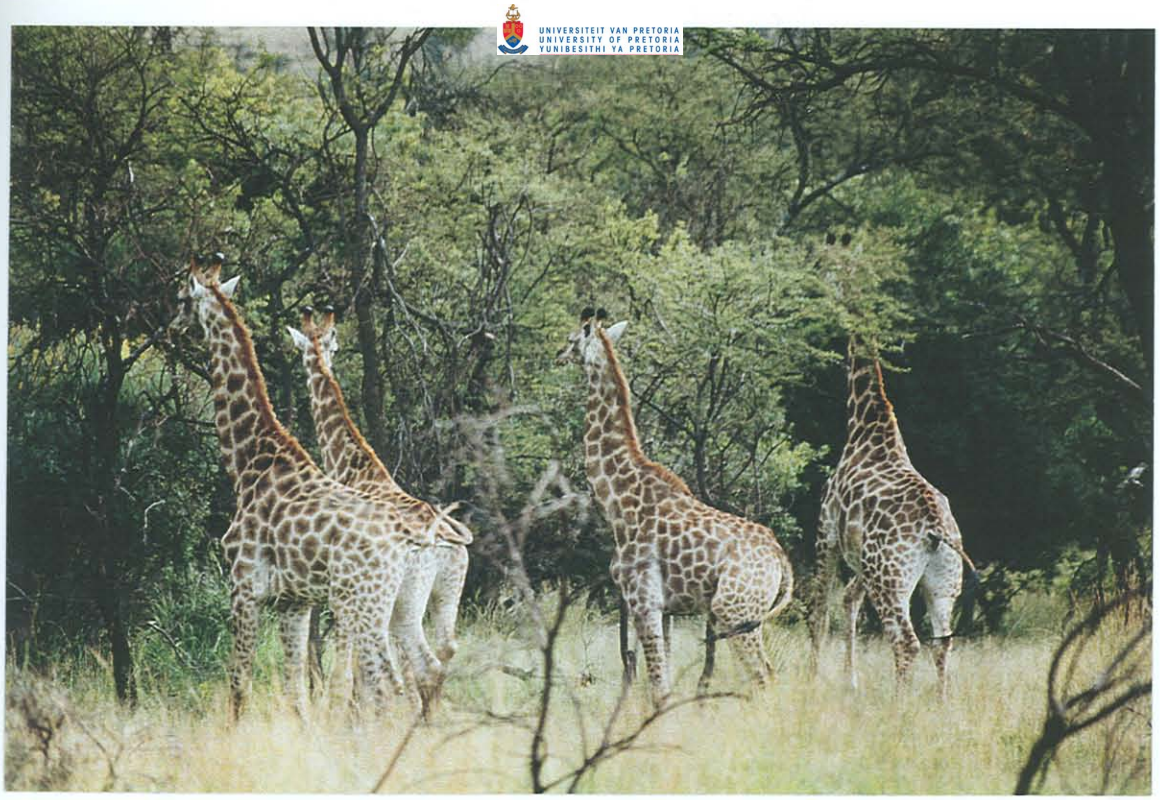


Fig 8: *Cynodon dactylon - Acacia karroo* bushveld



Fig 9: *Cynodon dactylon - Acacia karroo* bushveld

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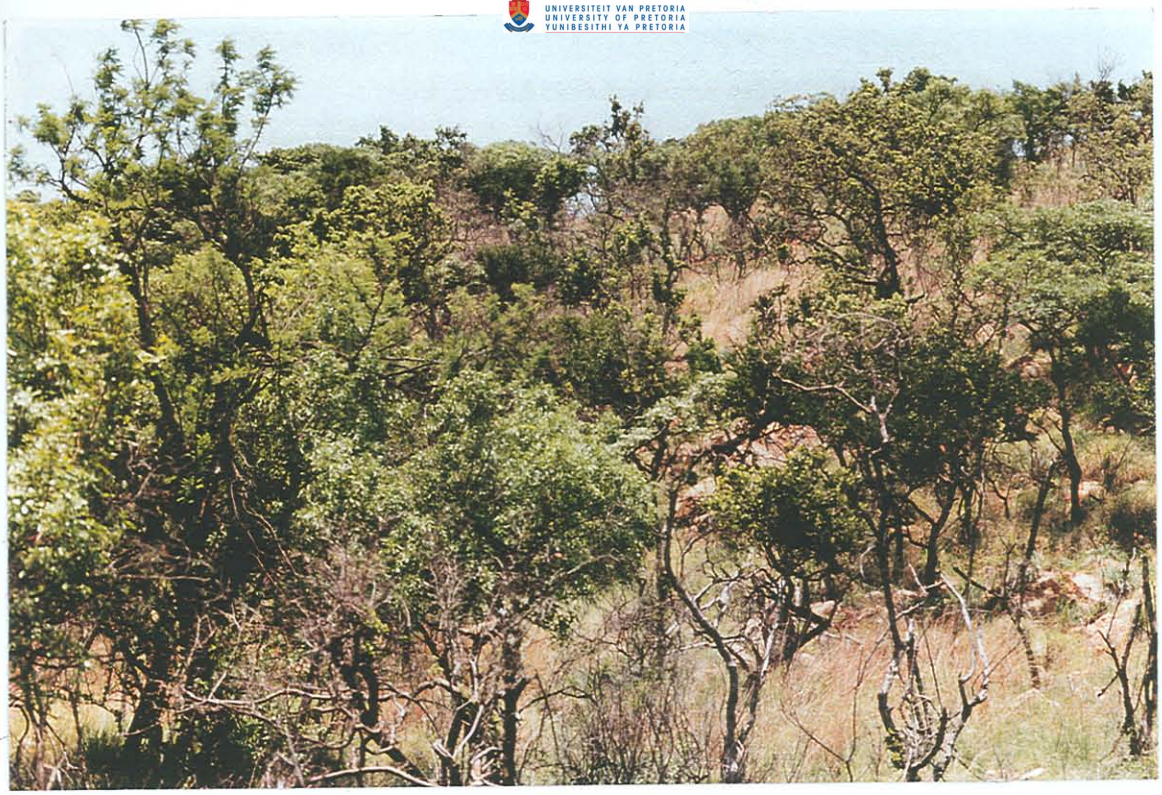


Fig 10: *Combretum apiculatum - Dombeya rotundifolia* bushveld of northern slopes



Fig 11: *Eucalyptus grandis* plantation

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Fig 12: *Ischaemum fasculatum - Phragmites australis* wetland



Fig 13: *Phragmites australis* slimes dams wetland

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## 4.2. Grazing capacity and veld condition

The veld condition and grazing capacity was determined for nine plant communities. The analyses for plant communities one, four and five include all variations within those communities. Analyses were done for three different rainfall scenarios: A year of average rainfall (600 mm), a year of below average rainfall (400 mm) and a year with a high rainfall (851 mm).

1. *Harpochloa falx - Elionurus muticus* mountain grassland

The veld condition index is 58,1%(Table 2). The grazing capacity for this community is 8,7 ha/L.S.U for game in an average rainfall year or 4,9 ha/L.S.U for cattle. Because of the size (130 ha) this community can theoretically support 14,9 L.S.U. game or 26,7 L.S.U. cattle.

The condition of the veld is relatively good, but as a result of the rocky habitat, the grass cover is only 70%.
This community shows signs of moderate grazing with a high percentage of Increasers 2b.

In a below average rainfall year when the mean annual rainfall drops to 400 mm the grazing capacity is almost halved to 16,2 ha/L.S.U. for game or 9,1

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ha/L.S.U. for cattle. In such a year the veld can only support 8,0 L.S.U. game or 14,4 L.S.U. cattle (Table 3).

In an above average year where the rainfall is 851mm, as it was in 1996, the grazing capacity was 5,5 ha/L.S.U. for game or 3,1 ha/L.S.U. for cattle. In such a year the veld can support 27,2 L.S.U. cattle or 15,2 L.S.U. game (Table 4).

2. *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland

The veld condition index for this community is 39,3% (Table 2). This is the second lowest of all the plant communities, as a result of the lack of decreaser species. Because of the history of disturbance in this community pioneer species abound, and this is seen by the great number of Increaser species.

In an average rainfall year with rainfall of 600 mm the grazing capacity is 5,7 ha/L.S.U. for cattle or 10, ha/L.S.U. for game. This is the worst grazing capacity of all the communities, possibly because of its recovering status, as well as slight overgrazing. The size of the community is 80 ha and therefore the community can sustain 14 L.S.U. cattle or 7,9 L.S.U. game(Table 2).

In a below average rainfall year of 400 mm the grazing capacity drops to 13,2 ha/L.S.U. for cattle or 23,4 ha/L.S.U. for game. this in fact means that only 6,1 L.S.U. cattle or 3,4 L.S.U. game can be sustained (Table 3)

In an above average rainfall year the grazing capacity is 3,3 for cattle or 5,9 for game. In such conditions 24 L.S.U. cattle or 13,6 L.S.U. game can be supported (Table 4).

3. *Terminalia sericea - Burkea africana* sour bushveld

The veld is mostly in a good condition, however, the fairly high percentage of increasers 1 indicate that there is slight under-utilisation of this community.

The veld condition index for this community is 61,0% (Table 2). The grazing capacity of 3,7 ha/L.S.U. for cattle or 5,3 ha/L.S.U. for game in a normal year is also indicative of a healthy veld condition. 37,2 L.S.U. cattle or 25,5 L.S.U. game can be sustained by the community in an average rainfall year (Table 2).

In a below average rainfall year with a mean rainfall of 400 mm the grazing capacity for cattle is 6,6 ha/L.S.U. or for game is 9,6 ha/L.S.U.. This relates to 20,5 L.S.U. cattle or 14,1 L.S.U. game that can be sustained (Table 3).

In a particularly good rainfall year with a rainfall of 851mm, the grazing capacity is 2,3 ha/L.S.U. for cattle or 3,4 ha/L.S.U. for game. In such a year 58,0 L.S.U cattle or 39,8 L.S.U. game can be supported (Table 4).

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4. *Tristachya leucothrix - Trachypogon spicatus* mountain savanna

The community is the second largest (174 ha) in the Game Park,and it is therefore important for the grazing animals. A fair percentage of decreasers (14%) causes the veld condition index to be relatively high (63,8%) (Table 2).

In an average rainfall year with a rainfall of 600 mm, the grazing capacity is 3,6 ha/L.S.U. for cattle or 5,2 ha/L.S.U. for game, which indicates a good grazing capacity. In such circumstances the community can sustain 48,9 L.S.U. cattle or 33,7 L.S.U. game (Table 2). This is an important percentage of the total game numbers in the Park.

In a below average rainfall year where the mean rainfall is only 400 mm the grazing capacity decreases to 6,3 ha/L.S.U. for cattle or 9,2 ha/L.S.U. for game. In such a year the number of L.S.U. that can be sustained is 27,5 for cattle or 19,0 for game (Table 3).

In a good rainfall year (851 mm), the grazing capacity of the veld recovers to 2,3 ha/L.S.U. for cattle or 3,3 ha/L.S.U. for game. In such times 75,7 L.S.U. cattle or 52,2 L.S.U. game can be sustained (Table 4).

In this community there is a high percentage of Increasers 1. This indicates that the veld is under-utilised. This is possibly as a result of the inaccessibility of the rocky terrain and sour grasses to animals that prefer the plains. Only species fond of rocky terrain were seen in this community.

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5. *Cynodon dactylon - Acacia karroo* bushveld

Being by far the largest community in the Game Park, covering 838 ha, it is the most important resource for the ungulates to utilise.

From the veld condition index of 58,6% (Table 2), it can be seen that the veld is in a fairly good condition. The grazing capacity in an average rainfall year (600 mm) is 4,0 ha/L.S.U. for cattle or 5,2 ha/L.S.U. for game. Because of this, and the large size, by far the greatest numbers of game or cattle can be supported by this community, being 209,9 L.S.U. cattle or 159,7 L.S.U. game (Table 2).

In a below average rainfall year (400 mm) the grazing capacity drops to 7,4 ha/L.S.U. for cattle or 9,7 ha/L.S.U. for game. This however is not critical and the community can still support 113,6 L.S.U. cattle or 86,4 L.S.U. game (Table 3).

In a good rainfall year (851 mm), the grazing capacity is 2,5 ha/L.S.U. for cattle or 3,3 ha/L.S.U. for game. In such a good season the veld can support 330,9 L.S.U. cattle or 251,8 L.S.U. game (Table 4).

In this community there is a balance between Decreasers, Increasers 1 and Increasers 2. This indicates that the community is not under-utilised, nor is it particularly over-utilised, yet light grazing does take place. As many parts of the community were previously disturbed, it is clear that they have recovered

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well to become relatively stable areas that provide valuable resources to the game that utilise them.

6. *Euclea crispa - Acacia karroo* bushveld on diabase

The grazing capacity in a normal rainfall year (600mm) is 5,4 ha/L.S.U.(Table 2) for cattle or 6,7 ha/L.S.U. for game. this means that 1,3 L.S.U. cattle or 1,0 L.S.U. game can be supported by this community (Table 2).

In a below average rainfall year (400 mm) the grazing capacity is 10,2 ha/L.S.U. for cattle or 13,3 ha/L.S.U. for game. In such a year the community is virtually useless to ungulates and offers subsistence for only 0,7 L.S.U. cattle or 0,5 L.S.U. game (Table 3).

In an above average rainfall year the grazing capacity increases to 3,3 ha/L.S.U. for cattle or 4,1 ha/L.S.U. for game. In such a time the community can support 2,1 L.S.U. cattle or 1,3 L.S.U. game (Table 4).

This is a fairly insignificant community as it covers only 7 ha. However it is a unique association of plants and therefore needs to be protected.

As a result of trees covering most of this community the bush factor is high. The high percentage of Increasers 2 is a cause for concern as it indicates overgrazing. This is understandable as the grasses that grow under the trees are sweet and palatable species, and the trees also provide shelter and shade. Although insignificant in size, this community provides an important

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habitat for bushbuck and nyala that depend on these densely wooded areas for shelter and feeding.

7. *Combretum apiculatum - Dombeya rotundifolia* bushveld on northern slopes

This community is preferred by particularly impala and wildebeest, as is also shown in the habitat selection analysis. This is reiterated by the fact that there is a particularly high percentage of Increasers 2c (56%) (Table 2), and a very low percentage of decreasers.

This leads to a disturbed veld and a low veld condition index of 31,3% (Table 2) which is an indication of a poor veld condition.

In an average rainfall year (600 mm) the grazing capacity for cattle is 5,7 ha/L.S.U. or for game is 7,7 ha/L.S.U. Because of the small size of the community (25ha) it can only sustain 4,4 L.S.U. cattle or 3,4 L.S.U. game (Table 2).

In a below average rainfall year (400 mm) the grazing capacity deteriorates rapidly to 15,5 ha/L.S.U. for cattle or 20,0 ha/L.S.U. for game. In such a year the community can only support 1,6 L.S.U. cattle or 1,2 L.S.U. game (Table 3).

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In an above average rainfall year the grazing capacity for cattle is 3,2 ha/L.S.U. or for game is 4,1 ha/L.S.U. In such a case the community can support 7,8 L.S.U. cattle or 4,1 L.S.U. game (Table 4).

8. *Euclalyptus grandis* plantations

In an average rainfall year (600 mm) the grazing capacity is 4,2 ha/L.S.U. for cattle or 7,5 ha/L.S.U. for game. In such a time 8,2 L.S.U. cattle or 4,7 L.S.U. game can be supported (Table 2).

In a below average rainfall year (400 mm) the grazing capacity deteriorates to 7,3 ha/L.S.U. for cattle or 13,0 ha/L.S.U. for game, which means that only 4,8 L.S.U. cattle or 2,7 L.S.U. game can be sustained (Table 3).

In a good rainfall year the grazing capacity for this community is 2,8 ha/L.S.U. for cattle or 4,9 ha/L.S.U. for game. In such a time 12,6 L.S.U. cattle or 7,1 L.S.U. game can be sustained (Table 4).

This community is dominated by alien vegetation, and is therefore avoided by most of the game species, as alien vegetation usually causes a decrease in biodiversity. This is proven by the fact that game was seen very seldom in this community, and there is a high percentage of Increasers 1 that indicates under-utilisation taking place.

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9. *Ischaemum fasciculatum - Phragmites australis* wetlands

This community consists mainly of grass species and reeds which grow vigorously and rapidly, and form a dense blanket which covers the whole community. The large number of decreasers causes the veld condition index to be fairly high at 65,2%. This community also contains a number of invader species, which could pose a problem to the community in the future.

In an average rainfall year (600 mm) the grazing capacity for cattle is 4,2 ha/L.S.U. or for game is 7.4 ha/L.S.U. (Table 2). This calculates to 17,6 L.S.U. cattle or 9,4 L.S.U. game for the whole community (Table 2).

In a below average rainfall year (400 mm) the grazing capacity drops to 7,4 ha/L.S.U. for cattle or 13,0 ha/L.S.U. for game. At such a time the community can sustain 9,5 L.S.U. game or 5,4 L.S.U. game (Table 3). A result of the perennial streams which are part of the community there will always be moisture to sustain a good grazing capacity.

In a good rainfall year (851 mm) the grazing capacity is 2,7 ha/L.S.U. for cattle or 4,8 ha/L.S.U. for game. In such a time the community can sustain 25,8 L.S.U. cattle or 14,5 L.S.U. game (Table 4).

General

The overall grazing capacity in an average rainfall year of 600 mm per annum, is 4,1 ha/L.S.U. for cattle or 5,7 ha/L.S.U. for game. This implies that 262 L.S.U. game can be sustained by the whole Game Park.

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In a poor rainfall year of 400 mm per annum the grazing capacity for cattle is 7,5 ha/L.S.U. or for game is 10,6 ha/L.S.U.. This is calculated to a total of 141 L.S.U. game that can be supported. This scenario is important to be assessed carefully as there are predictions of droughts in the not too distant future as a result of the El Nino phenomenon. Management schemes for this scenario are discussed in the next chapter

In the good rainfall year such as the one from March 1996 - March 1997 (851 mm), it is interesting to see how much more game can be supported. Here the grazing capacity is 2,6 ha/L.S.U. for cattle or 3,6 ha/L.S.U. for game. In such a year the Game Park can support 410 L.S.U. game. This is the capacity and not necessarily the stocking rate, as the next year may be dry, and the game will suffer. It is important to take note that the model uses an average annual rainfall over a 20 year period, and therefore one year with an unusually high or low rainfall period does not necessarily cause the game park to be under or overstocked, as the model might show. If the veld condition is poor however, an unusually poor rainfall year might be the trigger that pushes the ecological processes beyond the recovery threshold.

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**Table 2: Graze analysis for nine plant communities in an average rainfall year (600 mm)**

| Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Size (ha) | 130 | 80 | 136 | 174 | 838 | 7 | 25 | 35 | 70 |
| Trees % | 1 | 0 | 33 | 34 | 52 | 85 | 57 | | |
| Shrubs % | 10 | 3 | 5 | 5 | 15 | 10 | 15 | 2 | 2 |
| Bush factor | 1,00 | 0,99 | 0,76 | 0,76 | 0,60 | 0,40 | 0,57 | 0,99 | 0,99 |
| | | | | | | | | | |
| Decreasers | 23 | 1 | 20 | 14 | 27 | 23 | 8 | 22 | 40 |
| Increasers 1 | 14 | 28 | 40 | 63 | 22 | 9 | 11 | 55 | 36 |
| Increasers 2a | | | | | | | | | |
| Increasers 2b | 49 | 42 | 13 | 13 | 37 | 49 | 25 | 17 | |
| Increasers 2c | 5 | 32 | 17 | 11 | 14 | 19 | 56 | 6 | |
| Encroachers | | | | | | | | | 26 |
| Bare soil | | | | | | | | | |
| Total | 92 | 103 | 90 | 101 | 100 | 100 | 100 | 100 | 102 |
| **Veld Condition Index %** | **58,1** | **39,3** | **61,0** | **63,8** | **58,6** | **50,8** | **31,3** | **67,9** | **65,2** |
| | | | | | | | | | |
| Grass cover % | 71 | 80 | 74 | 74 | 85 | 80 | 80 | 81 | 100 |
| Rainfall (mm/yr) | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| Accessibility | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fire (0.8\1) | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 |
| | | | | | | | | | |
| **Grazing Capacity** | | | | | | | | | |
| *In a normal year* | | | | | | | | | |
| ha/LSU Cattle | 4,9 | 5,7 | 3,7 | 3,6 | 4,0 | 5,4 | 5,7 | 4,2 | 4,2 |
| ha/LSU Game | 8,7 | 10,1 | 5,3 | 5,2 | 5,2 | 6,7 | 7,4 | 7,5 | 7,4 |
| **Number Cattle** | **26,7** | **14,0** | **37,1** | **48,9** | **209,9** | **1,3** | **4,4** | **8,2** | **16,7** |
| **Number LSU Game** | **14,9** | **7,9** | **25,5** | **33,7** | **159,7** | **1,0** | **3,4** | **4,7** | **9,4** |
| | | | | | | | | | |
| **Grazing Capacity** | 8,4 | 11,0 | 8,1 | 7,8 | 8,1 | 9,1 | 12,7 | 7,3 | 7,2 |
| *In a bad year* | | | | | | | | | |
| ha/LSU Cattle | 8,4 | 10,6 | 6,3 | 6,0 | 6,9 | 9,5 | 11,2 | 7,1 | 7,0 |
| ha/LSU Game | 15,1 | 18,8 | 9,1 | 8,8 | 9,0 | 11,8 | 14,5 | 12,6 | 12,5 |
| **Number Cattle** | **15,4** | **7,5** | **21,7** | **28,8** | **122,1** | **0,7** | **2,2** | **4,9** | **9,9** |
| **Number LSU Game** | **8,6** | **4,3** | **14,9** | **19,8** | **92,9** | **0,6** | **1,7** | **2,8** | **5,6** |
| **Total Grazing Capacity (ha/LSU)** | | | | **Cattle** | **4,1** | **Game** | **5,7** | | |

# Table 3: Graze analysis for nine plant communities in a below average rainfall year (400 mm)

| Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Size (ha) | 130 | 80 | 136 | 174 | 838 | 7 | 25 | 35 | 70 |
| Trees % | 1 | 0 | 33 | 34 | 52 | 85 | 57 | | |
| Shrubs % | 10 | 3 | 5 | 5 | 15 | 10 | 15 | 2 | 2 |
| Bush factor | 1,00 | 0,99 | 0,76 | 0,76 | 0,60 | 0,40 | 0,57 | 0,99 | 0,99 |
| | | | | | | | | | |
| Decreasers | 23 | 1 | 20 | 14 | 27 | 23 | 8 | 22 | 40 |
| Increasers 1 | 14 | 28 | 40 | 63 | 22 | 9 | 11 | 55 | 36 |
| Increasers 2a | | | | | | | | | |
| Increasers 2b | 49 | 42 | 13 | 13 | 37 | 49 | 25 | 17 | |
| Increasers 2c | 5 | 32 | 17 | 11 | 14 | 19 | 56 | 6 | |
| Encroachers | | | | | | | | | 26 |
| Bare soil | | | | | | | | | |
| Total | 92 | 103 | 90 | 101 | 100 | 100 | 100 | 100 | 102 |
| **Veld Condition Index %** | **58,1** | **39,3** | **61,0** | **63,8** | **58,6** | **50,8** | **31,3** | **67,9** | **65,2** |
| | | | | | | | | | |
| Grass cover % | 71 | 80 | 74 | 74 | 85 | 80 | 80 | 81 | 100 |
| Rainfall (mm/yr) | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 |
| Accessibility | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fire (0.8\1) | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 |
| | | | | | | | | | |
| **Grazing Capacity** | | | | | | | | | |
| *In a normal year* | | | | | | | | | |
| ha/LSU Cattle | 9,1 | 13,2 | 6,6 | 6,3 | 7,4 | 10,7 | 15,5 | 7,3 | 7,4 |
| ha/LSU Game | 16,2 | 23,4 | 9,6 | 9,2 | 9,7 | 13,3 | 20,0 | 13,0 | 13,0 |
| **Number Cattle** | **14,4** | **6,1** | **20,5** | **27,5** | **113,6** | **0,7** | **1,6** | **4,8** | **9,5** |
| **Number LSU Game** | **8,0** | **3,4** | **14,1** | **19,0** | **86,4** | **0,5** | **1,2** | **2,7** | **5,4** |
| | | | | | | | | | |
| **Grazing Capacity** | 21,6 | 57,6 | 19,5 | 17,9 | 20,4 | 27,9 | 219,2 | 15,7 | 16,2 |
| *In a bad year* | | | | | | | | | |
| ha/LSU Cattle | 21,5 | 55,8 | 15,1 | 13,9 | 17,3 | 29,0 | 192,4 | 15,4 | 15,9 |
| ha/LSU Game | 38,4 | 98,7 | 22,0 | 20,2 | 22,8 | 36,2 | 248,7 | 27,3 | 28,1 |
| Number Cattle | 6,0 | 1,4 | 9,0 | 12,5 | 48,3 | 0,2 | 0,1 | 2,3 | 4,4 |
| Number LSU Game | 3,4 | 0,8 | 6,2 | 8,6 | 36,8 | 0,2 | 0,1 | 1,3 | 2,5 |
| Total Grazing Capacity (ha/LSU) | | | | Cattle | 7,5 | Game | 10,6 | | |

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## Table 4: Graze analysis for nine plant communities in an above average rainfall year (851 mm)

| Unit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Size (ha) | 130 | 80 | 136 | 174 | 838 | 7 | 25 | 35 | 70 |
| Trees % | 1 | 0 | 33 | 34 | 52 | 85 | 57 | | |
| Shrubs % | 10 | 3 | 5 | 5 | 15 | 10 | 15 | 2 | 2 |
| Bush factor | 1,00 | 0,99 | 0,76 | 0,76 | 0,60 | 0,40 | 0,57 | 0,99 | 0,99 |
| | | | | | | | | | |
| Decreasers | 23 | 1 | 20 | 14 | 27 | 23 | 8 | 22 | 40 |
| Increasers 1 | 14 | 28 | 40 | 63 | 22 | 9 | 11 | 55 | 36 |
| Increasers 2a | | | | | | | | | |
| Increasers 2b | 49 | 42 | 13 | 13 | 37 | 49 | 25 | 17 | |
| Increasers 2c | 5 | 32 | 17 | 11 | 14 | 19 | 56 | 6 | |
| Encroachers | | | | | | | | | 26 |
| Bare soil | | | | | | | | | |
| Total | 92 | 103 | 90 | 101 | 100 | 100 | 100 | 100 | 102 |
| **Veld Condition Index %** | **58,1** | **39,3** | **61,0** | **63,8** | **58,6** | **50,8** | **31,3** | **67,9** | **65,2** |
| | | | | | | | | | |
| Grass cover % | 71 | 80 | 74 | 74 | 85 | 80 | 80 | 81 | 100 |
| Rainfall (mm/yr) | 851 | 851 | 851 | 851 | 851 | 851 | 851 | 851 | 851 |
| Accessibility | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Fire (0.8\1) | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 | 0,80 |
| | | | | | | | | | |
| **Grazing Capacity** | | | | | | | | | |
| *In a normal year* | | | | | | | | | |
| ha/LSU Cattle | 3,1 | 3,3 | 2,3 | 2,3 | 2,5 | 3,3 | 3,2 | 2,8 | 2,7 |
| ha/LSU Game | 5,5 | 5,9 | 3,4 | 3,3 | 3,3 | 4,1 | 4,1 | 4,9 | 4,8 |
| **Number Cattle** | **42,1** | **24,0** | **58,0** | **75,7** | **330,8** | **2,1** | **7,8** | **12,6** | **25,8** |
| **Number LSU Game** | **23,6** | **13,6** | **39,8** | **52,2** | **251,7** | **1,7** | **6,1** | **7,1** | **14,5** |
| | | | | | | | | | |
| **Grazing Capacity** | 4,8 | 5,4 | 4,6 | 4,6 | 4,6 | 4,9 | 5,8 | 4,3 | 4,2 |
| *In a bad year* | | | | | | | | | |
| ha/LSU Cattle | 4,8 | 5,3 | 3,6 | 3,5 | 3,9 | 5,1 | 5,1 | 4,2 | 4,1 |
| ha/LSU Game | 8,5 | 9,3 | 5,3 | 5,1 | 5,1 | 6,4 | 6,6 | 7,5 | 7,4 |
| **Number Cattle** | **27,2** | **15,2** | **37,6** | **49,2** | **214,6** | **1,4** | **4,9** | **8,2** | **16,9** |
| **Number LSU Game** | **15,2** | **8,6** | **25,8** | **33,9** | **163,3** | **1,1** | **3,8** | **4,6** | **9,5** |
| **Total Grazing Capacity (ha/LSU)** | | | | **Cattle** | **2,6** | **Game** | **3,6** | | |

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# Chapter 5. Structural analysis of the woody stratum of Bynespoort Game Park

## 6.1 Structural analysis

Following the BECVOL analysis (Smit, 1996) described in chapter 3, the following results and conclusions can be presented for each of the plant communities determined. The same communities were used, as in the previous chapter for the veld condition. Figure 14 to Figure 20 graphically compare each of the values given in Table 5. They just confirm and justify the explanations given in this chapter.

1. *Harpochloa falx - Elionurus muticus* mountain grassland

The community is dominated by perennial grasses, and contains few trees as a result of the exposed high altitude in the rocky quartzite ridge. There is a total of 250 ind./ ha (Fig 14). Only three species were encountered in the transect. *Burkea africana* was the most dominant at 150 individuals per hectare. These were all young or coppiced individuals. *Combretum molle*

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and *Acacia karroo* were the next most abundant at 50 individuals per hectare.

The leaf volume of the community is 583 $m^3.ha^{-1}$ (Fig 15), and the evapotranspiration tree equivalent is only 1167.$ha^{-1}$ (Table 5)(Fig 16). This emphasises that there are few trees in the community. It is therefore not an important community for browsers.

The total leaf mass is 277 $kg.ha^{-1}$ (Fig 17). The leaf mass is by far the highest below a height of 1.5 m where it is 189 $kg.ha^{-1}$, with only 17 $kg.ha^{-1}$ (Fig 18). In the height class of 2 m to 5 m, the leaf dry mass is 69 $kg.ha^{-1}$ (Fig 19)(Fig 20).

2. *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland

This community was identified as an old field grassland. The woody vegetation was only coppiced individuals of *Acacia karroo*. There are 250 individuals per hectare in the community. With a very low leaf volume (285 $m^3.ha^{-1}$)(Fig 15), and evapotranspiration tree equivalent (571.$ha^{-1}$)(Fig 16), it is clear that the importance of the woody stratum is insignificant for browsers. The coourance of these young *Acaia karroo* individuals may be an indication that they are encroaching into the old field. This may often be indicative of the stage of succession, *Acacia karroo* being a pioneer species, although the

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species may also be dominant in climax vegetation, eg. Community 5.1 (*Ziziphus mucronata Acacia karroo* bushveld variation).

Almost all of the leaf dry mass occurs below 1.5 m (128 $kg.ha^{-1}$)(Fig 18). With a total of 137 $kg.ha^{-1}$, only 9 $kg.ha^{-1}$ occurs above 1.5 m (Table 5).

3. *Terminalia sericea - Burkea Africana* bushveld on sand

This community contains 950 woody individuals per hectare. The community is dominated by *Terminalia sericea* with 600 $ind.ha^{-1}$, followed by *Burkea Africana* with approximately 150 $ind.ha^{-1}$. *Dichrostachys cinearia* is also present at a density of 50 individuals per hectare, and it will be valuable to monitor this density as this tree can be highly invasive. The total leaf volume of the community is 3918 $m^3.ha^{-1}$ with *Acacia caffra* and *Terminalia sericea* contributing the most. The evapotranspiration tree equivalent is 7836 $m^3.ha^{-1}$ (Fig 16) which is fairly high, especially in the sandy soil where water drains very rapidly.

The stratum has a leaf dry mass of 1721 $kg.ha^{-1}$. Below a height of 1.5 m only 56 $kg.ha^{-1}$ is found, between 1.5 and 2 m, 69 $kg.ha^{-1}$, and the largest percentage (1056 $kg.ha^{-1}$) between 2 and 5 m (Table 5). The high density of *Terminalia sericea* and the fact that all the individuals are of a similar age suggests that this species is encroaching on the surrounding grassland as found by Brown (1997) in the Borakolalo Nature Reserve. However, the

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abundance of this species is probably a result of the sandy conditions that prevail in these areas.

4. *Tristachya leucothrix - Trachypogon spicatus* mountain bushveld

The community contains approximately 850 individuals per hectare. *Rhus leptodictya* dominates with 450 individuals per hectare, followed by *Acacia caffra* with 200 individuals per hectare. The leaf volume is 728 $m^3.ha^{-1}$ and the evapotranspiration tree equivalent of 1457 per hectare. This is not very high as a result of the lack of broad leafed trees and large individuals, because of shallow soils, and the cooler conditions of the higher altitude and the south facing slopes. *Protea caffra* is very specific to the cool south facing slopes of the quartzite ridges.

The leaf dry mass is 334 $kg.ha^{-1}$, which is not high, because of the lack of broad leafed species, and the presence of the non-edible *Protea caffra.* The most important browsing height is below 1.5 m (Table 5).

5. *Cynodon dactylon - Acacia karroo* bushveld

For this community three separate analyses were done. The first was on the typical *Cynodon dactylon – Acacia karroo* bushveld. The second was done on the *Ziziphus mucronata – Acacia karroo* bushveld variation, ad the third on the *Solanum panduforme – Acacia karroo* disturbed bushveld variation.

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5. *Cynodon dactylon - Acacia karroo* bushveld

Being the community that covers the largest area, its woody stratum is also valuable for browsers. It contains approximately 1000 individuals per hectare, with *Acacia karroo* making up 75% of this. The other 25 % is made up by *Acacia caffra, Rhus lancea, R. leptodictya, R pyroides,* and *Ziziphus mucronata.* The total leaf volume is 6653 m3.ha$^{-1}$, with A. karroo making up 6419 m$^3$.ha$^{-1}$ of this. The evapotranspiration tree equivalent is 13306. ha$^{-1}$, which is rather high, but can be supported by the clayey soil, and relatively high rainfall.

The leaf dry mass is 3363 kg.ha$^{-1}$ in total, with 480 kg.ha$^{-1}$ below 1.5 m, 437 kg.ha$^{-1}$ between 1.5 and 2 m, and 2383 kg.ha$^{-1}$ between 2 and 5 m. This confirms the presence of tall trees with a conical shape typical of the *Acacia* spp., carrying much of the leaf mass near the top (Table 5).

5.1 *Ziziphus mucronata - Acacia karroo* bushveld variation

This variation appears to be more wooded than any of the other communities, and this is evident in the assessment of 1300 individuals per hectare. This variation is dominated by *Acacia karroo* with 900 individuals per hectare. The leaf volume of this variation is 7064 m$^3$.ha$^{-1}$, and has a high

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evapotranspiration tree equivalent of 14129 per hectare. This is a result of the general high density of trees, as well as the occurrence of some broad-leafed and evergreen species.

The total leaf dry mass is 3325 $kg.ha^{-1}$, and the most (2497 $kg.ha^{-1}$) occurs between the 2 m and 5 m browsing heights (Table 5), making this variation very valuable for the browsers giraffe and kudu.

5.2 *Solanum panduniforme - Acacia karroo* disturbed bushveld variation

This variation is slightly less wooded than variation 5.1 with 900 individuals per hectare. It is dominated by *Acacia karroo* with 800 individuals per hectare. The other 100 individuals per hectare are made up by *Burkea africana*. The leaf volume of the variation is 5184 $m^3.ha^{-1}$, and the evapotranspiration tree equivalent is 10367. $ha^{-1}$.

The leaf dry mass is 2547 $kg.ha^{-1}$ with none of it below 1.5 m, 189 $kg.ha^{-1}$ between 1.5 and 2 m, and 2148 $kg.ha^{-1}$ in the highest browsing height (Table 5).

6. *Euclea crispa - Acacia karroo* bushveld on diabase

This community is the most densely wooded with 3000 ind./ ha (Fig 14). *Euclea crispa* is the most dominant with 1200 individuals per hectare,

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followed by *Acacia robusta* with 800 individuals per hectare. *Rhus lancea* also has a fairly high density of 400 individuals per hectare. The high density of woody vegetation causes the leaf volume (11682 $m^3.ha^{-1}$)(Fig 15), and the evapotranspiration tree equivalent (23364 $ha^{-1}$) to be particularly high. The mineral rich diabase substrate supports this high density of trees.

The leaf mass is also very high (5429 $kg.ha^{-1}$)(Fig 17), providing a very high density of leaf material. Below a browsing height of 1.5 m there is a dry mass of 698 $kg.ha^{-1}$, between 1.5 and 2 m it is 415 $kg.ha^{-1}$ and 3546 $kg.ha^{-1}$ between 2 m and 5 m (Table 5).

7. *Combretum apiculatum - Dombeya rotundifolia* bushveld of northern slopes

The community contains a density of 950 individuals per hectare. This density is shared with 250 individuals per hectare by *Combretum molle*, 200 individuals per hectare by *Rhus leptodictya*, 150 individuals per hectare by *Acacia karroo*, 100 individuals per hectare by *Burkea africana* and 50 individuals per hectare by *Acacia caffra, Combretum molle, Dichrostachys cinerea, Dombeya rotundifolia, Rhus lancea* and *Strychnos pungens*. The leaf volume is 3009 $m^3.ha^{-1}$, and the evapotranspiration tree equivalent of 6019. $ha^{-1}$. The uniqueness of the woody stratum of this community is also as a result of the hotter and drier micro-climate being induced by the north facing slopes of the quartzite ridges. The species are likely to occur in

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warmer bushveld areas to the north, and this type of climate is created by the northern aspect of the slopes.

The total leaf dry mass is 1342 $kg.ha^{-1}$, with 107 $kg.ha^{-1}$ below a browsing height of 1.5 m, 268 $kg.ha^{-1}$ between a height of 1.5 m and 2 m, and 943 $kg.ha^{-1}$ between 2 m and 5 m (Table 5). This structure makes it an important community for browsers.

8. *Eucalyptus grandis* plantation

As this community is totally dominated by *Eucalyptus grandis,* which is not utilised by any of the ungulates, it is of no importance in this study, and it was not included in this analyses.

9. *Ischaemum fasciculatum - Phragmites australis* wetland

This wetland area has a relatively low density of 500 individuals per hectare. The species encountered in the transect were: *Acacia karroo* (300 individuals per hectare), *Rhus lancea* (50 individuals per hectare), and *Ziziphus mucronata* (150 individuals per hectare). The leaf volume is 2380 $m^{-3}.ha^{-1}$ and this is dominated by the broad leafed *Ziziphus mucronata*. The evapotranspiration tree equivalent is 4760. $ha^{-1}$.

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The leaf dry mass for the community is 1123 kg.ha$^{-1}$, with 101 kg.ha$^{-1}$ below a browsing height of 1.5 m, 108 kg.ha$^{-1}$ between 1.5 m and 2 m, and 907 kg.ha$^{-1}$ between 2 m and 5 m (Table 5).

10. *Phragmites australis* slimes dams wetland

The community contains 200 individuals per hectare of woody vegetation. This represents a community with few trees, dominated by *Phragmites australis*. The only trees found in the transect were individuals of *Acacia karroo*, and most of these seedlings or coppiced. The coppiced *Acacia karroo* were calculated at 150 individuals per hectare, and the normal individuals 50 individuals per hectare.

This results in a very low leaf volume (66 m$^3$. ha$^{-1}$), and evapotranspiration tree equivalent (132 .ha$^{-1}$). The leaf dry mass is a total of 31 kg.ha$^{-1}$, with the largest mass being below a browsing level of 1,5 m (16 kg.ha$^{-1}$). This is supported by the fact that most of the individuals were coppiced (Table 5).

As most of the slimes dams are still water saturated, after 40 years, the presence of trees could only have a positive effect in drying out the soil. The planting of trees could also assist in beginning the rehabilitation of the slimes dams.

| Table: 5 Results of BECVOL (Smit, 1996) analysis for Bynespoort Game Park | | | | | | | |
|---|---|---|---|---|---|---|---|
| Community # | Plants/ha | Leaf volume | ETTE | LMass | LMass 1.5 | LMass 2 | LMass 5 |
| 1 | 250 | 583 | 1167 | 277 | 189 | 206 | 277 |
| 2 | 250 | 285 | 571 | 137 | 128 | 137 | 137 |
| 3 | 950 | 3918 | 7836 | 1721 | 56 | 125 | 1181 |
| 4 | 850 | 728 | 1457 | 334 | 103 | 114 | 168 |
| 5 | 1000 | 6653 | 13306 | 3363 | 480 | 917 | 3300 |
| 5.2 | 1300 | 7064 | 14129 | 3325 | 419 | 812 | 3309 |
| 5.3 | 900 | 5184 | 10367 | 2547 | 0 | 189 | 2337 |
| 6 | 3000 | 11682 | 23364 | 5429 | 698 | 1113 | 4659 |
| 7 | 950 | 3009 | 6019 | 1342 | 107 | 268 | 1211 |
| 9 | 500 | 2380 | 4760 | 1123 | 101 | 209 | 1116 |
| 10 | 200 | 66 | 132 | 31 | 16 | 28 | 31 |
| AVERAGE | 922.7273 | 3777.45455 | 7555.273 | 1784.455 | 208.8182 | 374.3636 | 1611.455 |

| Table 6: Results of BECVOL (Smit, 1996) analysis concerning the browsing capacity for Bynespoort Game Park | | | | | | |
|---|---|---|---|---|---|---|
| Community # | BTE | BTE 1.5 | BTE 2 | BTE 5 | CSI 2 | CSI 4 |
| 1 | 1108 | 756 | 824 | 1108 | 3.7 | 3.7 |
| 2 | 547 | 513 | 547 | 547 | 0 | 0 |
| 3 | 6884 | 226 | 500 | 4726 | 69.6 | 58 |
| 4 | 1335 | 636 | 800 | 1335 | 10.4 | 0 |
| 5 | 13452 | 1919 | 3667 | 13198 | 111.9 | 67.3 |
| 5.2 | 13330 | 1676 | 3248 | 13237 | 136.4 | 42.2 |
| 5.3 | 10185 | 0 | 754 | 9349 | 101.9 | 70.1 |
| 6 | 21714 | 2793 | 4454 | 18637 | 210.2 | 131.2 |
| 7 | 5369 | 427 | 1073 | 4844 | 60 | 31 |
| 9 | 4493 | 402 | 838 | 4463 | 48 | 31 |
| 10 | 122 | 65 | 114 | 122 | 1.6 | 0 |
| AVERAGE | 7139.909 | 855.727273 | 1529 | 6506 | 68.51818 | 39.5 |

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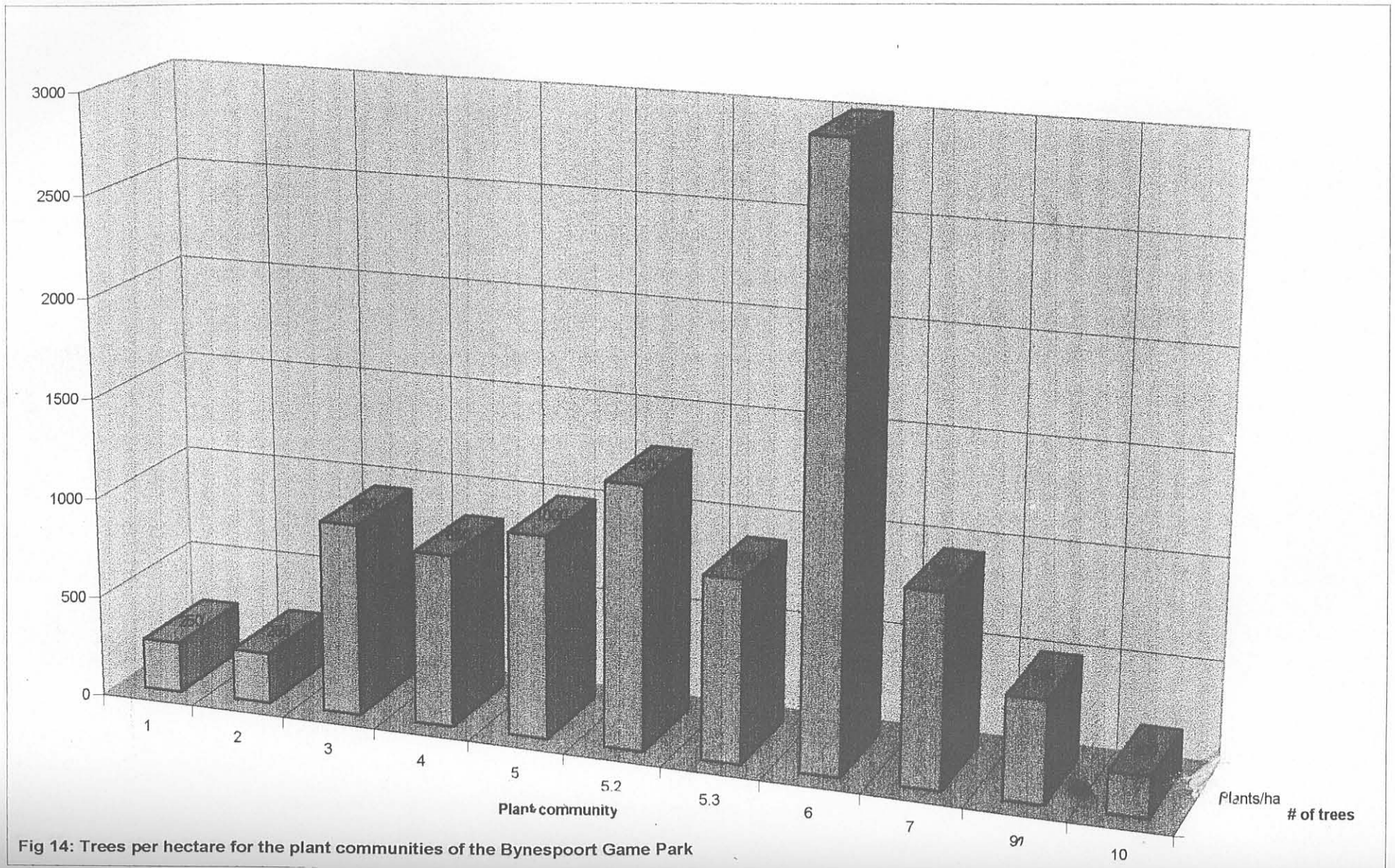



**Fig 14: Trees per hectare for the plant communities of the Bynespoort Game Park**

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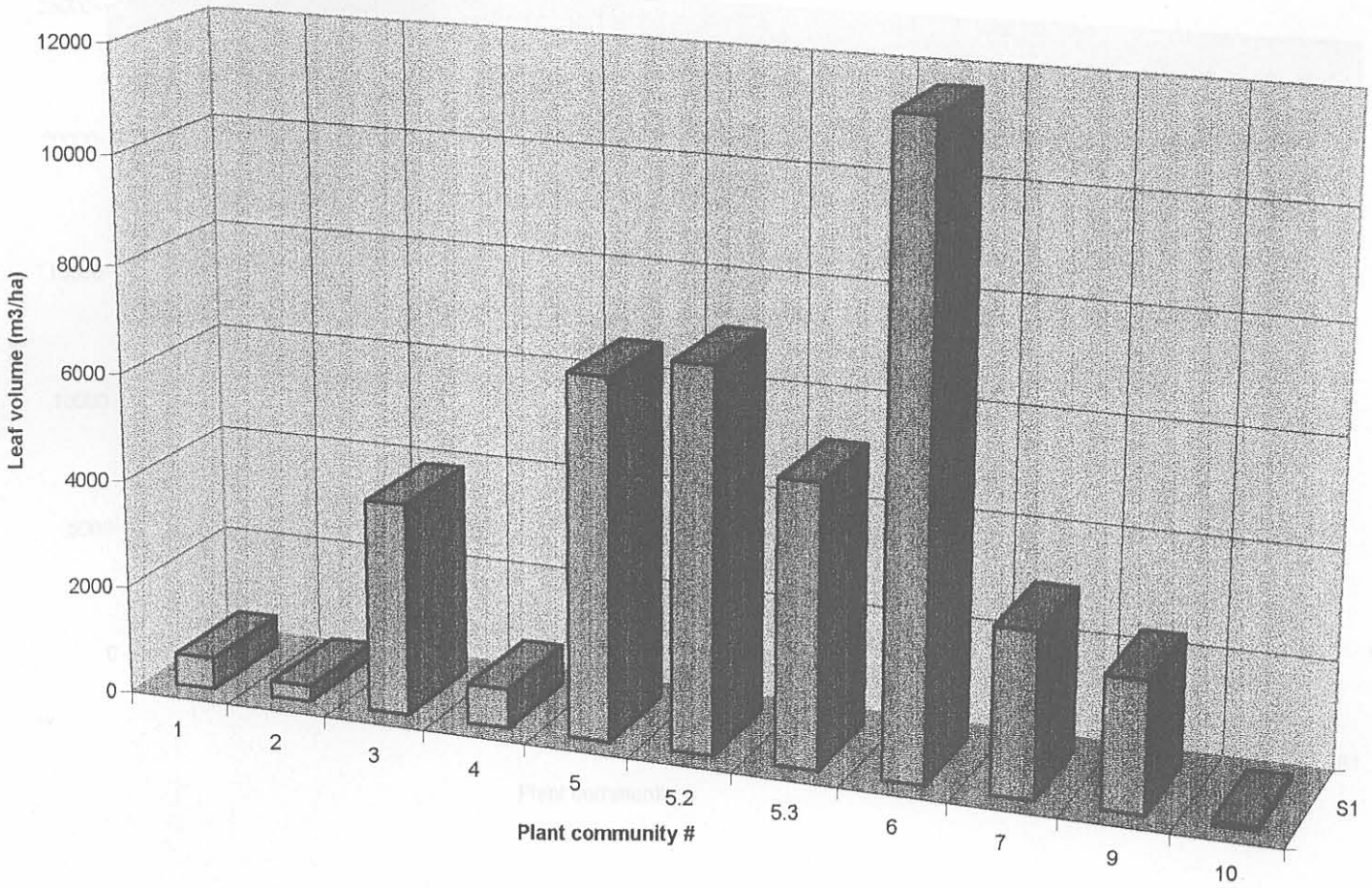



Fig 15: Leaf volume for the plant communities of the Bynespoort Game Park

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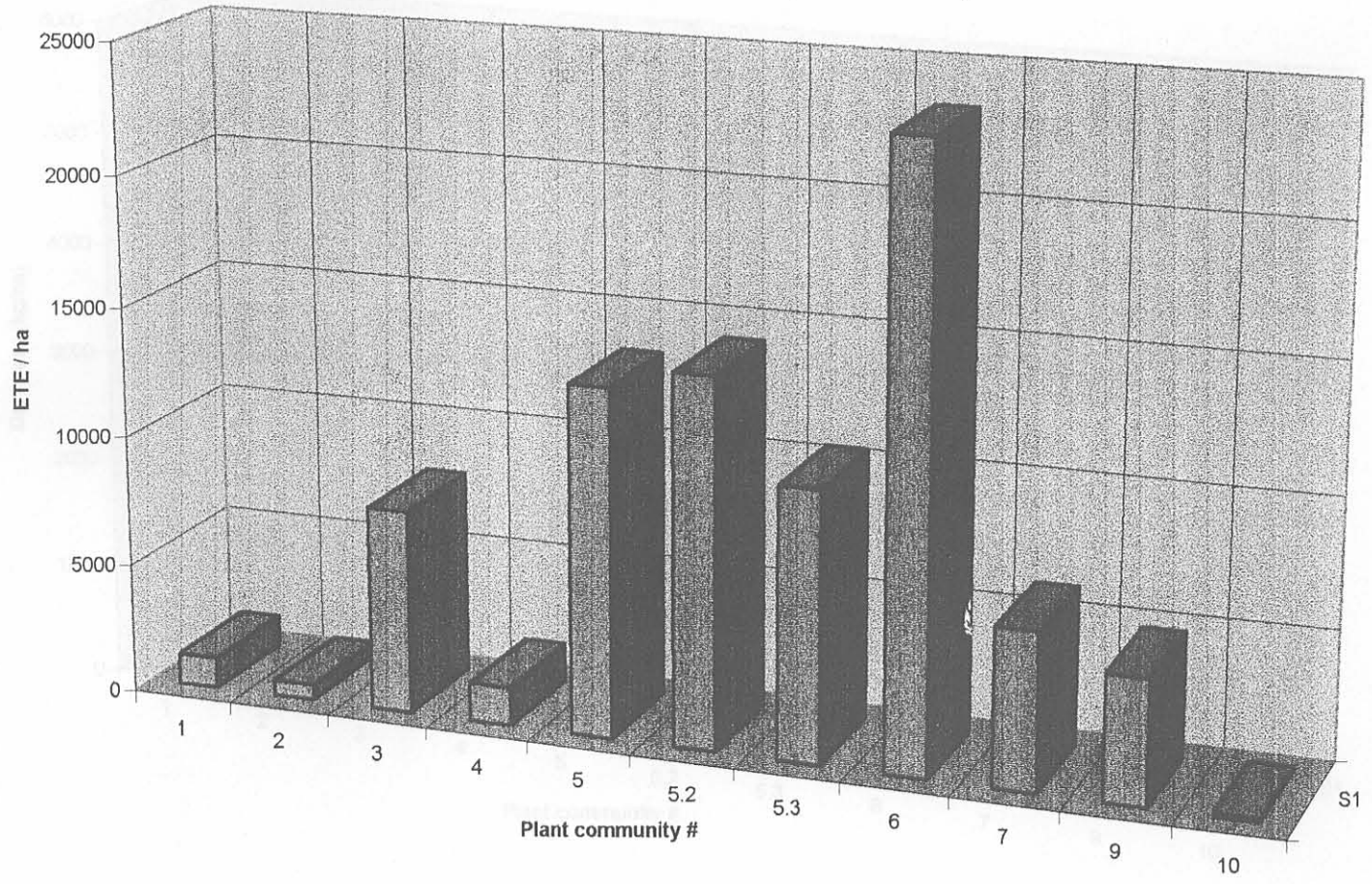



Fig 16: Evapotranspiration tree equivalent for the plant communities of the Bynespoort Game Park

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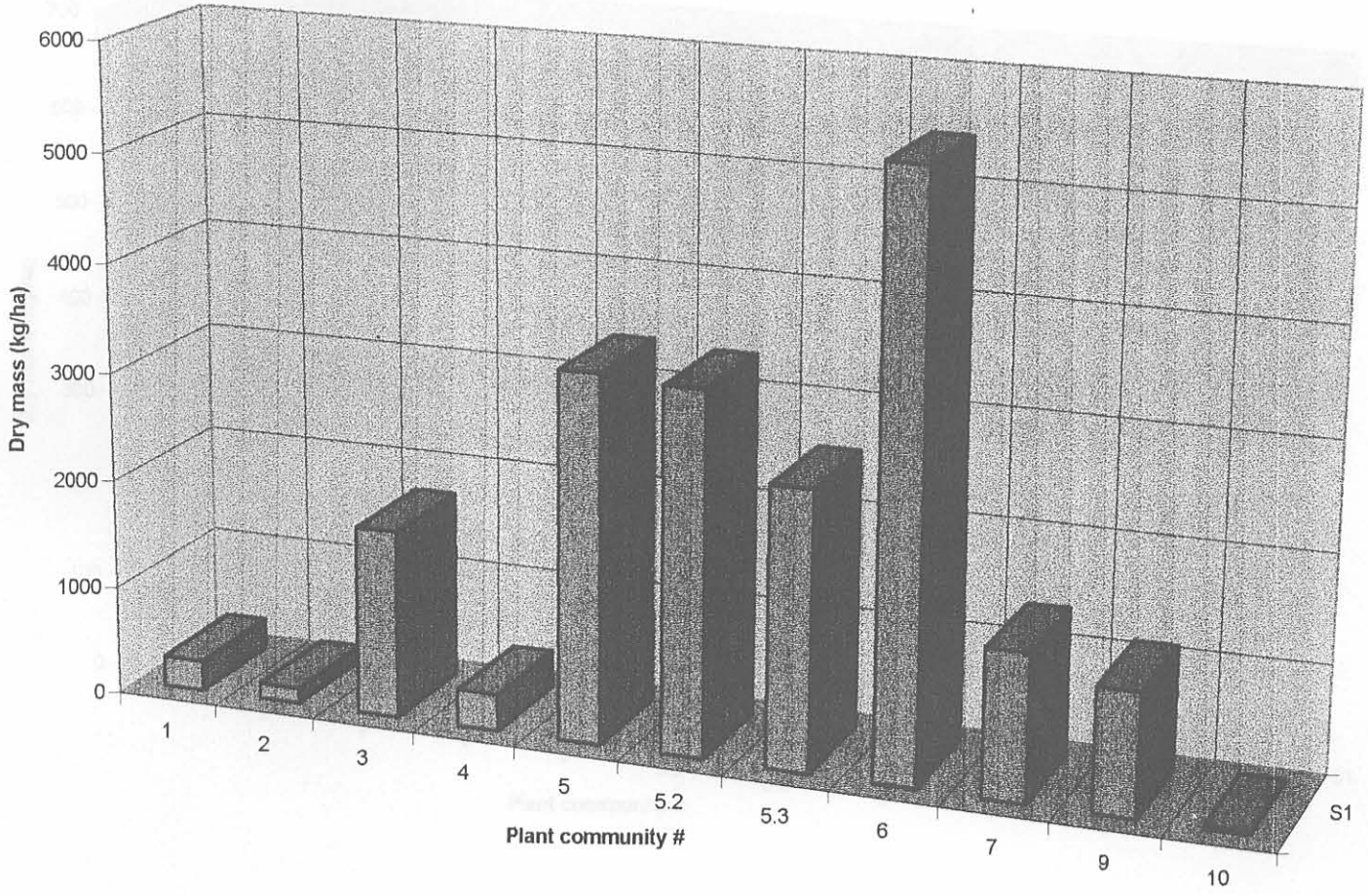



**Fig 17: -Leaf dry mass for the plant communities of the Bynespoort Game Park**

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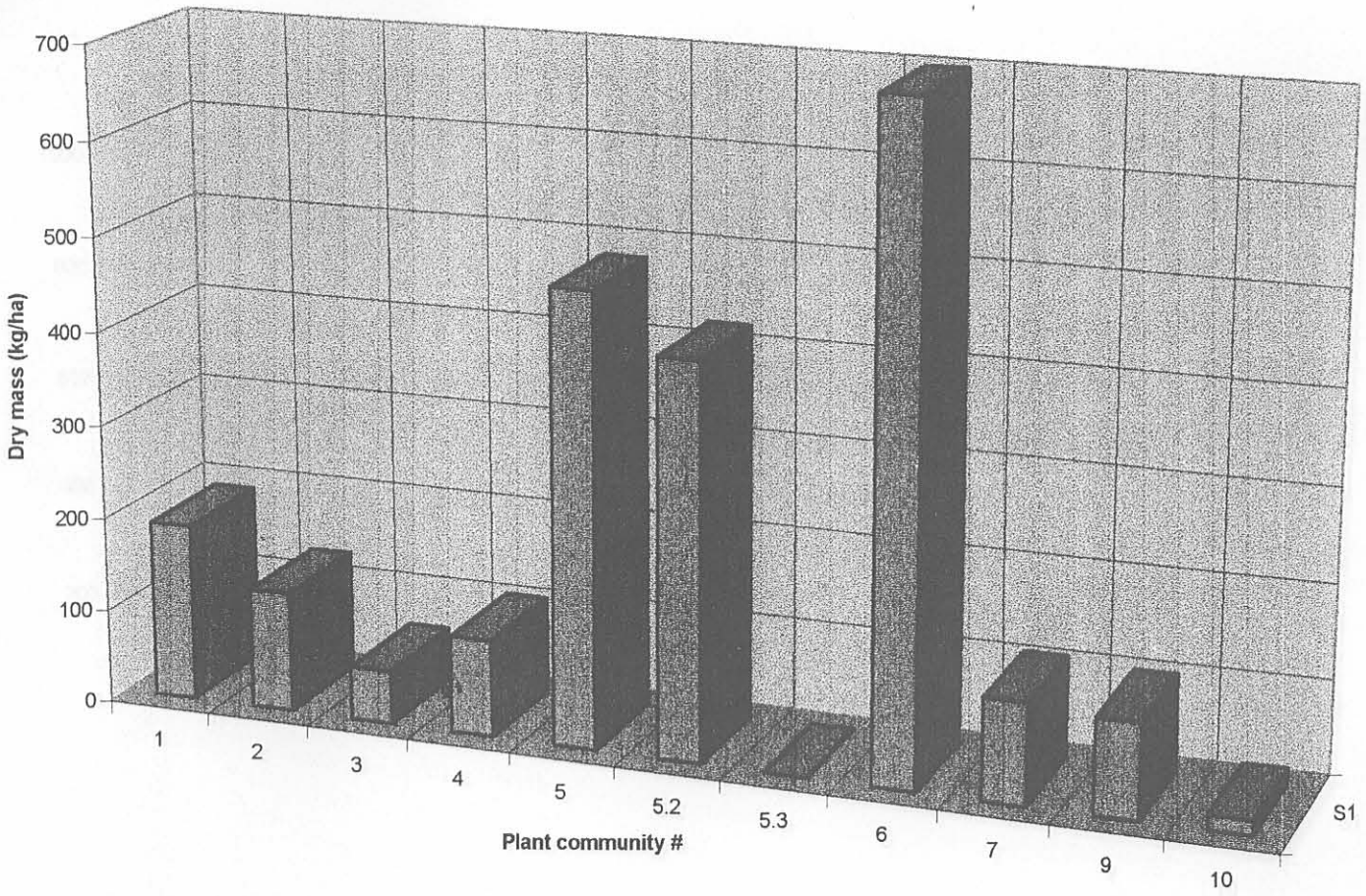



Fig 18: Leaf dry mass below a height of 1.5m for the plant communities of the Bynespoort Game Park

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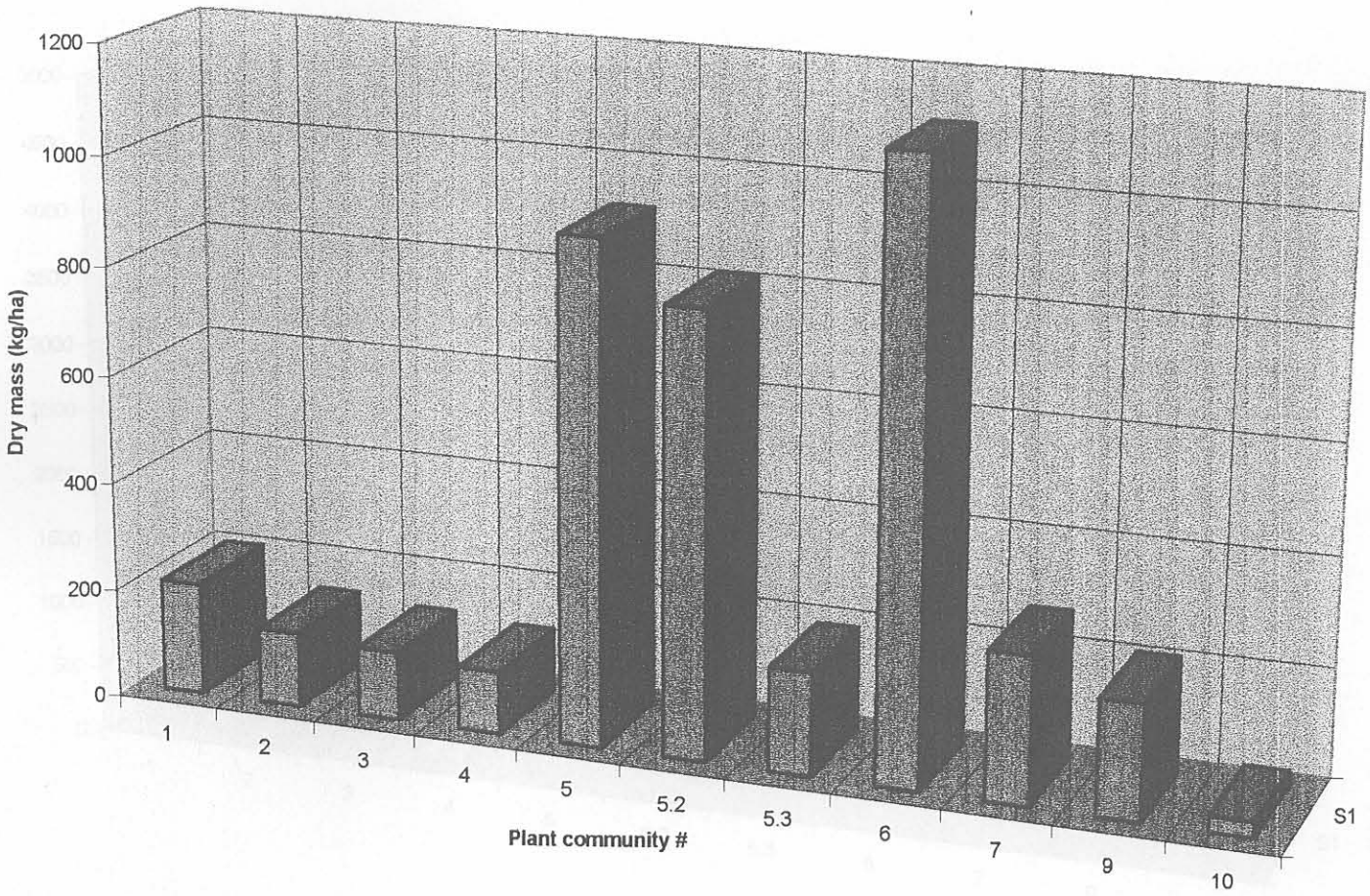



Fig 19: Leaf dry mass below a height of 2m for the plant communities of the Bynespoort Game Park

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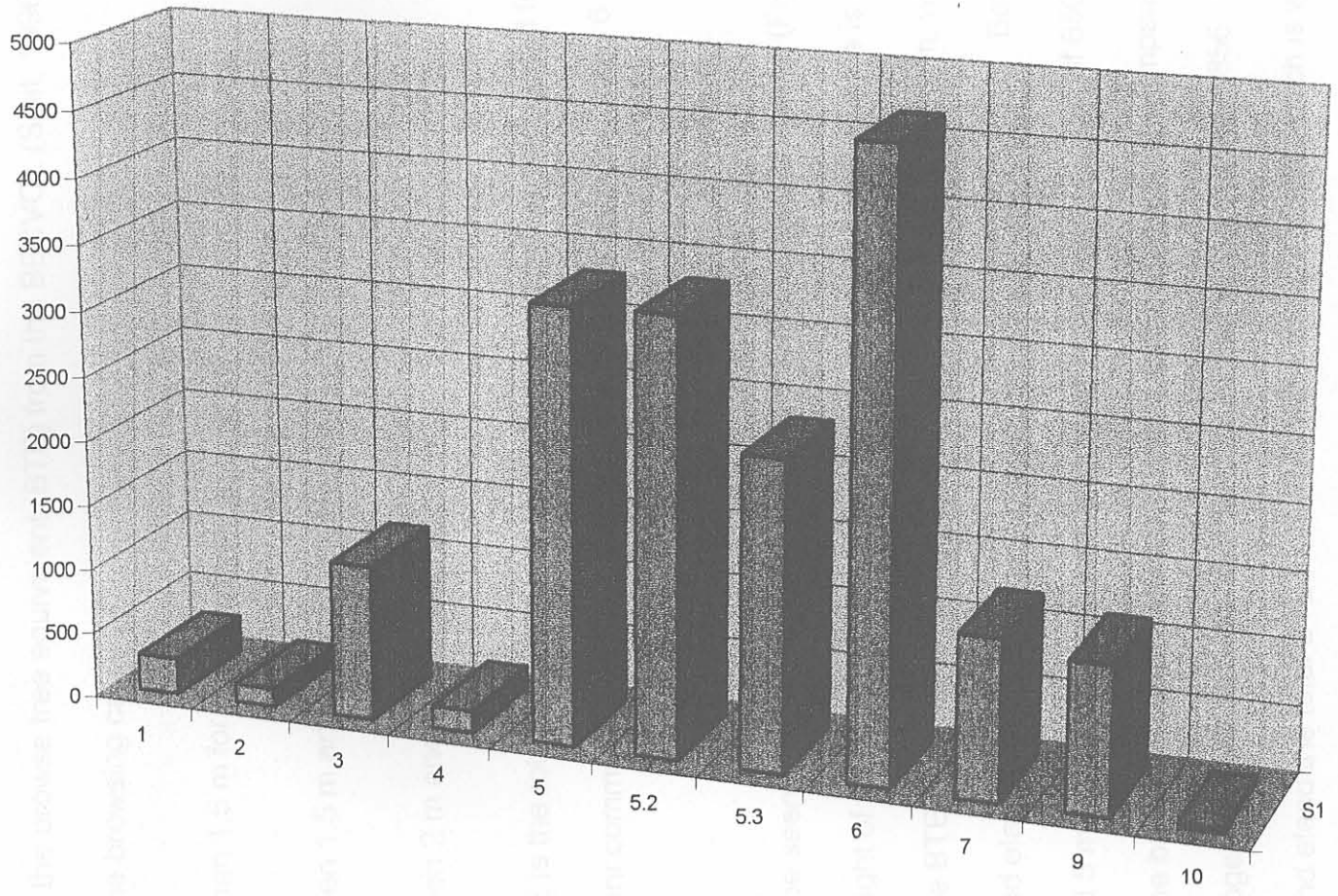



Fig 20: Leaf dry mass below a height of 5m for the plant communities of the Bynespoort Game Park

# Chapter 6. Browsing capacity

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By using the browse tree equivalent (BTE) from the BECVOL (Smit, 1996) model, the browsing capacity was calculated for three browse heights:

- less than 1.5 m for browsers such as impala
- between 1.5 m and 2 m for browsers such as kudu and eland
- between 2 m and 5 m for giraffe

The BTE is the total available browse of the woody stratum, calculated for each plant community, and Bynespoort Game Park as a whole (Table 6.)(Fig 21-26)

As can be seen in table 6, the total BTE for the entire area is 7139.9 (Fig 21). At a height of less than 1.5 m where impala and nyala browse, there is an available BTE of 856 (Fig 22). At a height of between 1.5 m and 2 m, where kudu and eland browse, there is an available BTE of 1529 (Fig 23). Between 2 m and 5 m, where the giraffe browse, there is an available BTE of 6506. By using the browsing equivalents used in Swart (1995), the BTE of impala and nyala together adds up to 66.45. This is well below the available 856. For kudu and eland the total BTE for the current numbers is 106, which is well below the available 1529. The present number of giraffe (26), require 98.8 BTE, where there is 6505 available (Fig 24).

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Not all of the BTE which is available is utilisable to the ungulates, a plant is never totally stripped of twigs, branches, bark, and leaves, and protective mechanisms by plants against browsers, such as the productions of tannins, other secondary metabolites, and thorns, also prevent a total effective browse. The insect herbivore factor is also not taken into account, as much of the available plant material is utilised, by this, the largest group of herbivores.

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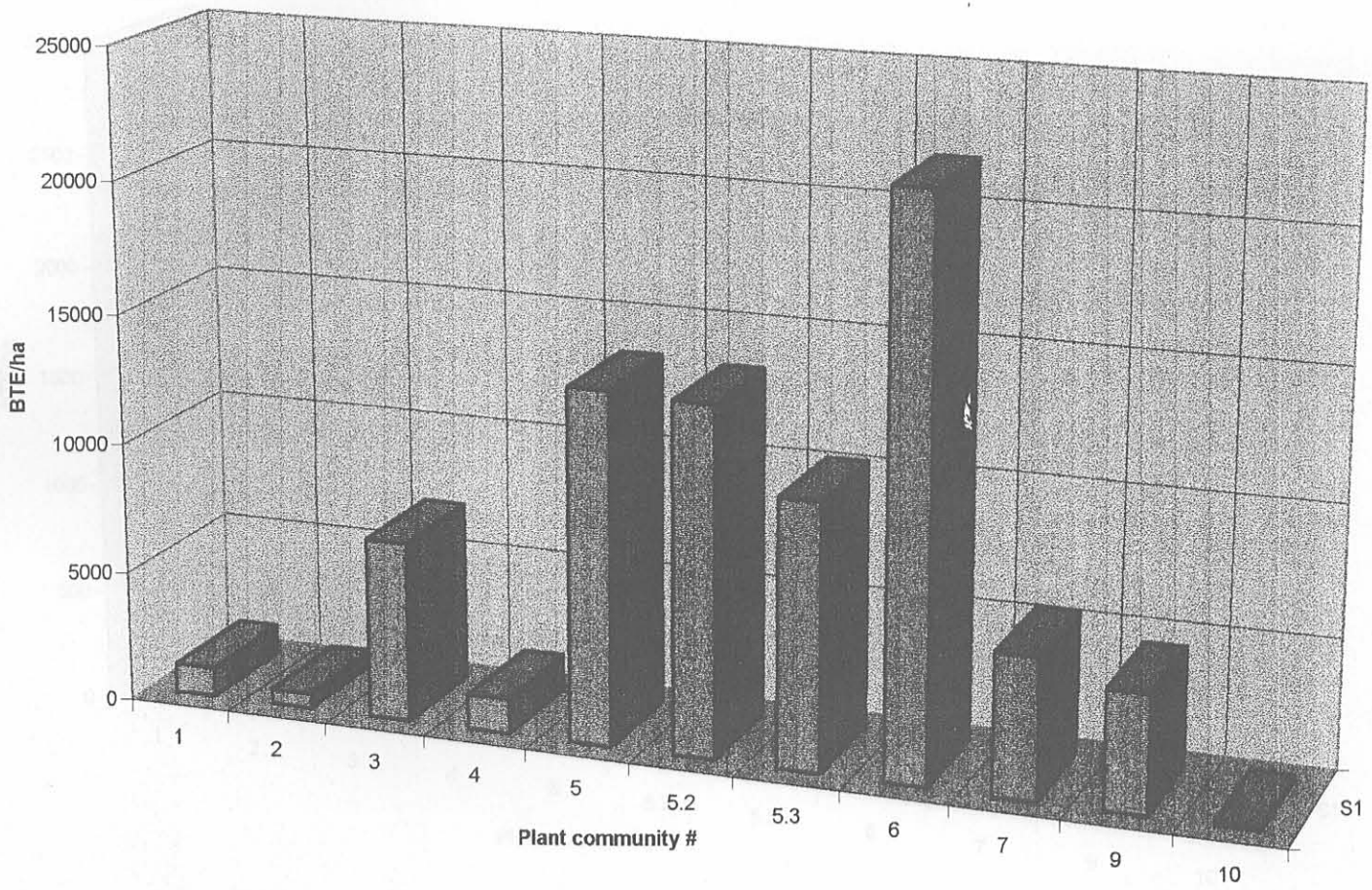



Fig 21: Browse tree equivalent for the plant communities of the Bynespoort Game Park

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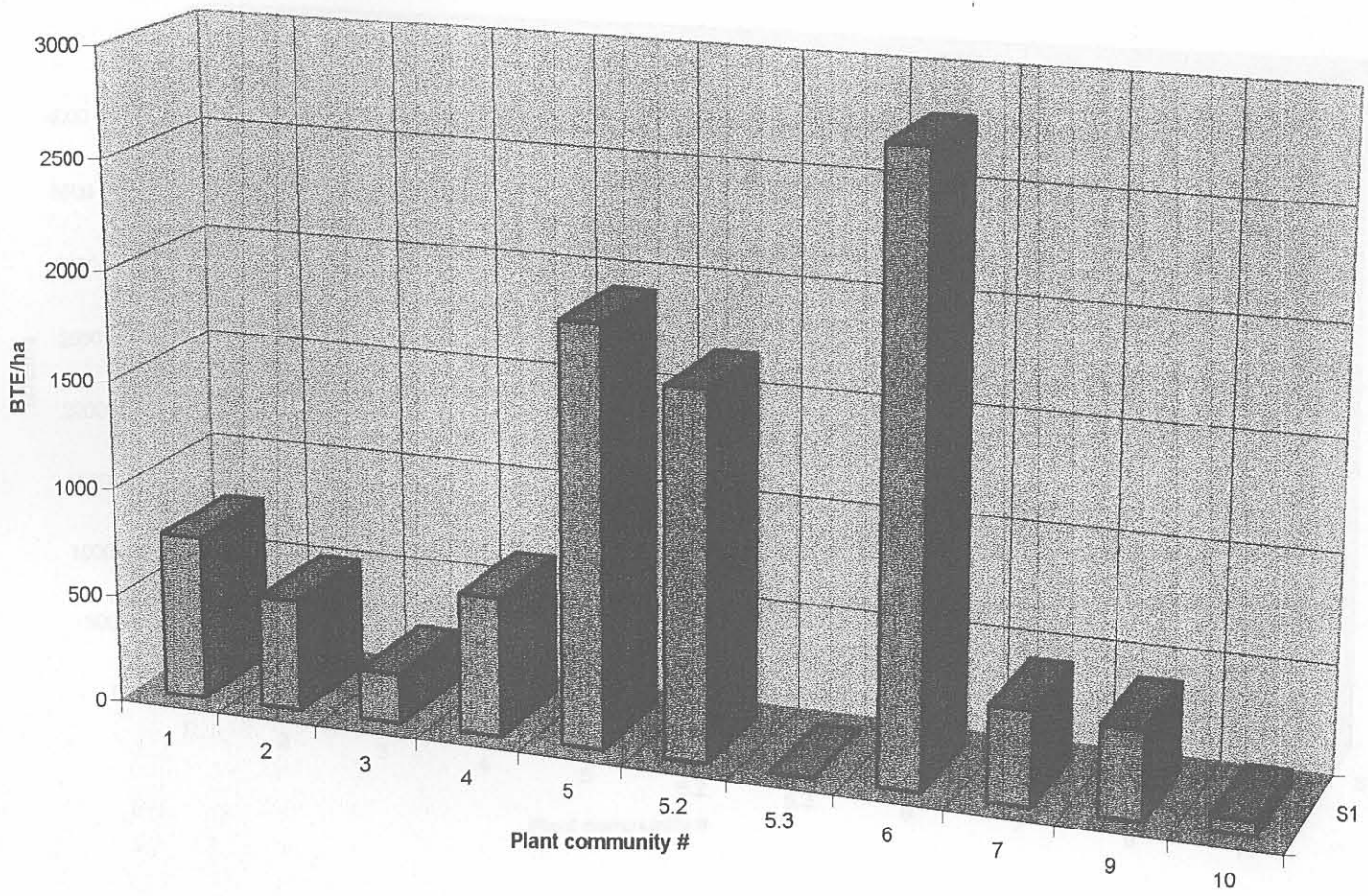



Fig 22: Browse tree equivalent below a height of 1.5m for the plant communities of the Bynespoort Game Park

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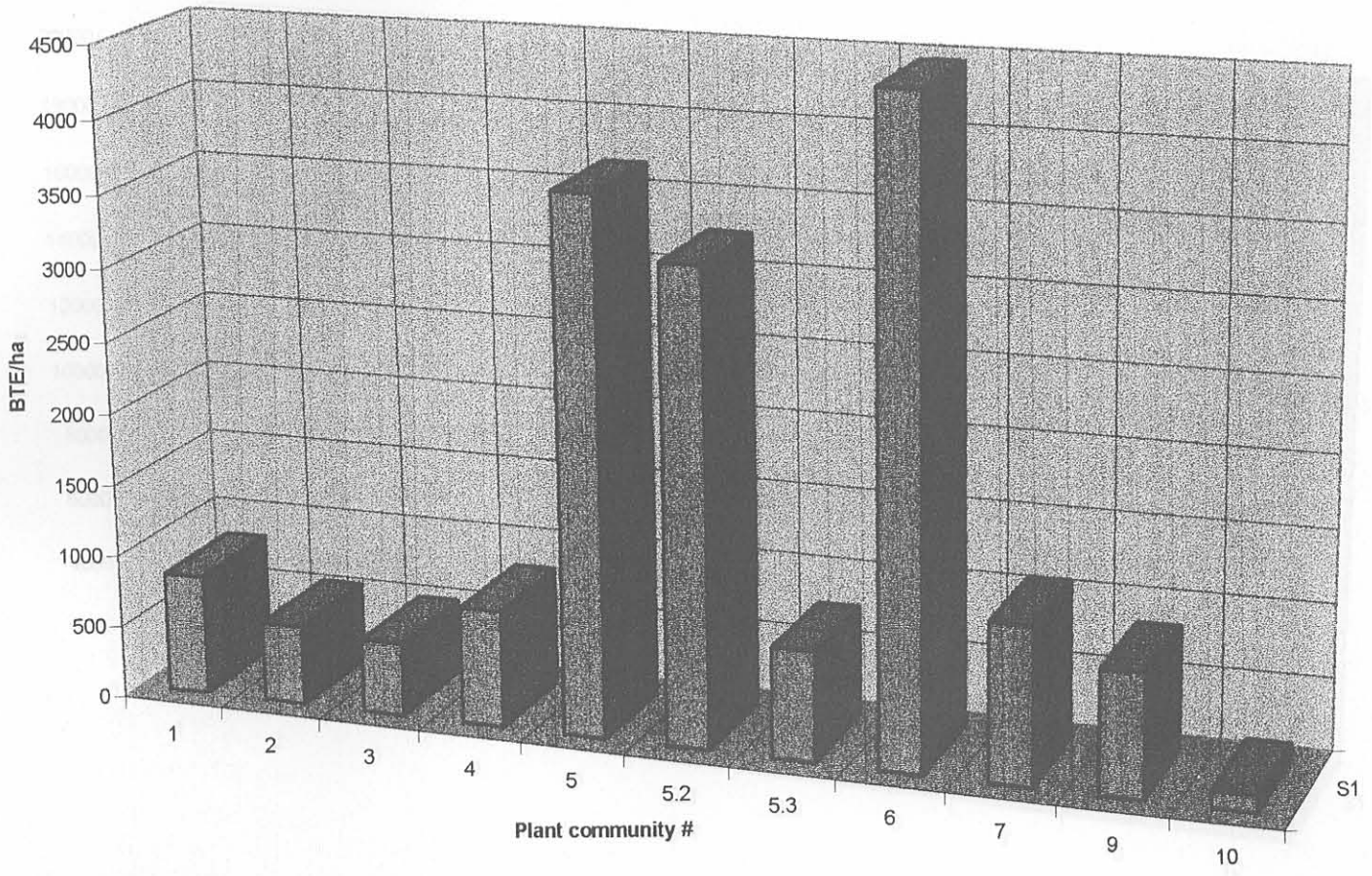



**Fig 23: Browse tree equivalent below a height of 2m for the plant communities of the Bynespoort Game Park**

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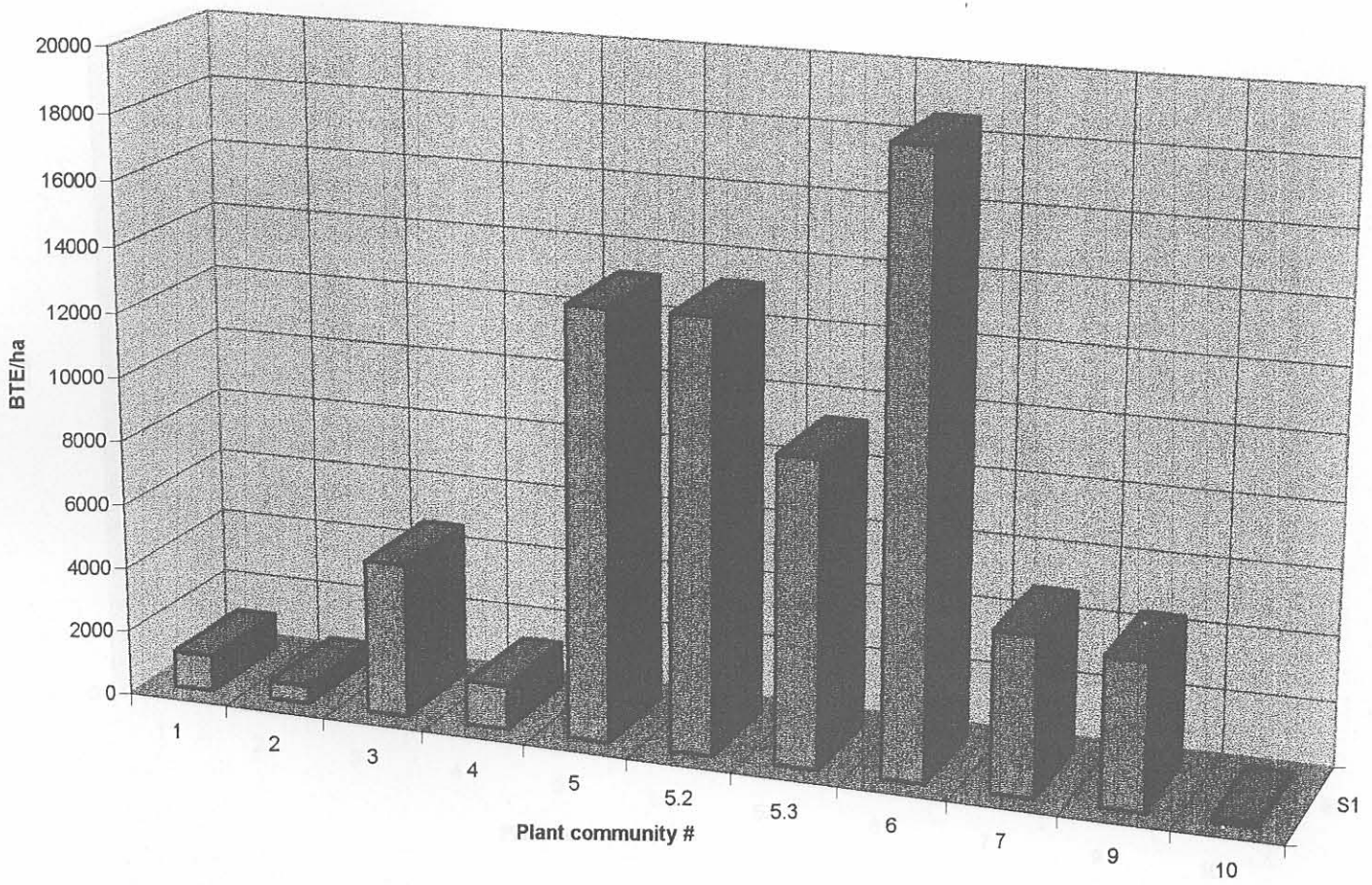



**Fig 24: Browse tree equivalent below a height of 5m for the plant communities of the Bynespoort Game Park**

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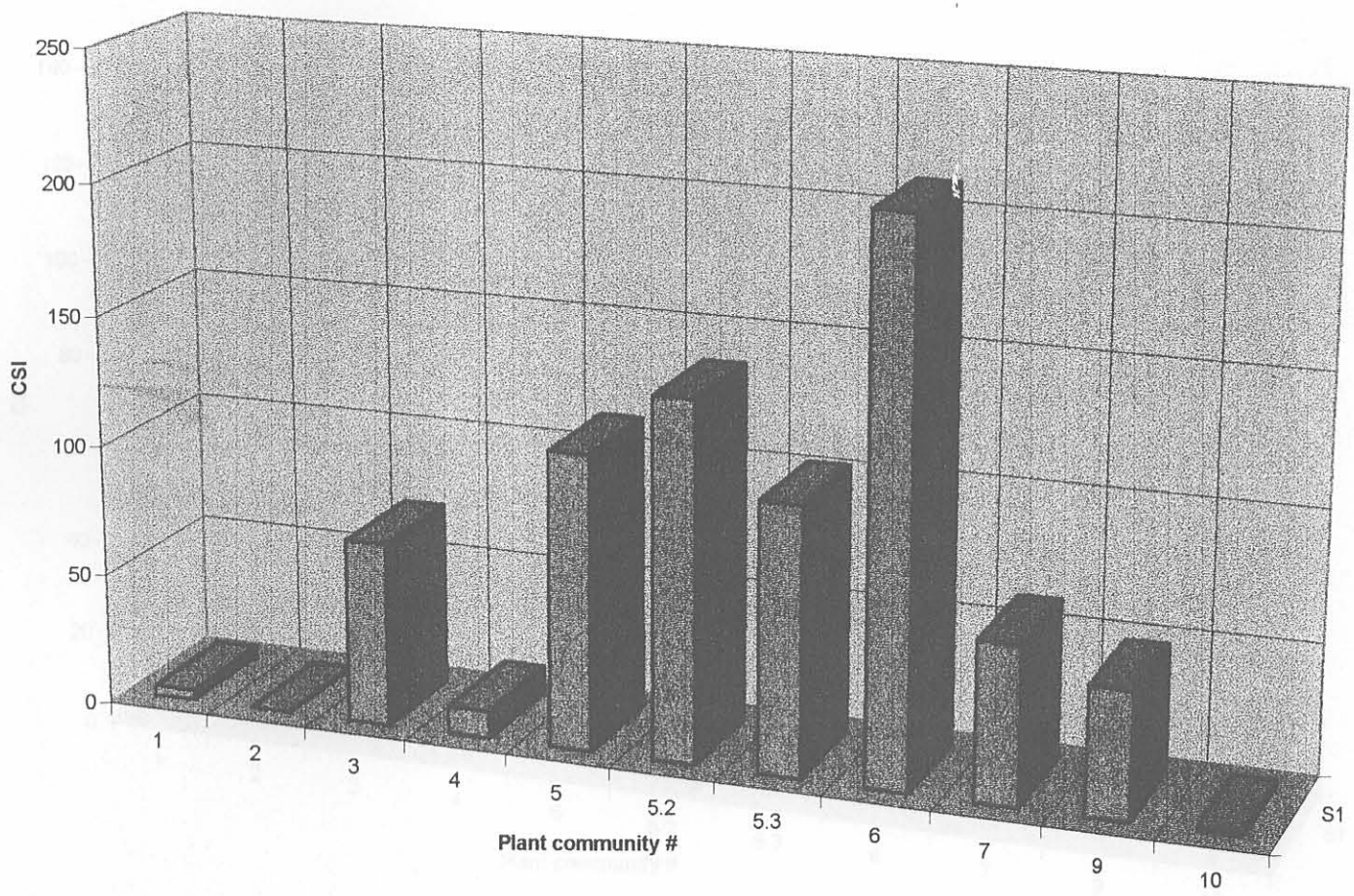



**Fig 25: Canopied subhabitat index of trees with a minimum height of 2m for the plant communities of the Bynespoort Game Park**

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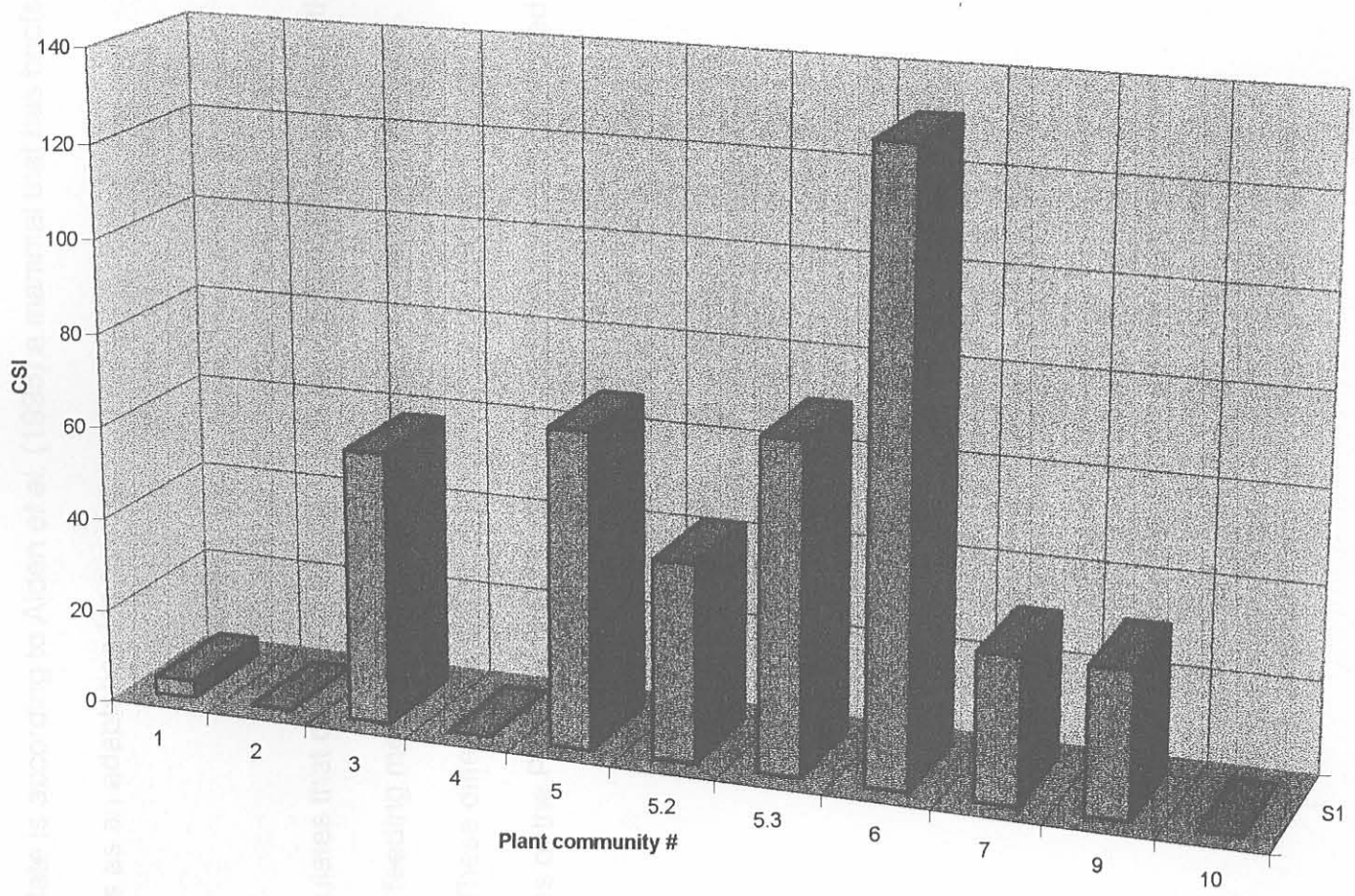



**Fig 26: Canopied subhabitat index for trees with a minimum height of 4m for the plant communities of the Bynespoort Game Park**

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# Chapter 7. Ungulates of Byespoort Game Park

An ungulate is according to Alden *et.al.* (1995) a mammal that has hoofs, and not claws as an adaptation for running.

The ungulates that occur in the Bynespoort Game Park all have distinctly different feeding methods, habits and preferences (Skinner & Smithers, 1990). These differences will have an influence on the way that the resources of the Park are utilised. The utilisation spectrum is illustrated in fig 27.

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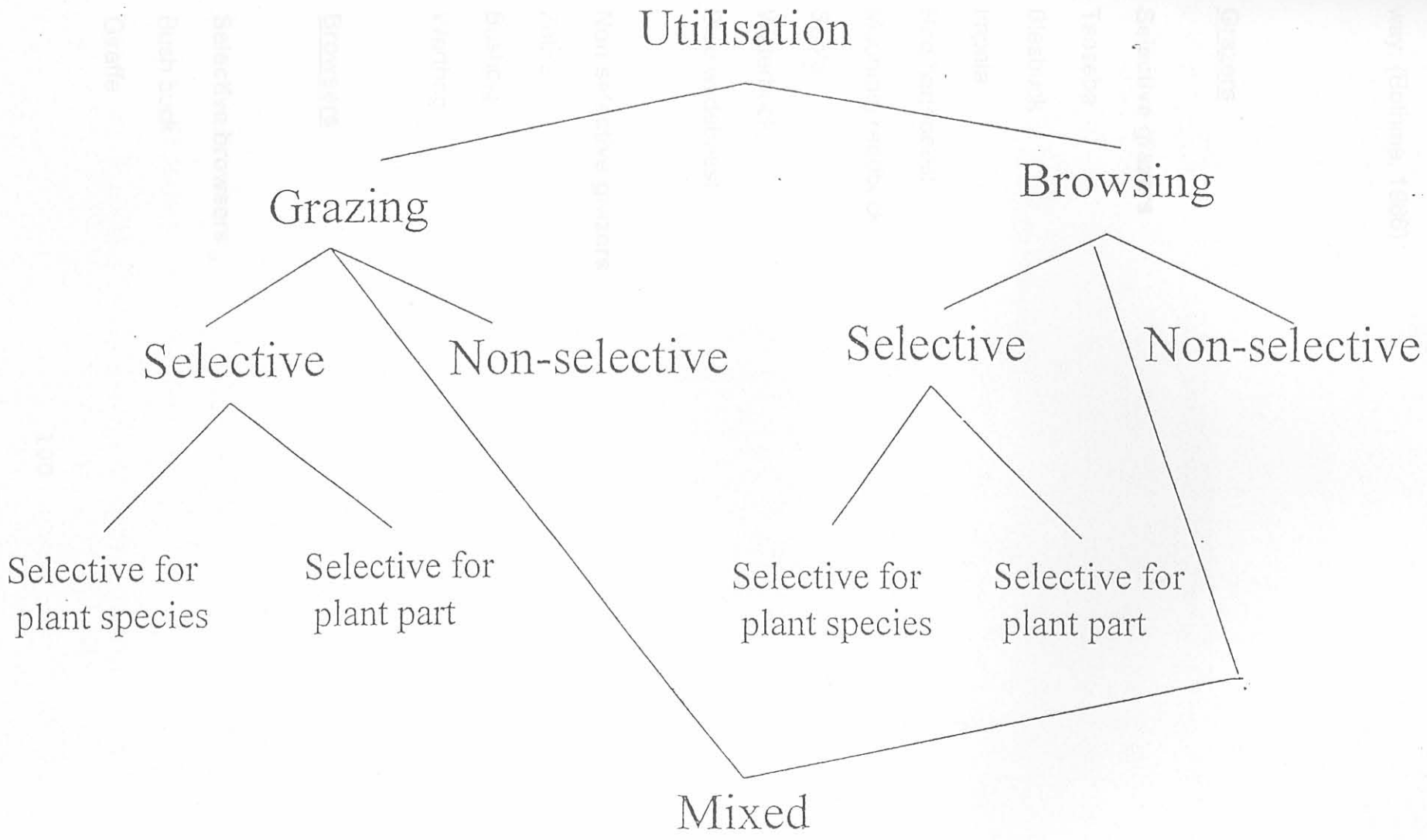



Fig 27: Utilisation spectrum of ungulates

The ungulates of Bynespoort Game Park can be classified in the following way: (Bothma, 1986)

## Grazers

### Selective grazers

Tsesebe

Blesbuck

Impala

Red hartebeest

Mountain reedbuck

Sable

Waterbuck

Blue wildebeest

### Non selective grazers

Zebra

Bushpig

Warthog

## Browsers

### Selective browsers

Bush buck

Giraffe

Kudu

Nyala

Steenbuck

**Non selective browsers**

Eland

Impala

**Mixed (Grazers & Browsers)**

Impala

Bushpig

Bushbuck

Eland

Nyala

Red Hartebeest

Mountain reedbuck

Steenbuck

Waterbuck

Utilisation of the Veld

As a result of the very wide spectrum of habitats and niches in the Game Park, it is important to have a variety of herbivores to fill all these niches. The differences in diet, spatial distribution and activities will cause animals

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that seemingly utilise the same resources to co-exist (Bothma, 1986). This is all part of forming a dynamic ecosystem in which the food resources will either adapt to the herbivores or vice-versa.

The herbivores show specific spatial ecological separation (Bothma, 1986). These are illustrated in Fig.28.

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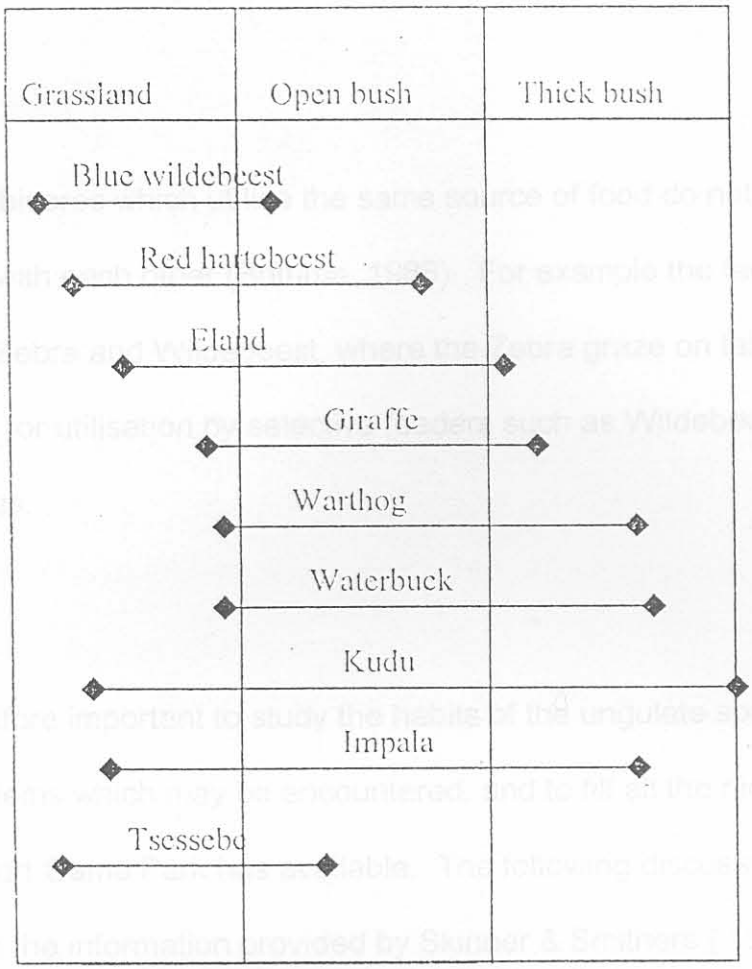



Fig **28:** Ecological separation of habitats for 11 species of ungulate

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Large herbivores which utilise the same source of food do not necessarily compete with each other (Bothma, 1986). For example the facilitation between Zebra and Wildebeest, where the Zebra graze on tall grass and shorten it for utilisation by selective feeders such as Wildebeest which prefer short grass.

It is therefore important to study the habits of the ungulate species, to identify any problems which may be encountered, and to fill all the niches that Bynespoort Game Park has available. The following discussion is mostly based on the information provided by Skinner & Smithers ( 1990).

**Impala**

*Aepyceros melampus* (Lichtenstein, 1812)

Impala are associated with woodland, preferring light open associations. They are commonly associated with *Acacia, Combretum* and *Terminalia* woody species. They usually avoid open grassland and montane areas.

Impala are browsers and grazers (mixed feeders), the intensity of each however depends on the locality in which they occur, and the season of year.

Studies done in the former Transvaal have shown that in this area they are predominantly browsers (Skinner & Smithers, 1990).

In the dry season they focus on riverine areas, and in the growing season they partially feed on flush or fresh green grass.

The leaves or twigs of the following woody species are eaten:

*Acacia spp., Combretum spp., Maytenus spp., Ziziphus spp., Dichrostachys cinneria, Grewia spp.*and *Terminalia spp.*

The following grass species are commonly eaten:

*Digitaria eriantha, Themeda triandra, Cynodon dactylon, Panicum maximum*

*Eragrostis spp.* and *Urochloa spp.*

In Bynespoort Game Park the impala herds can be found mostly in the *Cynodon dactylon - Acacia karroo* community. Impala are coping well in the Game Park and provides the opportunity for hunting which produces a healthy income.

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**Red Hartebeest**

*Alcelaphus buselaphus* (Pallas, 1766)

Red hartebeest are associated with open or semi-open grasslands. They do not occur in dense woodland. These animals are not very dependent on water.

They are gregarious antelope, that is, they occur in herds of up to about 20 individuals in a herd, when total numbers in an area are not too large.

They are grazers, but in some situations, also browse. Grass species eaten by this antelope are:

*Eragrostis spp., Panicum spp., Themeda triandra, Cynodon dactylon* and *Sporobolus spp.*.

In Bynespoort Game Park the herds occur over the entire park. They were observed to frequent the old land grasslands and the disturbed areas in the north east of the park. The species has adapted well to conditions in the Park, and is also a species used for hunting.

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## Eland

*Taurotragus oryx* (Pallas, 1766)(Fig 34)

Eland are very adaptable antelope, occurring in virtually all habitats, from dry arid places to montane grasslands.

They are predominantly browsers and therefore require trees and shrubs for their feeding requirements, and prefer to drink water regularly. They are also a gregarious species and can occur in herds of up to 1000 individuals. They are generally docile and tractable and are therefore very valuable for game viewing.

As mentioned before. Eland are predominantly browsers, but will feed on sprouting grass after a fire.

Plant species utilised are:

*Combretum molle, Combretum spp., Burkea africana* and *Acacia spp.*.

All of the above mentioned plant species are found in the Game Park and this underlines the success of eland. The weed species *Tagetes minuta* and

*Bidens pilosa* are also eaten by the Eland, and these occur widespread throughout the Park.

In Bynespoort Game Park Eland are most commonly encountered on the Quartzite hills in the south west of the Game Park, and a herd of up to 40 individuals was commonly encountered. During the winter, however, they tend to break up into smaller herds and search for available browsing. Their movements also differ in summer and winter, as their preference for grass and tree leaves changes.

**Kudu**

*Tragelaphus strepsiceros* (Pallas, 1766)(Fig 29)(Fig 31)

Kudu are mostly found in woodland savanna and avoid the open grassland. They prefer the rocky and broken terrain with nearby woodland and water. They are also commonly found in *Acacia* and *Terminalia* woodland. Kudu occur in small herds, usually up to about a dozen individuals.

This species of antelope is a browser and will only occasionally feed on fresh green grass. They prefer the leaves and twigs of the following species:

*Acacia spp.*, *Combretum apiculatum* and *Dichrostachys cinnerea*.

They are also known to feed on plants which are distasteful to other species, such as certain species of *Aloe*.

In the Park the kudu are found in the densely wooded areas, and have a fairly good browse available throughout the year.

**Blesbuck**

*Damaliscus dorcas phillipsi* (Harper, 1939)

These antelope are very versatile in their requirements, but sweet grasses and water are essential to their survival.

Blesbuck are gregarious, diurnal and predominantly grazers. Because of their habit to walk in single file, they can often cause the formation of footpaths, which are a source for erosion and veld degradation. They are territorial and males defend their territories vigorously.

They are grazing herbivores, but are known to browse occasionally. They are fond of sprouting grasses which appear after a burn. They also have the ability to minimise their activity in the late winter before the seasonal rains,

and only graze lightly in this time, when stress on the environment is usually at its greatest.

Grass species preferred by this antelope are:

*Themeda triandra, Eragrostis curvula, Eragrostis chloromelas* and *Setaria spp.*

In Bynespoort Game Park this species is often encountered in the old land grassland in the south west, and the surrounding *Acacia* savanna. All the most preferred grass species mentioned occur in the Game Park and the Park therefore provides an ideal habitat for this antelope.

**Zebra**

*Equus burchellii* (Gray, 1824)(Fig 33)

This is a savanna species, and they prefer open grassland where there is enough water available. It was found that this species had a definite preference for habitat.

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They are gregarious and occur in family groups of one stallion, one or two mares and their foals. They are not territorial and move freely through large areas.

Zebras are grazers. They most commonly prefer the following species: *Themeda triandra* and *Cynodon dactylon*.

They do however feed on a wide variety of grasses as a wide variety of grass structures, but also prefer flush grass after a burn.

In Bynespoort Game Park the Zebra are found in herds of up to 20 individuals and graze freely throughout the park. They perform an important role as they are the only bulk grazers in the park.

**Waterbuck**

*Kobus elipsiprymnus* (Ogilby, 1833)

As the name of these elegant antelope suggests they are associated with water. Apart from this requirement they can be found in open reedbeds of vleis and also woodlands.

They are favourable antelope to have as they do not overgraze or over-utilise available resources. They are predominantly grazers but are known to also browse.

Grass species commonly eaten are:

*Cynodon dactylon, Panicum maximum, Heteropogon contortus, Digitaria spp., Andropogon amplectens* and *Themeda triandra*

They have also been seen to eat reeds (*Phragmites spp.*) and bulrushes (*Typha capensis*), and this could be particularly useful as the wetland community is under-utilised and therefore has to be burned frequently.

As a result of their small numbers in Bynespoort Game Park, and the fact that they do not compete well with other animals such as Impala and Nyala, they need to be watched carefully, to ensure their success in the park.

**Blue wildebeest**

*Connochaetes taurinus* (Burchell, 1823)

Blue wildebeest are particularly associated with savanna woodland and occur near water.

They are gregarious, and occur in herds of 20-30. These herds consist of territorial males, female herds and bachelor herds.

Blue wildebeest are grazers, and prefer feeding on short green grass. They very rarely feed on grass which is more that $10^{-1}5$ cm tall. For this reason

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they show an association with Zebra which feed on the taller grass, and then shorten it for the wildebeest to feed on.

Grass species often utilised are:

*Panicum spp., Themeda triandra, Digitaria spp.*and *Cynodon dactylon.*

In Bynespoort Game Park blue wildebeest occur throughout the park, but show preference for the disturbed areas where *Cynodon dactylon* is dominant.

**Giraffe**

*Giraffe camelopardalis* (Linnaeus, 1758)(Fig 30)

Giraffe occur in a wide variety of savanna areas, ranging from scrub to woodland. As they are so tall they utilise a niche that no other animals are capable of, and are therefore not in competition with any other animals for their food resources. They therefore do not play a part in the general degeneration of veld condition.

Giraffe are browsers, but will occasionally graze on fresh green grass shoots. They mainly prefer the following tree species:

*Acacia spp., Combretum spp., Terminalia serricea, Ziziphus mucronata* and *Dichrostachys cinerea.*

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In Bynespoort Game Park the Giraffe frequent the *Acacia* associations but all their favourite food occur in the park, and they are therefore successful animals.

**Warthog**

*Phacochoerus aethiopicus* (Pallas, 1766)(Fig 32)

Warthog are particularly associated with open ground, grassland, floodplain, vleis and also open woodland. These animals are diurnal, spending their nights in burrows in the ground.

Warthogs are generally vegetarians. They live on short swards of grass, and also freshly sprouted grass and underground rhizomes. They are very selective feeders, and push aside unwanted grass to get at the favourable ones, and can therefore be considered as messy and destructive feeders. They will also eat the flowers and seeds of grass.

Grasses preferred are:

*Urochloa spp., Panicum maximum, Chloris virgata, Digitaria spp.* and *Cynodon dactylon.*

They will also feed on the fruit of certain other plant species:

*Ficus spp., Sclerocarya birrea* and *Strychnos spp.*.

In Bynespoort Game Park their burrows are frequently found in the deep sandy soils of the south west, and were often seen feeding on the grasses on the edge of the old land grassland in this area. They also move outside the park into neighbouring farms where they forage for cultivated crops.

**Tsessebe**

*Damaliscus lunatus* (Burchell, 1823)

The availability of sweet grasses, water and shade are all the requirements for this antelope's habitat.

They are known to sometimes frequent grasslands, especially if there is woodland fairly close, to satisfy the shade requirement. Bush encroachment is also know to result in a reduction of the species in an area (Skinner & Smithers, 1990).

Tsessebe are gregarious and occur in small herds of about 8 to 12 individuals. They are grazers and studies have found that they prefer grass less than 60 cm tall and also show preference for burned patches, and will graze heavily on such areas.

In Bynespoort Game Park there are many areas which present a suitable habitat, especially the south western area of the Game Park, where the old land grassland meets the *Acacia* woodland.

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These rare antelope are successful in the Game Park and are popular hunting specimens, and fetch good prices at game auctions because of their rare status.

**Nyala**

*Tragelaphus angasii* (Gray, 1849)

These attractive antelope are most often associated with thickets in dry savanna woodland. Riverine forests also provide a suitable habitat for these antelope. They do however use open grassland, but in areas where there is a constant disturbance, will only venture into the open at night. Areas which have been invaded by thickets pose an acceptable habitat for the species. They are territorial antelope and are usually found in two's or three's.

They are predominantly browsers, feeding of leaves, twigs, flowers and fruit.

Important food sources for the species includes:

*Acacia spp., Spirostachys africana, Strychnos spp.* and *Ziziphus mucronata.*

They do however also graze on fresh green grass, often after rains or fire. In Bynespoort Game Park nyala seem to keep to the thickets nearer the mining area in the north east. They are most often seen at night.

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**Sable antelope**

*Hippotragus niger* (Harris, 1838)

These are described by Smithers (1983) as a savanna woodland species, dependent on cover and the availability of water. They were found to show a definite preference for open woodland with nearby wetlands with tall grass and reeds. They do not occur in areas of over-utilisation or in highly wooded areas.

These are territorial antelope which are gregarious. They are predominantly grazers, selectively at that, and prefer fresh grass of medium height.

Some of the grass species preferred by sable include: *Panicum maximum, Heteropogon contortus, Eragrostis spp., Themeda triandra, Urochloa spp., Hyparrhenia hirta* and *Eragrostis gummiflua.*

Sable are very dependent on water, and seldom stray far from it. In Bynespoort Game Park they are mostly found in the vicinity of the slimes dams, and adjacent to the wetland. They seem to have formed one herd, and the presence of a number of young confirms their success in the Park.

**Mountain reedbuck**

*Redunca fulvufula* (Afzelius, 1815)

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They are known to frequent dry, stony, grass covered slopes of hills, which have trees and shrubs to provide cover. The availability of water is also an essential requirement for its habitat.

They are gregarious and are usually found in herds of three to six.
They are grazers, which feed selectively. They almost exclusively feed on the greenest freshest leaves of grasses.

Grass species commonly eaten are:
*Themeda triandra, Hyparrhenia hirta, Aristida spp., Cynodon spp.* and *Eragrostis spp.*.

Mountain reedbuck are commonly encountered on the slopes of the quartzite hills, especially on the southern slopes in the *Protea* and *Faurea* dominated vegetation.

**Steenbok**

*Raphicerus campestris* (Thunberg, 1811)

These small antelope do not occur in forests or in thick woodland, and prefer open grassland. They are also found in open woodland, or in clearings in woodland. They are often found along roads or fire breaks.

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Steenbok are as much browsers as they are grazers. Of the species browsed are:

*Acacia nigrescens, Colophospermum mopane, Grewia spp., Terminalia serricea, Ziziphus mucronata, Faurea saligna* and *Solanum spp.*.

**Bush Pig**

*Potamochoerus porcus* (Linnaeus, 1758)

Bush pigs are associated with forests, thickets, reed beds or very tall grass with abundant water.

They are predominantly nocturnal and this in combination with their habitat makes them difficult to come across.

They use their snouts to dig up roots, which they eat, as well as browsing. They mainly feed on the underground rhizomes of grasses as well as roots and tubers. In the process of digging for roots, they will eat any underground fauna which they come across.

In Bynespoort Game Park the bush pigs are found in the thicket on the eastern side of the Park, but are seldom seen during the day.

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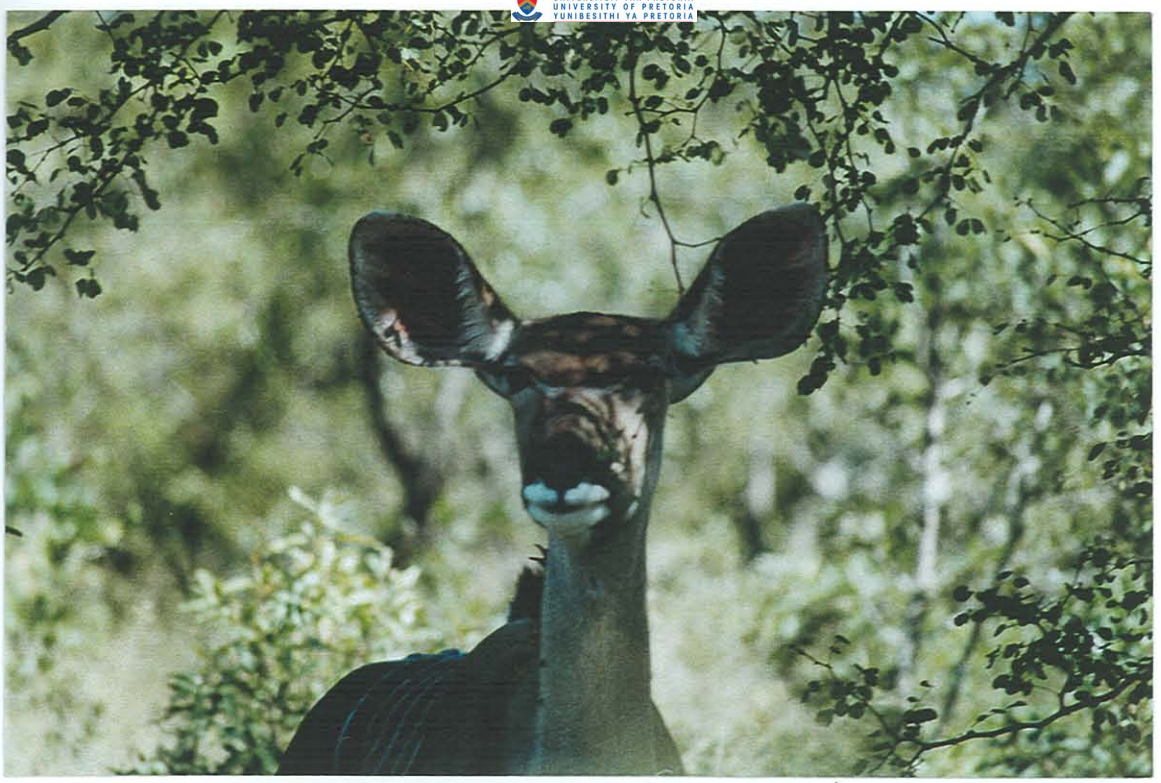


Fig 29 : A kudu cow



Fig 30: Giraffe mother and calf in the Game Park

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Fig 31: A kudu bull



Fig 32: A warthog in the Game Park

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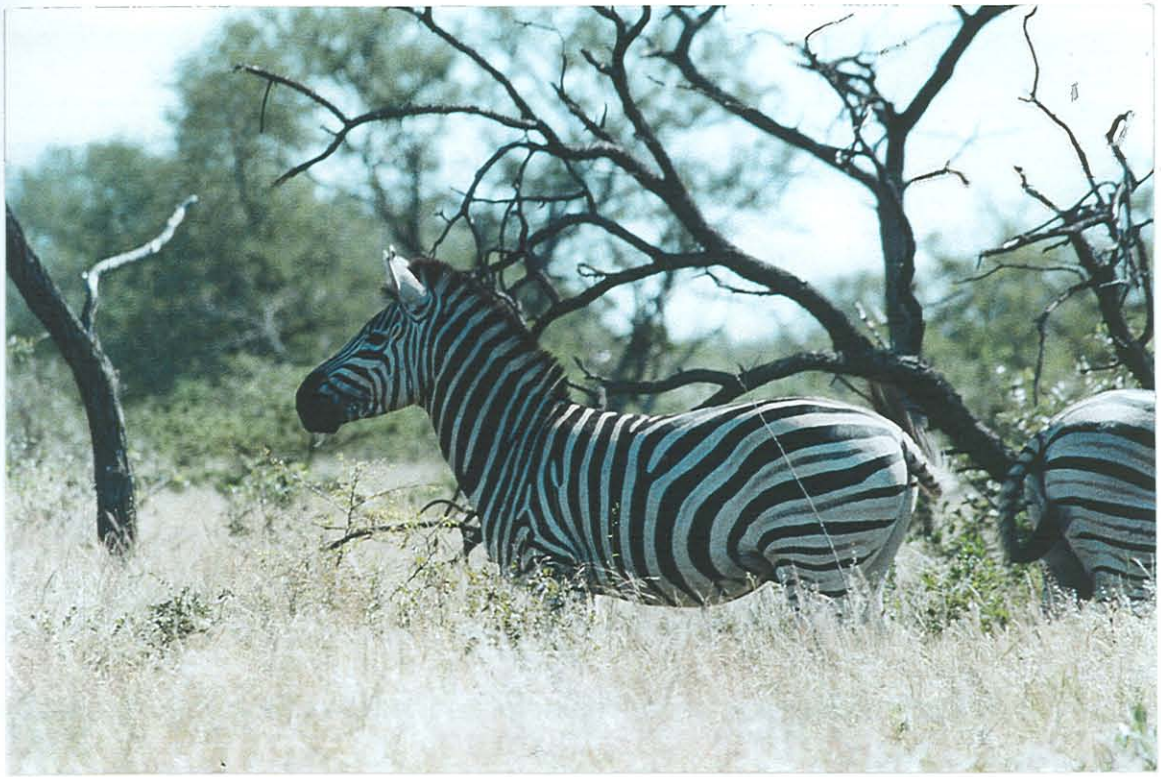


Fig 33: Zebra are unselective grazers and found throughout the Game Park



Fig 34: A herd of eland in the mountain grassland of the Game Park

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# Chapter 8. Ungulate Habitat Survey

The study of the habitat selection of the various game species on Bynespoort Game Park generally reflected the results of the veld condition analyses (Chapter5).

One of the most difficult problems facing wildlife management is the widespread occurrence of serious imbalances in the herbivore/habitat relationships. Such imbalances can also cause an imbalance in the utilisation of the habitats. Therefore a study of the habitat selection is imperative to the development of a wildlife management strategy.

The method used in this analysis is described in Chapter 3. The result of the study is shown in the table below. The results are in large stock unit per sample per hectare, where a sample is a complete survey of a specific game species along a fixed route, taken twice: once in the morning, and once in the afternoon (Chapter 3). The results are given in Table 7.

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Table 7: Numbers observed within each of the plant communities:

| Plant Community | Average number of game in L.S.U. per sample per hectare |
|---|---|
| 1 | 0.01 |
| 2 | 0.13 |
| 3 | 0.03 |
| 4 | 0.02 |
| 5 | 0.03 |
| 6 | 0.07 |
| 7 | 0.23 |
| 8 | 0.01 |
| 9 | 0.05 |

From the results it can be seen that plant community 7 (The *Combretum apiculatum - Dombeya rotundifolia* north slope bushveld) is the most preferred. This is also supported by the veld condition index, (31,3%, Chapter 5) which shows overgrazing. This habitat is particularly used by impala and the short grass by blue wildebeest. The rocky habitat is also frequented by kudu.

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Plant community 2 (the *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland) also showed a relatively high utilisation. This was primarily as a result of the herds of blesbuck, blue wildebeest and zebra. The low number of Decreaser grass species in the community (Chapter 5) can indicate the overgrazing status of the grassland. Being the only true grassland in the Game Park, ungulate species that prefer grassland will all occur here.

Over the rest of the habitats there is a relatively even distribution of ungulates, and this is reflected in the relatively good condition of the veld.

It was, however, also observed that little game occur in the *Eucalyptus* plantations, as these monotonous stands of alien vegetation do not provide suitable habitats and resources for the ungulates.

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# Chapter 9. Management of Ungulates-

## Present Game Numbers

The 1997 game numbers were approximated by using data from a helicopter count, and a ground count, as well as personal observations of species not observed in the counts.

The recommended ratio of the different types of feeders according to Bothma(1986) should be the following:

40% non selective grazers

20% selective grazers

20% mixed grazers (grazing and browsing)

20% browsers

The present game numbers are given in Table 8. In this table the ungulates are divided into four different types of feeders. The percentage of the total grazing capacity that each species occupies is given and totalled for each category of feeder. The large stock unit conversion according to Meisner (1982) is also given, and from this the L.S.U. conversion for each species is given.

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From the game numbers in Table 8 it can be seen that the ratios of the different types of feeders is as follows:

| | |
|---|---|
| Non selective grazers: | 13.5% |
| Selective grazers: | 37.4% |
| Mixed feeders: | 39.9% |
| Browsers: | 22.8% |

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## Table 8: Present game numbers of the Game Park

| | |
|---|---|
| Maximum LSU game (minus cattle) | 260 |
| Maximum LSU cattle (minus game) | 367 |

| Game type | Number | LSU Conversion | LSU Equivalent | % of capacity |
|---|---|---|---|---|
| **Non-selective grazers** | | | | |
| Buffalo | 0 | 1.00 | 0.0 | 0.0 |
| Bushpig | 0 | 4.00 | 0.0 | 0.0 |
| Hippopotamus | 0 | 0.55 | 0.0 | 0.0 |
| Mountain Zebra | 0 | 1.84 | 0.0 | 0.0 |
| Ostrich | 22 | 3.50 | 6.3 | 2.4 |
| White Rhinoceros | 0 | 0.41 | 0.0 | 0.0 |
| Zebra | 53 | 1.84 | 28.8 | 11.1 |
| Total | 75 | | 35.1 | 13.5 |
| **Selective grazers** | | | | |
| Black wildebeest | 0 | 2.69 | 0.0 | 0.0 |
| Blesbok | 58 | 4.97 | 11.7 | 4.5 |
| Blue wildebeest | 66 | 2.65 | 24.9 | 9.6 |
| Gemsbok | 0 | 2.30 | 0.0 | 0.0 |
| Grey rhebok | 0 | 7.00 | 0.0 | 0.0 |
| Red hartebeest | 118 | 2.61 | 45.2 | 17.4 |
| Reedbuck | 0 | 6.14 | 0.0 | 0.0 |
| Roan antelope | 0 | 2.28 | 0.0 | 0.0 |
| Sable antelope | 14 | 1.95 | 7.2 | 2.8 |
| Springbok | 0 | 9.00 | 0.0 | 0.0 |
| Tsessebe | 17 | 3.32 | 5.1 | 2.0 |
| Waterbuck | 7 | 2.17 | 3.2 | 1.2 |
| Total | 280 | | 97.3 | 37.4 |
| **Mixed grazers** | | | | |
| Eland | 56 | 1.23 | 45.53 | 17.5 |
| Impala | 320 | 6.14 | 52.12 | 20.0 |
| Mountain Reedbuck | 9 | 7.00 | 1.29 | 0.5 |
| Nyala | 5 | 3.91 | 1.28 | 0.5 |
| Warthog | 21 | 5.62 | 3.74 | 1.4 |
| Total | 411 | | 103.9 | 39.9 |
| **Browsers** | | | | |
| Black rhinoceros | 0 | 0.64 | 0.00 | 0 |
| Bushbuck | 0 | 7.62 | 0.00 | 0 |
| Duiker | 4 | 12.00 | 0.33 | 0 |
| Giraffe | 26 | 0.68 | 38.24 | 15 |
| Klipspringer | 0 | 12.00 | 0.00 | 0 |
| Kudu | 50 | 2.45 | 20.41 | 8 |
| Steenbok | 4 | 15.00 | 0.27 | 0 |
| Total | 84 | | 59.2 | 22.8 |
| **Grand total** | **850** | | **295.6** | **113.6** |

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The recommended number of game for the Game Park is given in Table 9. Similarly to Table 8, the species were categorised according to their feeding habits. The conversion was made to large stock units (Meisner, 1982), and the percentage of the total grazing capacity utilised by each ungulate species was calculated. The total percentage of the grazing capacity utilised by each of the four types of feeders was then calculated. With the optimal sex ratios and minimum herd size (Bothma, 1986) taken into account, the recommended numbers of each species was calculated.

It was found that the percentage of non selective grazers is low (about 13.5%)(Table 8). To combat this it is normally recommended that buffalo are introduced to the Game Park. This will bring the ratio up slightly, this is however not essential and perhaps not practical in Bynespoort Game Park as there is a distinctive safety risk for hikers, involved in keeping buffalo. In general however, the game numbers are under the grazing capacity for Bynespoort Game Park, and can be given time to multiply, with none of the species over the limit. Studies of kudu habitat recommend that the quota for kudu should be 3 kudu/100 ha (Bredenkamp pers. comm.) and if seen in this light the numbers are high. The stocking rate is recommended to be 107.25% when the ratio of the selective feeders is corrected. This is over the 100% capacity as giraffe occupy 13% of the capacity and in fact they do not affect general condition of the veld as they utilise a unique niche.

In Table 10 the recommended game numbers under a low rainfall (400 mm) is given. The grazing capacity for the Game Park then drops to 141 large stock units. Selective grazers would have to be decreased by quite some margin. This scenario is important to take into account because of the predictions by scientists of the drought effects of El-Nino. In such times it can be seen that the game numbers recommended are much less than in the normal rainfall year, and too high numbers could result in deaths and also in increased stress on all game in the Park.

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## Table 9: Recommended game numbers in an average rainfall year

| | |
|---|---|
| Maximum LSU game (minus cattle) | 260 |
| Maximum LSU cattle (minus game) | -28 |

| Game type | % of Capacity | LSU Conversion | LSU Equivalent | Number Animals | Sex Ratio | Number Male | Numbe Female | Minimum Herd Size |
|---|---|---|---|---|---|---|---|---|
| **Non-selective grazers** | | | | | | | | |
| Buffalo | 10,00 | 1,00 | 26,02 | 26 | 1:3 | 7 | 20 | 12 |
| Bushpig | 0,80 | 4,00 | 2,08 | 8 | 2:3 | 3 | 5 | 5 |
| Hippopotamus | 0,00 | 0,55 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Mountain Zebra | 0,00 | 1,84 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Ostrich | 4,00 | 3,50 | 10,41 | 36 | 1:1 | 18 | 18 | 6 |
| White Rhinocero | 0,00 | 0,41 | 0,00 | 0 | 1:2 | 0 | 0 | 6 |
| Zebra | 15,00 | 1,84 | 39,04 | 72 | 3:7 | 22 | 50 | 10 |
| Total | 29,80 | | 77,55 | 143 | | | | |
| **Selective grazers** | | | | | | | | |
| Black Wildebeest | 0,00 | 2,69 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Blesbok | 4,00 | 4,97 | 10,41 | 52 | 3:7 | 16 | 36 | 10 |
| Blue Wildebeest | 8,60 | 2,65 | 22,38 | 59 | 1:4 | 12 | 47 | 15 |
| Gemsbok | 0,00 | 2,30 | 0,00 | 0 | 1:4 | 0 | 0 | 5 |
| Grey Rhebok | 0,00 | 7,00 | 0,00 | 0 | 1:3 | 0 | 0 | 4 |
| Red hartebeest | 12,00 | 2,61 | 31,23 | 82 | 3:5 | 31 | 51 | 8 |
| Reedbuck | 0,00 | 6,14 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Roan antelope | 0,00 | 2,28 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Sable antelope | 2,80 | 1,95 | 7,29 | 14 | 3:5 | 5 | 9 | 8 |
| Springbok | 0,00 | 9,00 | 0,00 | 0 | 1:4 | 0 | 0 | 25 |
| Tsessebe | 2,04 | 3,32 | 5,31 | 18 | 3:5 | 7 | 11 | 8 |
| Waterbuck | 0,84 | 2,17 | 2,19 | 5 | 3:5 | 2 | 3 | 8 |
| Total | 30,28 | | 78,80 | 229 | | | | |
| **Mixed grazers** | | | | | | | | |
| Eland | 12,20 | 1,23 | 31,75 | 39 | 1:3 | 10 | 29 | 12 |
| Impala | 14,00 | 6,14 | 36,43 | 224 | 1:4 | 45 | 179 | 25 |
| Mountai Reedbuc | 0,50 | 7,00 | 1,30 | 9 | 1:3 | 2 | 7 | 8 |
| Nyala | 0,60 | 3,91 | 1,56 | 6 | 3:7 | 2 | 4 | 10 |
| Warthog | 0,80 | 5,62 | 2,08 | 12 | 2:3 | 5 | 7 | 10 |
| Total | 28,10 | | 73,13 | 290 | | | | |
| **Browsers** | | | | | | | | |
| Black Rhinoceros | 0,00 | 0,64 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Bushbuck | 0,00 | 7,62 | 0,00 | 0 | 1:3 | 0 | 0 | 8 |
| Duiker | 0,30 | 12,00 | 0,78 | 9 | 1:1 | 5 | 5 | 4 |
| Giraffe | 13,00 | 0,68 | 33,83 | 23 | 3:5 | 9 | 14 | 8 |
| Klipspringer | 0,00 | 12,00 | 0,00 | 0 | 1:1 | 0 | 0 | 4 |
| Kudu | 6,00 | 2,45 | 15,61 | 38 | 1:3 | 10 | 29 | 12 |
| Steenbok | 0,20 | 15,00 | 0,52 | 8 | 1:1 | 4 | 4 | 6 |
| Total | 19,50 | | 50,75 | 78 | | | | |
| **Grand total** | **107,68** | | **280,22** | **740** | | | | |

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**Table 10: Recommended game numbers in a below average rainfall year**

| | |
|---|---|
| Maximum LSU game (minus cattle) | 141 |
| Maximum LSU cattle (minus game) | -15 |

| Game type | % of Capacity | LSU Conversion | LSU Equivalent | Number Animals | Sex Ratio | Number Male | Numbe Female | Minimum Herd Size |
|---|---|---|---|---|---|---|---|---|
| **Non-selective grazers** | | | | | | | | |
| Buffalo | 10,00 | 1,00 | 14,08 | 14 | 1:3 | 4 | 11 | 12 |
| Bushpig | 0,80 | 4,00 | 1,13 | 5 | 2:3 | 2 | 3 | 5 |
| Hippopotamus | 0,00 | 0,55 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Mountain Zebra | 0,00 | 1,84 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Ostrich | 4,00 | 3,50 | 5,63 | 20 | 1:1 | 10 | 10 | 6 |
| White Rhinocero | 0,00 | 0,41 | 0,00 | 0 | 1:2 | 0 | 0 | 6 |
| Zebra | 15,00 | 1,84 | 21,11 | 39 | 3:7 | 12 | 27 | 10 |
| Total | 29,80 | | 41,95 | 77 | | | | |
| **Selective grazers** | | | | | | | | |
| Black Wildebeest | 0,00 | 2,69 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Blesbok | 4,00 | 4,97 | 5,63 | 28 | 3:7 | 8 | 20 | 10 |
| Blue Wildebeest | 8,60 | 2,65 | 12,11 | 32 | 1:4 | 6 | 26 | 15 |
| Gemsbok | 0,00 | 2,30 | 0,00 | 0 | 1:4 | 0 | 0 | 5 |
| Grey Rhebok | 0,00 | 7,00 | 0,00 | 0 | 1:3 | 0 | 0 | 4 |
| Red hartebeest | 12,00 | 2,61 | 16,89 | 44 | 3:5 | 17 | 28 | 8 |
| Reedbuck | 0,00 | 6,14 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Roan antelope | 0,00 | 2,28 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Sable antelope | 2,80 | 1,95 | 3,94 | 8 | 3:5 | 3 | 5 | 8 |
| Springbok | 0,00 | 9,00 | 0,00 | 0 | 1:4 | 0 | 0 | 25 |
| Tsessebe | 2,04 | 3,32 | 2,87 | 10 | 3:5 | 4 | 6 | 8 |
| Waterbuck | 0,84 | 2,17 | 1,18 | 3 | 3:5 | 1 | 2 | 8 |
| Total | 30,28 | | 42,62 | 124 | | | | |
| **Mixed grazers** | | | | | | | | |
| Eland | 12,20 | 1,23 | 17,17 | 21 | 1:3 | 5 | 16 | 12 |
| Impala | 14,00 | 6,14 | 19,71 | 121 | 1:4 | 24 | 97 | 25 |
| Mountai Reedbuc | 0,50 | 7,00 | 0,70 | 5 | 1:3 | 1 | 4 | 8 |
| Nyala | 0,60 | 3,91 | 0,84 | 3 | 3:7 | 1 | 2 | 10 |
| Warthog | 0,80 | 5,62 | 1,13 | 6 | 2:3 | 3 | 4 | 10 |
| Total | 28,10 | | 39,55 | 157 | | | | |
| **Browsers** | | | | | | | | |
| Black Rhinoceros | 0,00 | 0,64 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Bushbuck | 0,00 | 7,62 | 0,00 | 0 | 1:3 | 0 | 0 | 8 |
| Duiker | 0,30 | 12,00 | 0,42 | 5 | 1:1 | 3 | 3 | 4 |
| Giraffe | 13,00 | 0,68 | 18,30 | 12 | 3:5 | 5 | 8 | 8 |
| Klipspringer | 0,00 | 12,00 | 0,00 | 0 | 1:1 | 0 | 0 | 4 |
| Kudu | 6,00 | 2,45 | 8,45 | 21 | 1:3 | 5 | 16 | 12 |
| Steenbok | 0,20 | 15,00 | 0,28 | 4 | 1:1 | 2 | 2 | 6 |
| Total | 19,50 | | 27,45 | 42 | | | | |
| **Grand total** | **107,68** | | **151,57** | **400** | | | | |

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## Table 11: Recommended game numbers in an above average rainfall year

| | |
|---|---|
| Maximum LSU game (minus cattle) | 410 |
| Maximum LSU cattle (minus game) | -44 |

| Game type | % of Capacity | LSU Conversion | LSU Equivalent | Number Animals | Sex Ratio | Number Male | Numbe Female | Minimum Herd Size |
|---|---|---|---|---|---|---|---|---|
| **Non-selective grazers** | | | | | | | | |
| Buffalo | 10,00 | 1,00 | 41,02 | 41 | 1:3 | 10 | 31 | 12 |
| Bushpig | 0,80 | 4,00 | 3,28 | 13 | 2:3 | 5 | 8 | 5 |
| Hippopotamus | 0,00 | 0,55 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Mountain Zebra | 0,00 | 1,84 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Ostrich | 4,00 | 3,50 | 16,41 | 57 | 1:1 | 29 | 29 | 6 |
| White Rhinocero | 0,00 | 0,41 | 0,00 | 0 | 1:2 | 0 | 0 | 6 |
| Zebra | 15,00 | 1,84 | 61,53 | 113 | 3:7 | 34 | 79 | 10 |
| Total | 29,80 | | 122,24 | 225 | | | | |
| **Selective grazers** | | | | | | | | |
| Black Wildebeest | 0,00 | 2,69 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Blesbok | 4,00 | 4,97 | 16,41 | 82 | 3:7 | 24 | 57 | 10 |
| Blue Wildebeest | 8,60 | 2,65 | 35,28 | 93 | 1:4 | 19 | 75 | 15 |
| Gemsbok | 0,00 | 2,30 | 0,00 | 0 | 1:4 | 0 | 0 | 5 |
| Grey Rhebok | 0,00 | 7,00 | 0,00 | 0 | 1:3 | 0 | 0 | 4 |
| Red hartebeest | 12,00 | 2,61 | 49,22 | 128 | 3:5 | 48 | 80 | 8 |
| Reedbuck | 0,00 | 6,14 | 0,00 | 0 | 3:7 | 0 | 0 | 10 |
| Roan antelope | 0,00 | 2,28 | 0,00 | 0 | 3:5 | 0 | 0 | 8 |
| Sable antelope | 2,80 | 1,95 | 11,49 | 22 | 3:5 | 8 | 14 | 8 |
| Springbok | 0,00 | 9,00 | 0,00 | 0 | 1:4 | 0 | 0 | 25 |
| Tsessebe | 2,04 | 3,32 | 8,37 | 28 | 3:5 | 10 | 17 | 8 |
| Waterbuck | 0,84 | 2,17 | 3,45 | 7 | 3:5 | 3 | 5 | 8 |
| Total | 30,28 | | 124,20 | 361 | | | | |
| **Mixed grazers** | | | | | | | | |
| Eland | 12,20 | 1,23 | 50,04 | 62 | 1:3 | 15 | 46 | 12 |
| Impala | 14,00 | 6,14 | 57,43 | 353 | 1:4 | 71 | 282 | 25 |
| Mountai Reedbuc | 0,50 | 7,00 | 2,05 | 14 | 1:3 | 4 | 11 | 8 |
| Nyala | 0,60 | 3,91 | 2,46 | 10 | 3:7 | 3 | 7 | 10 |
| Warthog | 0,80 | 5,62 | 3,28 | 18 | 2:3 | 7 | 11 | 10 |
| Total | 28,10 | | 115,26 | 457 | | | | |
| **Browsers** | | | | | | | | |
| Black Rhinoceros | 0,00 | 0,64 | 0,00 | 0 | 2:3 | 0 | 0 | 5 |
| Bushbuck | 0,00 | 7,62 | 0,00 | 0 | 1:3 | 0 | 0 | 8 |
| Duiker | 0,30 | 12,00 | 1,23 | 15 | 1:1 | 7 | 7 | 4 |
| Giraffe | 13,00 | 0,68 | 53,32 | 36 | 3:5 | 14 | 23 | 8 |
| Klipspringer | 0,00 | 12,00 | 0,00 | 0 | 1:1 | 0 | 0 | 4 |
| Kudu | 6,00 | 2,45 | 24,61 | 60 | 1:3 | 15 | 45 | 12 |
| Steenbok | 0,20 | 15,00 | 0,82 | 12 | 1:1 | 6 | 6 | 6 |
| Total | 19,50 | | 79,99 | 124 | | | | |
| | | | | | | | | |
| **Grand total** | **107,68** | | **441,69** | **1166** | | | | |

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Table 11 reflects the recommended game numbers if the rainfall is particularly good (851mm). It can be seen that the grazing capacity is much higher (410 L.S.U.). This scenario is an indication of the stocking rates in a good rainfall year. It is not recommended that the Park be stocked to this quota as they can spoil the condition of the veld in normal times.

The general recommendation is that game should be stocked to the normal rainfall year, or a little below that, but that it does not get any higher over the next few years, because of the predictions of the dry cycle.

# Chapter 10. Environmental awareness education and ecological research

**" We are surrounded by evidence that centuries of obsession with science and technology, without due regard for these activities on the environment, have left the planet in trouble. Specific outcomes in the Natural Sciences and Technology learning areas emphasise that we now have to use science and technology in ways which show responsibility towards the environment and the health of others"** Clarke & Longman (1997)

..... and one way is using it to educate.

The world today is filled with systems and structures which are designed to abuse and exploit what they call human knowledge and human ignorance. People can easily manipulate the minds of others by "educating" them (Lacey & Williams, 1987). It is important to differentiate between more and less advanced communities, with regards to their environment. Environmental education should be approached as an holistic subject, which is interdisciplinary in methodology, innovative in creative processes, and should strive to renovate educational systems in total (Lacey & Williams, 1987).

The aims of an environmental education system should not be to inform people of their environment and purely try to convey knowledge, but develop

skills to be aware of their environment and be able to observe and question.

A possible curriculum should be able to:

- Criticise conventional wisdom
- To explore the principles and concepts which form a basis for these conventional wisdoms
- To be able to change mindsets towards alternative ecological views
- To be able to apply these concepts to practical situations
- To be able to act on these thoughts and change their own environments to suit their needs.

Ecological research is an important part of information gathering and developing the correct mindset for environmental educators. If environmental education is being practised on the particular study area, an ecological research study such as this is a useful and important process of creating the correct mindset for the education, and developing the necessary skills. The holistic basis of the study extracts the necessary information about he natural environment, and presents it in a way that can be easily interpreted by the general public. The investigation of interactions both intra- and inter-specific, also forms a basis for most ecological principles, and this cannot be executed without full understanding of the principles. Management of a game park such as Bynespoort Game Park, is not dissimilar in concept to the management of the environment on global scale, and thus the management of ones personal environment. This in esccence is environmental education.

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Environmental education must be seen as a dynamic form of education, whereby knowledge is constantly being gained, and concepts being challenged. According to Brown (1997) the key outcome of any research is the production of new knowledge by applying existing knowledge. Research is therefore the key to maintaining a healthy flow of knowledge and challenge of ideas. It is also important to produce research as scientific as possible. Many institutions apply certain viewpoints that cannot be scientifically supported, and educators are not sufficiently trained and skilled to use scientifically based principles, and they often convey these incorrectly. These institutions act in the name of environmental education and create tarnished images of the field.

Another advantage is that this type of research can be presented in a manner which is both interesting and informative to the general public, and could inspire further research within the field. By describing and interpreting research procedures and ongoing research, people could become better informed about the importance and rewards of research, thereby dispelling certain stigmas attached to scientists and scientific research. This is also where the G.I.S. survey is very important. The visuality is far more attractive and informative in a presentation, and can provide a channel of understanding whereby the research can be carried across to "unscientific" minds.

A well formulated environmental education programme should change the attitudes of students in the following way (Briceno & Apitt, 1988):

It develops caring attitudes and a sense of responsibility towards the environment;

It changes mindsets, by questioning existing ideas and beliefs;

It creates a sense of respect and recognition for the structures and systems in the environment;

It makes people aware of their community, and involvement in this;

It encourages a sense of continuity with past and future;

It develops the ability to use personal talents in improving the quality of the environment.

In general environmental education can be seen as a way of broadening the horizons of many people of the disadvantaged communities of South Africa. By making them aware of their environment and equipping them with some skills to interpret their own environment, the quality of their lives can be raised to a certain extent without too much capital expenditure. With such skills these people would also be able to live in their environments with a minimum of ecological disturbance, and become more self sustainable.

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# Chaper 11. Conclusion

The Bynespoort Game Park is generally in a good condition, and is well maintained to be able to sustain itself.

A Braun-Blanquet vegetation survey was done, and ten plant communities, and sub-communities within these were identified and described. The plant communities were named according to the dominant and diagnostic species. It was important to identify these as they each react differently to management methods such as burning and disturbance. The ten communities identified in Chapter 4 were:

1. *Harpochloa falx - Elionurus muticus* mountain grassland with variation

1.1 *Harpochloa falx - Eragrostis chloromelas* mountain grassland variation

2. *Wahlenbergia undulata - Hyparrhenia hirta* old field grassland

3. *Terminalia sericea - Burkea Africana* bushveld on sand

4. *Tristachya leucothrix - Trachypogon spicatus* mountain bushveld with variation

4.1 *Protea caffra - Faurea saligna* mountain savanna variation

5. *Cynodon dactylon - Acacia karroo* bushveld with variations

5.1 *Ziziphus mucronata - Acacia karroo* bushveld variation

5.2 *Solanum panduniforme - Acacia karroo* disturbed bushveld variation

6. *Euclea crispa - Acacia karroo* bushveld on diabase

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7. *Combretum apiculatum - Dombeya rotundifolia* bushveld of northern slopes

8. *Eucalyptus grandis* plantation

9. *Ischaemum fasciculatum - Phragmites australis* wetland

10. *Phragmites australis* slimes dams wetland

The Braun-Blanquet methodology was very successful in objectively determining the plant communities and variations on these communities.

The veld condition and grazing capacity was calculated for each of the communities and from this the recommended stocking rates were determined. This method has proven effective, and the overall satisfactory veld condition supports the method as it has been used for the management of Bynespoort Game Park before. The results of the method are however not to be considered a perfect recipe for the management of Bynespoort Game Park, as conditions change all the time. It is an effective guide to long term management of the Bynespoort Game Park.

A structural analysis of the woody stratum of each plant community was done. From this, the number of woody species per hectare, the leaf volume, evapotranspiration equivalent, leaf mass, and browse tree equivalent was calculated. These results were used to determine the browsing capacity for each of the plant communities. These available browse were however found to be very high, and a more effective way of calculating utilisable browse is still lacking. The BECVOL method takes all leaves and twigs of edible woody

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species as available browse, yet no factors such as defensive mechanisms of plants and competition are taken into account. The BECVOL method was therefore not considered as accurate when used in this study.

In order to maintain the condition of the fauna and flora within the reserve, the stocking rate should be kept at the recommended levels, and invasive plants must be controlled. This will ensure that the ecological processes which exist in Bynespoort Game Park are maintained at an optimal level, and the condition of ungulates and vegetation are maintained.

Bynespoort Game Park possesses an extraordinary diversity of wildlife and vegetation, in such close proximity to major human activities. This provides it with the potential to be a popular eco-tourism destination and can be used as a education centre to increase environmental awareness and knowledge.

By studying all aspects of the vegetation of such a Game Park, more can be understood about the history of the management, as well as the sustainability of the park.

Bynespoort Game Park can also be used as an example for industry, where not only the environment should be exploited for economic purposes, but how a major industrial player can also create an area of sustainablility for communities to utilise.

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In these times where sustainable utilisation is becoming increasingly important, the statement was made that Bynespoort Game Park is under-utilised in general. This view was accepted by management, and the Park is currently being made available to tourist operators, and school groups for Environmental Education. This study will hopefully also encourage the mine to allow more research to be done on the Park. In this way the area can be protected, and also play a role in the expansion of knowledge about the area.

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# Appendix A: Plant species list for the Bynespoort Game Park

## Trees

| | | |
|---|---|---|
| *Acacia caffra* | gewone haakdoring | common hook-thorn |
| *Acacia karroo* | soetdoring | sweet thorn |
| *Acacia nilotica* | lekkerruikpeul | scented thorn |
| *Acacia robusta* | enkeldoring | ankle thorn |
| *Acacia tortilis* | haak-en-steek | umbrella thorn |
| *Aloe marlothii* | bergalwyn | mountain aloe |
| *Englerophytum magalismontanum* | stamvrug | milk plum |
| *Burkea africana* | wildesering | wild saringa |
| *Carissa bispinosa* | bosnoemnoem | forst num num |
| *Cassine burkeana* | transvaalse koeboebessie | transvaalkooboo berry |
| *Celtis africana* | witstinkhout | white stinkwood |
| *Combretum apiculatum* | rooiboswilg | red bushwillow |
| *Combretum molle* | vluweelboswilg | velvet bushwillow |
| *Cussonia paniculata* | bergkiepersol | mountain cabbage tree |
| *Diplorhynchus condylocarpon* | horingpeultjieboom | horn pod tree |
| *Dombeya rotundifolia* | gewone drolpeer | common wild pear |
| *Dovyalis zeyheri* | wildeappelkoos | wild apricot |
| *Euclea crispa* | blougwarrie | blue guarrie |
| *Faurea saligna* | transvaalse boekenhout | transvaal beach |
| *Ficus ingens* | rooiblarvy | red-leafed fig |
| *Lannea edulis* | | |
| *Maytenus heterophylla* | gewone pendoring | common spike thorn |
| *Mundulea sericea* | kurkbas | cork bush |
| *Ozoroa paniculosa* | gewone harpuisbos | common resin tree |
| *Pappea capensis* | doppruim | jacket plum |
| *Pavetta gardeniifolia* | gewone bruidsbos | bride's bush |
| *Peltophorum africanum* | huilboom | weeping wattle |
| *Protea caffra* | gewone suikerbos | protea |
| *Rhus lancea* | gewone karee | common rhus |
| *Rhus leptodictya* | bergkaree | mountain rhus |
| *Rhus magalismontana* | | |
| *Rhus pyroides* | gewone taaibos | wild currant |
| *Rhus zeyheri* | blou taaibos | blue currant |
| *Sclerocarya birrea* | maroela | marula |
| *Strychnos pungens* | sekelblaarklapper | monkey orange |
| *Terminalia sericea* | vaalboom | sliver cluster leaf |
| *Ziziphus mucronata* | blink-blaar-wag-n-bietjie | buffalo thorn |

## Shrubs

| | | |
|---|---|---|
| *Acacia karroo* | | |
| *Aloe davyana* | kleinaalwyn | velvet rock alder |
| *Aloe marlothii* | bergaalwyn | mountain aloe |
| *Aloe pretoriensis* | | |
| *Asparagus suaveolens* | katdoring | wild asparagus |
| *Canthium gilfillani* | vluweelklipels | |
| *Carissa bispinosa* | bosnoemnoem | |
| *Dichapetalum cymosum* | gifblaar | poison leaf |
| *Dichrostachys cinerea* | sekelbos | sickle bush |
| *Diospyros lycioides* | bloubos | bluebush |
| *Ehretia rigida* | deurmekaarbos | puzzle bush |
| *Euclea crispa* | blougwarrie | blueguarri |
| *Euclea undulata* | fynblaargwarrie | smaal leaved guarri |

| | | |
|---|---|---|
| *Hermbsteadtia odorata* | | |
| *Landolphia capensis* | wilde appelkoos | wild apricot |
| *Lannea edulis* | | |
| *Ledebouria marginata* | wilde druif | wild grape |
| *Lippia javanica* | beukebossie | fever tea |
| *Maytenus heterophylla* | gewone pendoring | common spike thorn |
| *Maytenus polyacantha* | kraal pendoring | kraal spike thorn |
| *Maytenus tenuispina* | klapperbos | |
| *Mundulea sericea* | kurkbas | cork bush |
| *Ochna pulcra* | lekkerbreek | peeling plane |
| *Parinari capensis* | grysappeltjie | dwarf mobola |
| *Pavetta gardeniifolia* | klipels | rock alder |
| *Psydrax livida* | | |
| *Pygmaeothamnus zeyheri* | goorappeltjie | |
| *Rhus zeyheri* | blou taaibos | blue currant |
| *Rothmannia capensis* | kaapse katjiepiering | cape gardenia |
| *Salix woodii* | natal wilger | natal willow |
| *Stoebe vulgaris* | bankrotbos | bankrupt bush |
| *Tapiphyllum parvifolium* | bergmispel | mountain medlar |
| *Vangueria infausta* | wilde mispel | wild medlar |
| *Xerophyta retinervis* | bobbejaanstert | monkey's tail |
| *Ximenia caffra* | suurpruim | sour plum |
| *Zanthoxylum capense* | klein perdepram | small knobwood |

**Forbs**

*Acalypha indica*
*Achyranthes aspera*
*Anthericum sp.*
*Anthospermum hispidulum*
*Asclepias fruticosa*
*Babiana hypogea*
*Barleria elegans*
*Barleria sp.*
*Becium obovatum*
*Berkheya radula*
*Berkheya seminivea*
*Bidens bipinnata*
*Bidens pilosa*
*Blepharis integrifolia*
*Boophane distichya*
*Bulbostylis burchelii*
*Chamaecrista mimosoides*
*Chaetacanthus burchelii*
*Chamaesyce inaequilatera*
*Cheilanthes hirta*
*Chenopodium album*
*Chironia purpurascens*
*Cirsium vulgaris*
*Clematis brachiata*
*Cleome maculata*
*Cleome rubella*
*Clerodendron triphyllum*
*Coccinia rehmannia*
*Commelina aficana*

*Commelina erecta*
*Convolvulus saggitatus*
*Conyza albida*
*Conyza bonariensis*
*Conyza podocephala*
*Crabbea acualis*
*Crabbea angustifolia*
*Crassula capitella*
*Crassula sp.*
*Crossandra greenstockii*
*Cuscuta campestris*
*Cyanotus speciosus*
*Datura stramonium*
*Denekia capensis*
*Dianthus mooiensis*
*Dicerocaryum eriocarpum*
*Drimia elata*
*Equisetum ramosissimus*
*Eriosema burkei*
*Evolvulus alsinoides*
*Fadogia homblei*
*Felicia muricata*
*Gazania krebsiana*
*Gnaphalium alboluteum*
*Gnidia capitata*
*Gnidia sericocephala*
*Gomphrena celosoides*
*Haemanthus hirsutus*
*Haplocarpha scaposa*
*Helichrysum dasymallum*
*Helichrysum setosum*
*Helichrysum nudifolium*
*Hemizygia pretoriensis*
*Hermannia sp.*
*Hibiscus pussillus*
*Hibiscus trionum*
*Hypoxis sp.*
*Hypoxis rigidula*
*Hypoxis hemerocallidea*
*Indigofera melanadenia*
*Ipomoea crassipes*
*Ipomoea ommanyi*
*Justicia anagalloides*
*Kalanchoe paniculata*
*Kalanchoe thyrsiflora*
*Lantana rugosa*
*Ledebouria marginata*
*Leucas capensis*
*Leucas gabbrata*
*Limeum fenestratum*
*Lotononis sp.*
*Loudetia simplex*
*Menodora africana*
*Oenothera rosea*
*Oldenlandea herbacea*

*Oxygonum dregaenum*
*Pachycarpus schinzianus*
*Pearsonia sessilifolia*
*Pellaea calomelanos*
*Pentanisia angustifolia*
*Pentarrhinum insipidum*
*Phyllanthus burchellii*
*Phyllanthus parvulus*
*Plantago lanceolata*
*Plexipus sp.*
*Pollichia campestris*
*Polygala hottentotta*
*Portulaca oleracea*
*Ranunculus multifidus*
*Rhynchosia monophylla*
*Rhynchosia nitens*
*Rhynchosia totta*
*Rhynchosia venulosa*
*Rubia horrida*
*Salvia sisymbrifolia*
*Scabiosa columbaria*
*Selaginella dregei*
*Senecio oxyriifolius*
*Senecio coronatus*
*Senecio venosus*
*Sida cordifolia*
*Sida dregei*
*Solanum capensis*
*Solanum incanum*
*Solanum panduriforme*
*Sphenostylis angustifolius*
*Sutera burkeana*
*Tagetes minuta*
*Tephrosia longipes*
*Teucrium trifidium*
*Thesium sp.*
*Tragia rupestris*
*Tribulus terrestris*
*Triumfetta sonderi*
*Ursinia nana*
*Verbena bonariensis*
*Verbena brasiliensis*
*Venonia galpinii*
*Vernonia oligocephala*
*Vernonia poskeana*
*Vernonia sutherlandii*
*Wahlenbergia caledonica*
*Wahlenbergia undulata*
*Waltheria indica*
*Withania somnifera*
*Zinnea peruviana*
*Zornia milneana*

**Grasses**

*Agrostis lachnantha*
*Aristida congesta susp. barbicollis*
*Aristida congesta susp. congesta*
*Aristida diffusa*
*Aristida stipitata*
*Aristida transvaalensis*
*Bewsia biflora*
*Bothriochloa insculpta*
*Brachiaria nigropedata*
*Brachiaria serrata*
*Chloris virgata*
*Cymbopogon excavatus*
*Cymbopogon plurinoidis*
*Cymbopogon validus*
*Cynodon dactylon*
*Digitaria brazzae*
*Digitaria eriantha*
*Digitaria mondactyla*
*Diheteropogon amplectens*
*Elionurus muticus*
*Eragrostis capensis*
*Eragrostis chloromelas*
*Eragrostis curvula*
*Eragrostis gummiflua*
*Eragrostis lehmanniana*
*Eragrostis plana*
*Eragrostis racemosa*
*Eragostis rigidior*
*Eustachys paspaloides*
*Harpochloa falx*
*Heteropogon contortus*
*Hyparrhenia hirta*
*Hyparrhenia tamba*
*Imperata cylindrica*
*Loudetia simplex*
*Melinis repens*
*Panicum natalensis*
*Panicum maximum*
*Paspalum dilatatum*
*Paspalum urvillei*
*Perotis patens*
*Phragmites australis*
*Pogonarthria squarrosa*
*Setaria sphacelata*
*Setaria incrassata*
*Sporobolus africanus*
*Sporobolus fimbriatus*
*Themeda triandra*
*Trachypogon spicatus*
*Tragus berteronianus*
*Trichoneura grandiglumus*
*Tristachya biseriata*
*Tristachya leucothrix*
*Tristachya rehmannii*
*Urelytrum agropyroides*

**Exotic species**

*Agave sp.*
*Cereus peruvianus*
*Eucalyptus grandis*
*Jacaranda mimosifolia*
*Lantana camara*
*Melia azedarach*
*Opuntia ficus-indica*
*Schinus molle*