VEGETATION CLASSIFICATION OF THE UNIVERSITY OF THE FREE STATE CAMPUS, BLOEMFONTEIN

BY

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of the degree

MAGISTER SCIENTIAE (BOTANY)

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ABSTRACT

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Keywords: Braun-Blanquet, Classification, Grassland, Urban ecology, University of the Free State, Plant communities, Biotope mapping.

The aims of this study were to survey, classify, describe and ecologically interpret the natural plant communities of the University of the Free State campus in Bloemfontein.

A further aim was to apply the urban biotope mapping technique to the campus so that ecological information may be availed to decision makers at the University in an easily accessible format.

The phytosociological study was based on Braun-Blanquet procedures. A total of 222 reléves were classified using TURBOVEG, TWINSPAN and MEGATAB. Ordination using the DECORANA ordination algorithm was also applied to the floristic data in order to determine the relationship between the vegetation units and environmental variables.

The vegetation was classified into 5 Major Grassland Communities and 2 Major Wetland Communities. All the vegetation units and sub-units were ecologically interpreted and described.

Biotope mapping was conducted on the campus using a German technique that has been used in the city of Potchefstroom after being customized to South African conditions. The resultant biotope map showed that most of the space on the campus is taken up by 3 biotope types, namely the built-up area with its intensively managed lawns and gardens and planted trees mainly on the eastern side of the campus, the extensively managed open spaces (natural grassland) mainly in the middle and to the west and the intensively managed sports fields. This study also contributes to the building up of scientific knowledge about the Grassland Biome.

Recommendations are made as to how the vegetation on the campus and in other increasingly urbanizing areas of the Grassland Biome may be managed in a manner that is ecologically sound and that meets amenity needs as well.

OPSOMMING

Vegetation classification of the University of the Free State Campus, Bloemfontein

deur

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Sleutelwoorde: Braun-Blanquet, Klassifikasie, Grasveld, Stedelike ekologie, Universiteit van die Vrystaat, Plantgemeeskappe, Biotoop-kartering.

Die doel van hierdie studie was om die natuurlike plant gemeenskappe van die Universiteit van die Vrystaat se hoofkampus in Bloemfontein te ondersoek, te klassifiseer, te beskryf en ekologies te interpreteer.

‘n Verdere doel was om die stedelike biotoop karteringsmetode op die kampus toe te pas ten einde ekologiese inligting vir besluitnemers op die kampus, in ‘n maklik verstaanbare vorm, beskikbaar te stel.

Die fitososiologiese studie was gebaseer op Braun-Blanquet prosedures. ‘n Total van 222 reléves is deur die klassifikasie gebruik deur van TURBOVEG, TWINSPAN en MEGATAB gebruik te maak. Ordening deur middel van die DECORANA ordenings-algoritme was ook op die floristiese data toegepas om te bepaal wat die verwantskappe tussen die plantgemeenskappe en die betrokke omgewingsfaktore, is.

Die plantegroei is in 5 Hoof Grasveld-gemeenskappe en 2 Hoof Vleiland-gemeenskappe geklassifiseer. Al die eenhede en sub-eenhede is ekologies geïnterpreteer en beskryf.

Biotoop-kartering van die UV kampus is gedoen deur middel van ‘n gewysigde Duitse metode. Hierdie metode is aangepas vir Suid Afrikaanse toestande en is vir die eerste keer in Potchefstroom gebruik. Die biotoop-kaart van die UV-kampus toon dat meeste van die ruimte op die kampus deur drie biotoop-tipes beslaan word. Hulle is beboude gebied met tuine, aangeplante bome en grasperke (oos-kampus), uitgebreide oop areas wat deur natuurlike veld beslaan word, ook intensief-bestuurde sportvelde (wes-kampus). Hierdie studie dra by tot die steeds uitbreidende wetenskaplike kennis van die Grasveld Bioom.

Aanbevelings word gemaak om die natuurlike plantegroei op die kampus op ‘n ekologies verantwoordelike manier te bestuur en om die intrinsieke waarde van die veld te behou.

CHAPTER 1

INTRODUCTION

More than 50% of the human population will be concentrated in cities in less than 30 years because of increased population growth and migration from rural to urban areas (Shochat, Warren, Faeth, McIntyre and Hope, 2006). Grobler, Bredenkamp and Brown (2002) share this view stating that about 60% of the world's population is expected to be living in urban areas by 2025.

South Africa is among the countries with a population that is increasingly urbanizing. According to Cilliers, Müller and Drewes (2004) South Africa's national urbanization figure is 53% and it is expected to increase because continued droughts worsen the situation for poor people and reduce job opportunities in rural areas. Furthermore the population of South Africa has grown from about 44.8 million in 2001 to about 47.4 million in 2006 (Statistics South Africa, 2006). The average population growth in South Africa is therefore about 0.52 million people per year. This population growth undoubtedly also contributes to the country's increasing urbanization.

According to Rutherford and Westfall (1994) the Grassland Biome contains the highest concentration of urban areas in Southern Africa. This has resulted in large areas of the biome being cleared and replaced with impervious surfaces such as tarmac, buildings and pavements. Cities and large towns such as Bloemfontein, Johannesburg, Pietermaritzburg, Pretoria, Newcastle, Welkom, and Witbank are examples of such places.

The Rio Convention of 1992 proposes that at least 10% of all vegetation types be conserved in formal conservation areas, where the habitats should be in either pristine or near pristine condition (Low and Rebelo, 1996). Adoption of the 10% level was justified by predictions from biogeography that 10% of an area should protect about 50% of species (Rebelo, 1997).

Grassland conservation statistics in South Africa paint a very troubling picture. Less than 2% of this biome falls in conservation areas (Rutherford and Westfall, 1994). According to McAllister (1993), the remaining 98% of South Africa's grassland that is outside of conservation areas has been 60% to 80% irreversibly transformed by agriculture, urbanization and other land uses.

Therefore a lot of energy and money needs to be invested in conservation of the biome in order to improve this ecologically unsustainable situation. Low and Rebelo (1996) point out that although establishing formal conservation areas is important because such areas:

- give a good indication of which vegetation types require urgent action;
- indicate how much has still to be done in the quest to retain good examples of each vegetation type,

They do not reflect the entire picture of conservation. Urbanization (and other land uses) if planned and managed well, can be kept in harmony with conservation so that the biome remains in good condition.

In order for ecologically sustainable urbanization to be realized it is necessary that detailed ecological data be provided to decision makers in a useful and convincing format (Cilliers, *et al*. 2004).

Decision makers should use this data in order to ensure that a visible presence of native vegetation is maintained in urban areas as well as to protect other components of the ecosystem (Cilliers, *et al*. 2004). The maintenance of healthy native vegetation for the well being of ecosystems can not be emphasized enough. The reasons for this are as follows:

- Vegetation is the most obvious physical representation of an ecosystem in most parts of the world. It represents a large portion of the biodiversity of an area and is a self-organizing system driven and determined by the physical and biological factors of the site (Bredenkamp and Brown, 2001). When ecologists talk about different ecosystem types, they usually equate these with different vegetation types (Kent and Coker, 2002).

- The amount of green plant tissue accumulated within the area of a particular vegetation type over a given period of time forms the base of the trophic pyramid. All other organisms in the ecosystem therefore ultimately depend on vegetation for their food supply.

- Vegetation provides a habitat in which organisms live, grow, reproduce and die.

Since establishment of the Bloemfontein campus of the University of the Free State (UFS) a century ago, plant species were collected, but no vegetation classification has been conducted. It is likely that local extinction of some plant species and communities has occurred owing to campus growth. Information from this study will act as a baseline for future land use planning and management to prevent unnecessary environmental damage of this sort from continuing as the university expands.

This study therefore builds up on previous vegetation research conducted in the Bloemfontein area such as those of Potts and Tidmarsh (1937), Mostert (1958), Müller (1970), Du Preez (1979), Rossouw (1983), Dingaan (1999), Dingaan, Du Preez and Venter (2001; *in press*) and Dingaan and Du Preez (2002).

The aim of this study is to:

(i) Survey, classify, describe and ecologically interpret the various natural plant communities on the UFS campus in Bloemfontein;

(ii) Apply the biotope mapping technique to the campus.

CHAPTER 2
URBAN ECOLOGY

2.1 Introduction

Ecology is the scientific study of the inter-relationships between organisms as well as between organisms and all the living and non-living aspects of their environment (Allaby 1996). In other words it is the scientific study of ecological systems (ecosystems) (Kormondy 1996). It was earlier pointed out that ecologists usually equate different ecosystem types with different vegetation types. When the ecosystems that ecologists are dealing with, are in urban areas, then urban ecology is being practiced.

There are various views to the meaning of the term urban. Bryant (2006) acknowledges this but points out that the term typically refers to areas with a high human population density. Shochat *et al.,* (2006) describe urban areas as places dominated by built structures where humans have settled at high density and there is at least a 50% surface cover. Kaye, Groffman, Grimm, Baker and Pouyat (2006) express a similar view and add further that it is advisable to include suburbs on urban fringes, with their somewhat fewer built structures and less surface cover, in urban ecology studies.

In this study the term urban refers to areas that have a large number of built structures, high human population density, large percentage surface cover and they extend from the urban core to include suburban areas. The definitions of the above mentioned writers are therefore all embraced.

There are also various views regarding the vegetation that should be included in urban ecological studies. Urban vegetation can be divided into indigenous and spontaneous types. Millard (2004) describes the former as having originated in a rural landscape and developed over at least several centuries either naturally or under traditional management methods together with the supporting environmental conditions. On the other hand spontaneous vegetation is that, which has naturally colonized neglected and derelict urban sites, mainly during the 20th century (Millard, 2004). Spontaneous vegetation is generally not accepted as urban nature that is worthy of conservation by decision makers and the public while remnants of natural landscape (indigenous vegetation) are much more acceptable (Cilliers, *et al*. 2004).

This is so because the low level management associated with spontaneous vegetation is often mistaken for neglect by city residents (Gilbert, 1989). Work needs to be done to change this attitude because it encourages urban planning and management that fragmentizes the natural landscape, leaving urban indigenous vegetation as little islands in a sea of highly altered environment (Poynton and Roberts, 1985). It is not recognized that if corridors of spontaneous vegetation connecting the islands were maintained, then species extinctions on the islands would be countered by immigration facilitated by the corridors. In this way the ecological resilience and diversity of these habitat islands would be enhanced (Poynton and Roberts, 1985).

A further hindrance to effective urban open space management is the tendency of planning and maintaining open spaces as highly manicured parkland landscapes favouring exotic planting (Roberts and Poynton, 1985). This manicure complex as Poynton and Roberts (1985) put it creates parks of high amenity value that weave their way through urban areas but their biogeographical value is very low because very few indigenous species can use them effectively as connecting corridors for dispersal between habitat islands. In fact the tendency has instead enabled alien trees and shrubs to successfully invade South Africa's Grassland Biome at the fringes of urban areas. The most important of these species are Brambles (*Rubus* spp.), Bugweed (*Solanum mauritianum)*, Wattles (*Acacia mearansii*, *A. dealbata)*, Bluegums (*Eucalyptus* spp.), Syringa (*Melia azederach)* and Peaches (*Prunus persica)* (O' Connor and Bredenkamp, 1997). On The Transvaal Highveld the extensive planting of trees in gardens has shifted the avifauna from its original grassland species composition to one dominated by woodland species (Huntley, 1989; Fraser, 1987).

The manicure complex has been inherited shortsightedly from 17th Century Europe and needs to be reconsidered urgently (Roberts and Poynton, 1985). Its abandonment for a planning and management approach, that is more in favor of native (indigenous and spontaneous) vegetation, should prove more beneficial as native vegetation has good amenity, scientific and educational value, while remaining less costly too.

2.2 Previous studies on urban vegetation

In Europe research concerning urban vegetation has been conducted by workers form various disciplines during the past few decades. The disciplines include ecology, economics and sociology and in recent years medicine and psychology (Venn and Niemelä, 2004). The most notable interdisciplinary study of urban vegetation in Europe is arguably the URGE Project. URGE is an acronym for Development of Urban Green Spaces to Improve the Quality of Life in Cities and Urban Regions. It involved conducting a review of urban green spaces and urban green policy in several selected European cities in order to develop an Interdisciplinary Catalogue of Criteria (ICC) for urban green planning and management (Venn and Niemela, 2004). The ICC is intended to facilitate urban green planning and management that:

- Accommodates the demands of a large variety of recreation forms;
- Improves the quality of the urban environment;
- Meets the need to conserve nature and culturally important heritage sites; and
- Takes into account the importance of urban open spaces as places where the urban populace can learn about, experience and become familiar with nature.

The disciplines in the consortium conducting the study are shown in Table 2.1.

Table 2.1: Disciplines involved in the URGE consortium.

Partner No.	Institution	Location	Role
1	Interdisciplinary Department of Urban Landscapes	Leipzig, Germany	Project coordinator
2	Institute of ecology	Dresden, Germany	Technical support
3	University of Helsinki	Helsinki, Finland	Ecology
4	Free University,	Amsterdam, Holland	Economics
5	University of Central England	Birmingham, UK	Sociology
6	Commett Li. Sa.	Genoa, Italy	Planning
7	Hungarian Academy of Sciences	Budapest, Hungary	ICC
8	Municipality of Budapest	Budapest, Hungary	City partner
9	Budapest Urban Planning Ltd	Budapest, Hungary	City partner
10	Birmingham City Council	Birmingham, UK	City partner
11	Liguria region	Genoa, Italy	City partner
12	Leipzig City	Leipzig, Germany	City partner

(Venn and Niemelä, 2004).

Data were collected from the municipal archives of four case study cities and eight other reference cities as shown in Figure 2.1. The data were used to compile city profiles that were the basis of project analyses of the four case study cities (Venn and Niemela, 2004).

Figure 2.1: Cities involved in URGE study (Venn and Niemelä, 2004).

The case study cities also developed criteria, specific for their respective disciplines (see Table 2.1), which were later combined for inclusion in the ICC. The criteria in the ICC therefore cover aspects that the consortium considered relevant to the quality and provision of urban green space. The ICC also has indicators such as isolation of site, management costs, and field work results of species diversity of given taxa as well as indicators derived from questionnaire surveys or reviews of policy (Venn and Niemelä, 2004).

There are two versions of the ICC. The version for evaluating entire municipal systems has criteria such as connectivity, contribution to city identity and urban green planning system (Venn and Niemelä, 2004). The version for assessing sites has criteria such as local identity, location and naturalness (Venn and Niemelä, 2004).

All the partakers in the project worked together to assess the four case study cities using the ICC. On project completion in 2004 there was therefore not only the ICC but also the results of assessing the four case study cities using it.

The URGE Project is a major step forward for urban ecology because as Putter (2004) put it, if only traditional criteria such as rarity, high biodiversity, large size, naturalness, high productivity and historical continuity are considered, then conservation will occur only on the urban fringe and the meaning of nature in cities will not come to its own. Furthermore calls for urban open spaces to be preserved and restored are likely to be taken much more seriously when made by workers from a number of disciplines rather than when made by ecologists alone (Johnson, 1995).

2.3 Urban nature conservation in South Africa

The concept of urban nature conservation is relatively new in South Africa as it is only in the last 15 years that certain cities came to adopt some kind of urban nature conservation strategy (Cilliers, *et al*. 2004). One such strategy is the Metropolitan Open Space System (MOSS) project that was initiated by the Wildlife Society of South Africa in Durban in 1989. It has since been adopted in other places such as Pietermaritzburg, East London, Port Elizabeth, Empangeni, Port Alfred and Bloemfontein (Collins, 2001).

The aim of MOSS is to see established a system of urban parks that are biogeographically linked together and that are managed according to ecological principles. Cilliers *et al*. (2004) give the following as reasons behind the project:

- It was in response to changing perceptions towards the environment within the nature conservation movement coupled with an increase in environmental awareness;
- It was realized that urban nature conservation should shift its emphasis from protecting only particular species of interest to conservation of functional communities, the maintenance of maximum sustainable biotic diversity and the minimization of extinctions.

In addition to insights such as MOSS South Africa has environmentally sound legislation that incorporates environmental protection in urban areas. For example the National Environmental Management Act of 1998 (NEMA) states in its principles that:

- Development should be socially, environmentally and economically sustainable;
- Disturbance of ecosystems and loss of biological diversity should be avoided, and if these can not altogether be avoided they are to be minimized and remedied; and
- Disturbance of landscapes and sites that constitute the nations cultural heritage should be avoided, or where it can not altogether be avoided, minimized and remedied.

The Act applies to all citizens and organs of state in the country. There is also the National Environmental Management: Biodiversity Act 10 of 2004 which aims to provide for the management and conservation of biodiversity within the framework of NEMA. The Municipal Systems Act 32 of 2000 mainly aims to curb urban sprawl and to encourage sustainable development in urban areas (Cilliers, *et al*. 2004).

Despite MOSS and the above mentioned laws, many urban parks merely fulfill the legal requirement of leaving a certain percentage of open space in any new suburb - so it inevitably becomes **s**pace **l**eft **o**ver **a**fter **p**lanning, or SLOAP (Seaman, 1997).

This is due to poor planning, and at times no planning at all because usually there is no money and no organizational structure to handle the process of urbanization (Seaman, 1997).

Poverty is also a problem. A large number of people live in urban squatter camps where poverty, homelessness, lack of essential services such as refuse removal and supply of fresh water are norms. South Africa's 2% per year population growth rate together with the unceasing migration of rural people to urban areas in search of a better life is causing the size and number of these squatter camps to grow. Urban nature conservation is highly challenged because of this as the goal of improving human living conditions has more weight attached to it than the need to invest in protecting urban nature from urban sprawl and habitat fragmentation (Cilliers, *et al*. 2004).

Another problem is that there is not enough ecological information. For example Putter (2004) states that no information exists on vegetation dynamics under different anthropogenic influences in urban open spaces in South Africa. In addition to that Cilliers and Bredenkamp (1999) state that besides studies on invasive alien woody plants and naturalized species the only vegetation analyses of spontaneous vegetation in urban open spaces that they know of in the Grassland Biome are in the Klerksdorp and Potchefstoom Municipal areas, and these did not take the vegetation of vacant lots into account. In an effort to address this shortage of ecological information a comprehensive research program on urban open spaces was undertaken in the North-West Province.

The studies conducted include hills and ridges in Klerksdorp (Van Wyk, Cilliers and Bredenkamp, 2000), natural grasslands and woodlands (Cilliers, van Wyk and Bredenkamp, 1999), wetlands in Potchefstroom (Cilliers, Schoeman and Bredenkamp, 1998), wetlands in Klerksdorp (van Wyk, Cilliers and Bredenkamp, 1998), railway reserve areas (Cilliers and Bredenkamp, 1998), road verges in Potchefstoom (Cilliers and Bredenkamp, 2000), vegetation of intensively managed urban open spaces in Potchefstroom (Cilliers and Bredenkamp, 1999), ruderal and degraded natural vegetation on vacant lots in Potchefstoom (Cilliers and Bredenkamp, 1999b).

The tendency to plant exotic vegetation in urban parks and gardens is evidence that nature in the city is generally approved of. However this approval is not extended to spontaneous vegetation on derelict sites, vacant lots and other parts of urban areas because such vegetation is regarded as a sign of neglect and untidiness. Research on how to bring about an end to the planting of exotics as well as research on how to increase the acceptance of spontaneous vegetation in urban areas is very necessary.

There is also the problem that provincial and municipal authorities lack the ecological expertise to apply legislation regarding conservation and management of urban open spaces (Cilliers, *et al*. 2004). The importance of providing information about vegetation units in urban areas in a format that is easily accessible and understandable for decision makers can not be emphasized enough (Grobler, 2000; Cilliers, *et al*. 2004). In order to satisfy this need in the North-West Province Rost and Röthig (2002) conducted urban biotope mapping similar to the kind used in Europe (Putter, 2004; Cilliers, *et al*. 2004). Their example is followed in this study.

CHAPTER 3
STUDY AREA

3.1 Geographical location

The UFS has its main campus in Bloemfontein, the capital city of the Free State Province. The geographical coordinates at the center of the campus are 29° 06’25.42’S and 26° 10’ 55.76’E. The campus is about 5 km west of the Central Business District (CBD). It is bounded by Grey College to its east, Koos van der Walt Street to its west, Nelson Mandela Drive to its north, and Universitas Hospital and the Universitas Suburb to its south. See Figure 3.1 below.

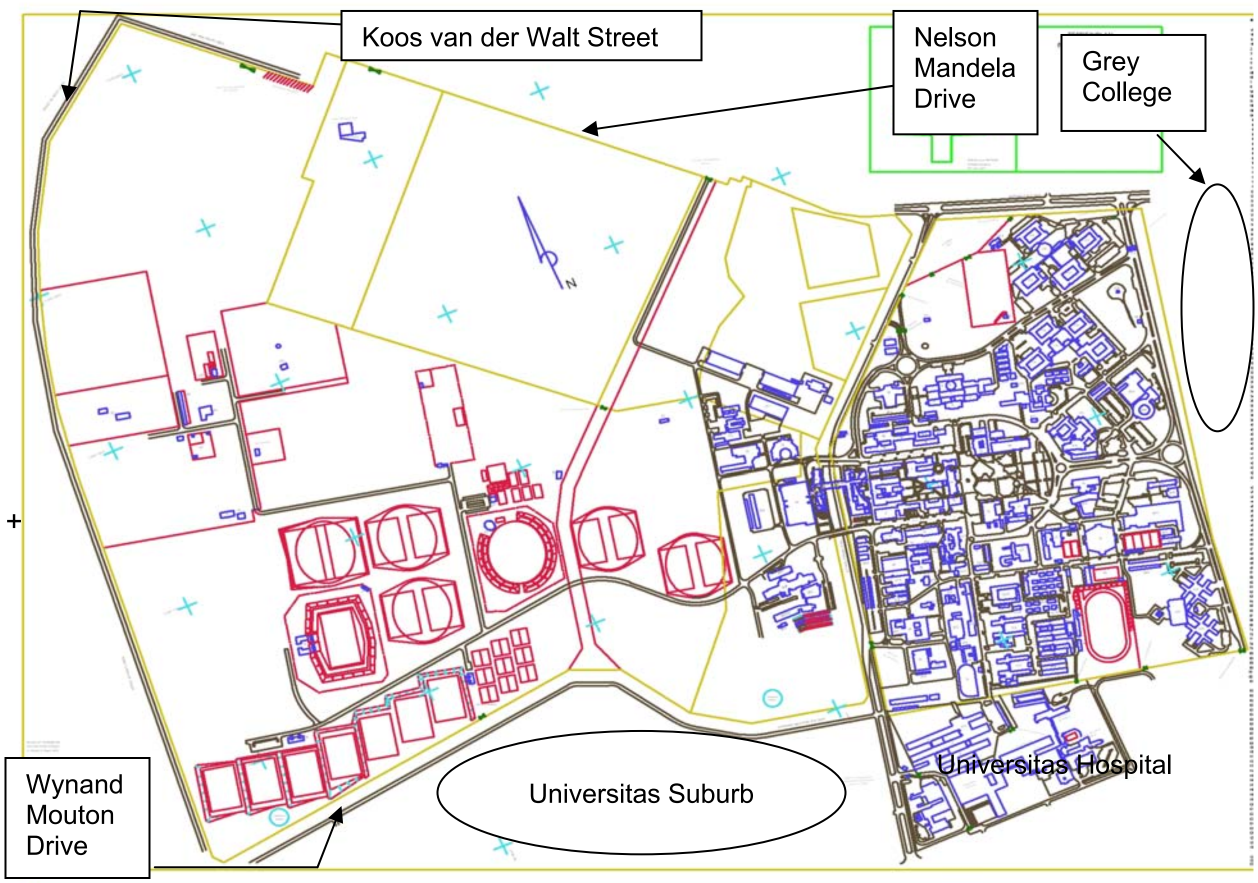


Figure 3.1: Computer aided drawing depicting UFS campus in Bloemfontein.

3.2 Brief history of the U.F.S.

Grey College School in Bloemfontein was founded on the 13th October 1855 by Sir George Grey. Fifty one years later on 28th January 1904 the school could for the first time register students for a full BA degree course. The first six students attended lectures in a tiny two-roomed building which was reconstructed in 1975 on the present-day UFS campus (UFS, 2006). This building is now a declared national monument (UFS, 2005). The first two graduates in 1905 were S.E.H. Grosskopf, who went on to become a missionary and cleric, and J.Z. van Schalkwijk. Other people who studied at UFS were E.B. Grosskopf (author), Dr W.F.C. Arndt (Mathematics professor), S.H. Pellisier (Director of Education), Dr N.J. van der Merwe (cleric and cabinet minister), Sir Pierre van Ryneveld (the first person to fly from London to Cape Town accompanied by only one person), and Dr Colin Steyn (politician and cabinet minister) (UFS, 2005).

In 1906 this institute became known as Grey University College (GUC), but shortly after that, the school and college parted ways. GUC was a college of the University of South Africa which at the time was a federal University with a number of colleges in different towns across the country. These colleges included Natal University College (presently University of KwaZulu-Natal), Potchefstroom University College (presently University of the North-West's Potchefstroom campus) and the Pretoria branch of the Transvaal University College (presently University of Pretotia) (UFS, 2006).

In 1907 the student body had grown to 29, and the number of lecturers to 10. A lack of funds contributed to the university's very slow growth at the time (Van Der Bank, 1995). The use of English more than Afrikaans as the medium of instruction was unsatisfactory to the Afrikaner community in the Free State (UFS, 2005). The editor of *De Express* even complained to his readers that their sons and daughters were becoming alienated from their parents in habits, ideas and everything else (UFS, 2006). It is possible that this state of affairs also contributed to the slow growth of student numbers.

In 1910, the Parliament of the Orange River Colony passed legislation declaring the GUC an official educational institution in the fields of the Arts and Sciences.

Over time the GUC had its name changed to University College of the Orange Free State (UCOFS) (UFS, 2005), or Universiteits Kollege van die Oranje-Vrystaat (UKOVS) as it was called in Afrikaans. The student name “Kovsie” originates from this Afrikaans abbreviation of the college’s name.

Reverend J.D. Kestell took up the position of rector in 1920 from Dr J. Brill who Van Der Bank (1995) points out as the founder of the University and first rector. Before stepping down as rector in 1927 Reverend Kestell had successfully raised much needed funds for UCOFS. He had also managed to substantially increase student numbers by undertaking public relations campaigns in the country districts (Van Der Bank, 1995).

The faculties of Education, Law and Social Sciences were established in 1945. In the late 1940s South Africa’s first Afrikaans Professor, D.F. Malherbe was rector of the UCOFS. Despite much opposition from the Bloemfontein City Council, The Friend and most of his colleagues he pushed on with a campaign to have Afrikaans become the official language of instruction at UCOFS. Professor Malherbe’s dream came true because Afrikaans did become the official language of instruction at the UCOFS in the late 1940s (UFS, 2005).

On 18 March 1950, Parliament declared UCOFS an independent university and it was named the University of the Orange Free State (UOFS). Former state president CR Swart was appointed the first chancellor. In 1954 the Economics and Administrative Sciences Faculty came into being and in 1958 the Faculty of Agriculture followed suit. During the 1960s and into the 80s the university grew substantially. For example the Faculty of Medicine was established in 1969 and the Faculty of Theology in 1980. Residences and other buildings were also erected, for example the Callie Human Centre and the Odeion (UFS, 2005).

In 1993 English was reinstated as a medium of instruction in addition to Afrikaans. The faculties that offer courses in both English and Afrikaans are Economic and Management Sciences (incorporating the School of Management), Health Sciences (consisting of the School of Medicine, the School of Nursing, and the School of Allied Health Professions), Humanities (incorporating the School of Education), Law, Natural and Agricultural Sciences and Theology (UFS, 2005).

In February 2001 the university's name was again changed to University of the Free State. The University of Qwa Qwa which was once a campus of the University of the North in Polokwane became a satellite campus of the UFS on 1st January 2003. This was in order to comply with the restructuring plan for higher education drawn up by the Minister of Education. Likewise in January 2004 the Bloemfontein campus of Vista University also became a satellite campus of the U.F.S. The official mediums of instruction at the UFS today are still English and Afrikaans.

The photographs below give an indication of the university's growth during the period 1912 to 2007.

Figure 3.2: UFS campus in 1912

Figure 3.3: UFS campus in 1930

Figure 3.4: UFS campus in 1940

Figure 3.5: UFS campus in 1950

Figure 3.6: UFS campus in 1960

Figure 3.7: UFS campus in 2007

It is evident in the photographs above that most of the campus growth occurred during the 1940s through into the 21st Century.

3.3 Physical environment

3.3.1 Topography

The most important topographic characteristics of Bloemfontein are the dolerite hills, plains, rivers, streams, pans and marshes (Dingaan, 1999). The UFS main campus is east of a low topographic high known as "Die Bult". See figure 3.8 below.

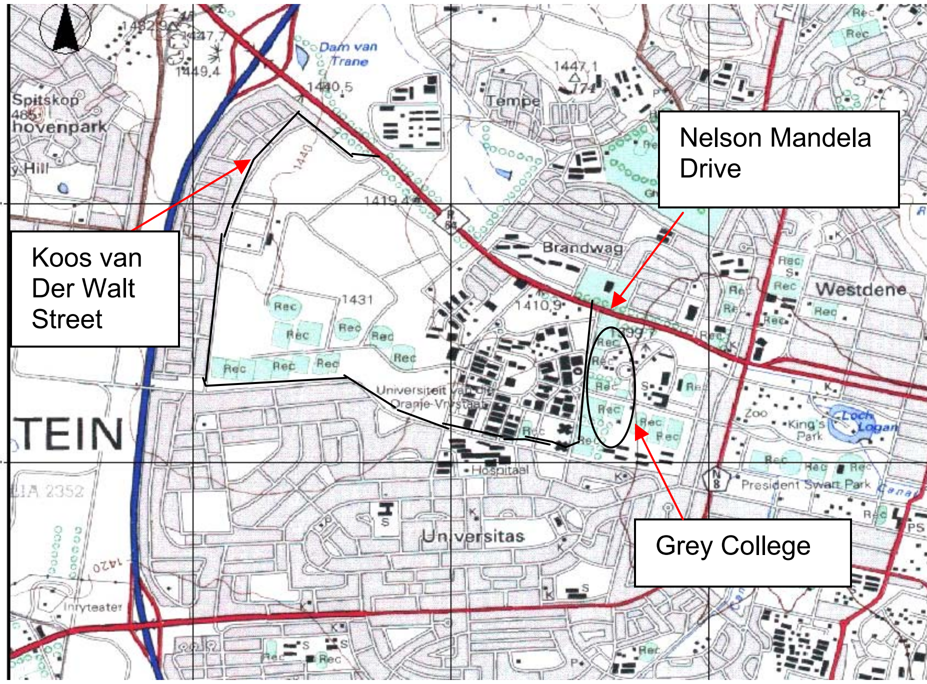


Figure 3.8: Topographic map showing UFS campus in Bloemfontein and surroundings.

The stormwater drains eastwards on a gentle to average slope of about 2m drop in altitude for every 100m traveled.

Three artificial wetlands (earth-walled dams) occur on the campus and their locations are shown in Figure 3.9 below. One is about 200 m west of the FARMOVS Complex. It has lots of reeds surrounding it and it is a roosting and nesting area for various finch species. The others are about 170m and 200 m north of the netball courts respectively. The latter wetlands are not surrounded by reeds but have hygro as well as hydrophytes associated with them. They are visited by various kinds of birds that include pigeons, plovers, herons and hadedah ibis.

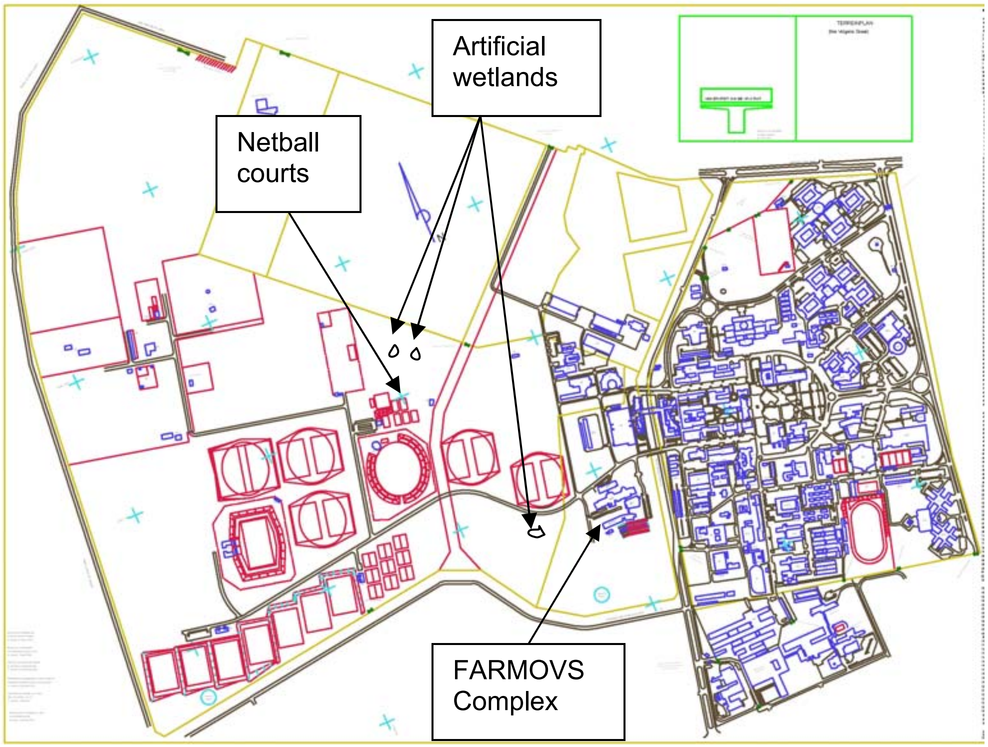


Figure 3.9: Computer aided drawing indicating location of artificial wetlands

3.3.2 Geology

Geology is important in soil formation as it provides parent material for soils. It also influences topography and therefore climate because it determines the extent to which weathering and leaching occur. Climate and soils in turn largely determine the kind of vegetation that will develop on a particular site (Scheepers, 1975).

Based on all this, Scheepers (1975) considers geology as a basic environmental factor on an extensive scale. Figure 3.10 below is a geologic map showing the UFS main campus and its surroundings.

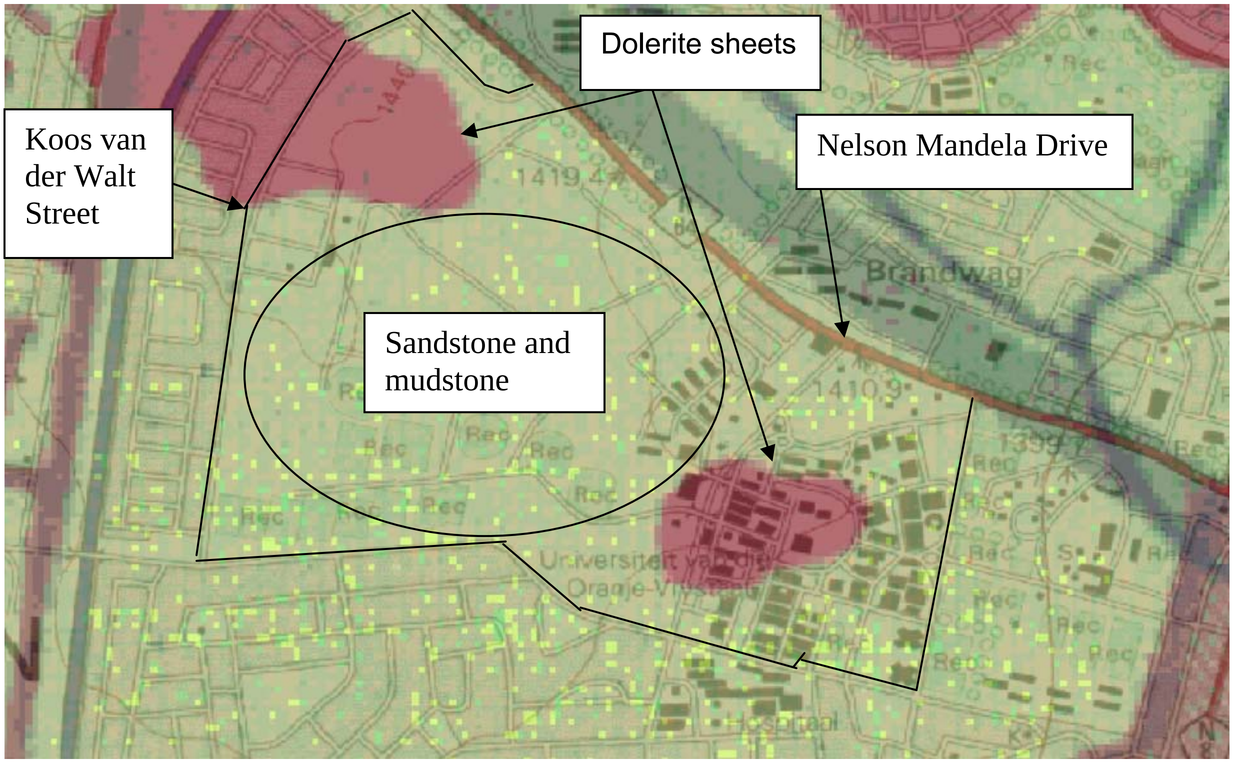


Figure 3.10: Geologic map showing the UFS Bloemfontein campus and surroundings.

The campus is underlain by sedimentary rocks of the Adelaide Sub-group of the Beaufort Group of the Karoo Sequence. These sedimentary rocks consist of fine grained grey sandstone and coarse arkose, alternating with green and maroon-colored mudstone beds. Occasional pebble washes occur in some of the coarse grained beds.

Palaeo-current measurements attribute the arkosic material to a source area towards the north and northeast whereas the fine grained sandstone's source is towards the south (Theron, 1963).

There are also two dolerite sheets, one to the northwest and another to the southeast as shown in Figure 3.10.

3.3.3 Climate

Climate has a very important influence on the vegetation cover of any given area. According to Rutherford and Westfall (1994), there is much support for the general statement by Walter (1979) that temperature and water availability are among the most important climatic factors influencing vegetation.

For example, Rutherford and Westfall (1994) point out that the vegetation of the Grassland Biome follows a rainfall gradient that generally corresponds to the relative contributions made by sweet and sour grasses to the plant cover. Where the biome experiences mean annual rainfall above 625mm (moist) sour grasses tend to dominate whereas in areas below 625mm (dry) sweet grasses are more common but seldom dominate as they tend to in parts of the Savannah Biome which is drier than the Grassland Biome (Rutherford and Westfall 1994).

Furthermore the lack of woody plants in the Grassland Biome is attributed not only to fires and grazing, but also frost which is common in the biome owing to its low winter temperatures (O'Connor and Bredenkamp, 1997). The biome's heavy frosts and great differences between day and night temperatures in winter make survival difficult for woody plants (Hugo, Meeuwis and Viljoen, 1997).

According to the Köppen climate classification system, Bloemfontein falls under the BSk climatic province. This means it has a steppe climate with dry winters and a mean annual temperature that is below 18 °C (Schulze and Mcgee, 1978).

3.3.3.1 Temperature

Temperature impinges on the physiology of plants because biochemical reactions such as respiration double if the temperature is increased by 10˚C in most organisms (Horne and Goldman, 1994). This temperature-metabolism relationship is called the Q_{10} index.

Temperature also influences the type of plants that grow in an area. In areas where temperatures become lethally high or low or where the correct annual or diurnal temperature cycle does not prevail for a species' ontogeny, it will be unable to survive for an extended period (Kellman, 1975).

Furthermore, evapotranspiration, which influences the availability of water for plants, is a function of temperature. When evapotranspiration is characteristically high, only well adapted plants will succeed in that environment.

Figure 3.11 below shows average temperature variation over the year in Bloemfontein.

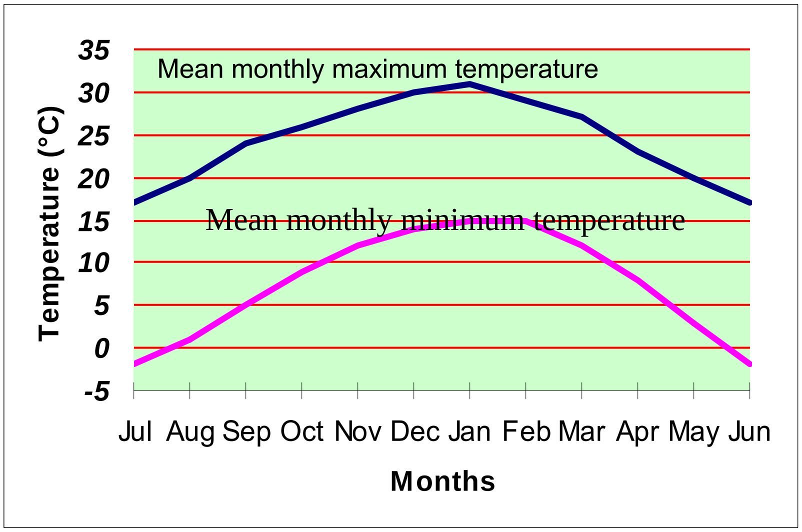


Figure 3.11: Bloemfontein’s mean monthly max and min temperatures.

According to Figure 3.11 the temperature in December and January can rise to 30 and 31°C respectively whereas in June and July it can be as low as -2°C. Such temperature extremes together with the considerable day and night temperature fluctuations (22 to 27°C) common in Bloemfontein are of prime importance and often the limiting factors for plant growth (Mostert, 1958).

3.3.3.2 Rainfall

In Southern Africa rainfall provides most of the soil water (Moon and Dardis, 1992). This is especially so in Bloemfontein where mist, dew, hail and snow are rare (Dingaan, 1999). Soil water is necessary for transpiration which helps keep plant temperatures from rising to levels at which physiologically harmful changes such as denaturation of enzymes and other proteins could occur. Water in the soil also dissolves nutrients in the soil, thereby enabling their uptake by plant roots. This water with dissolved nutrients, once absorbed by green plants is used in the leaf for primary production.

As water in unsaturated soil continually decreases, the forces holding this water in between the soil particles grow stronger. To remove more moisture, the plant must therefore apply more and more suction to overcome these forces. At some point along this energy gradient, the plant is unable to do so any further, becomes dehydrated, and wilts (Kellman, 1975). The soil moisture characteristics of an area and the ability of different plant species to cope with that partly determine the species that will prosper there. This applies not only in cases of decreasing soil water, but also where water logging is common. Water logging reduces root aeration, thereby reducing the likelihood of prosperity for non-adapted species in areas where water logging is common.

Bloemfontein experiences rain mainly in spring and summer in the form of thunderstorms. Figure 3.12 below is the climatic diagram of Bloemfontein. It was drawn using South African Weather Service data for the period 1961 to 1990.

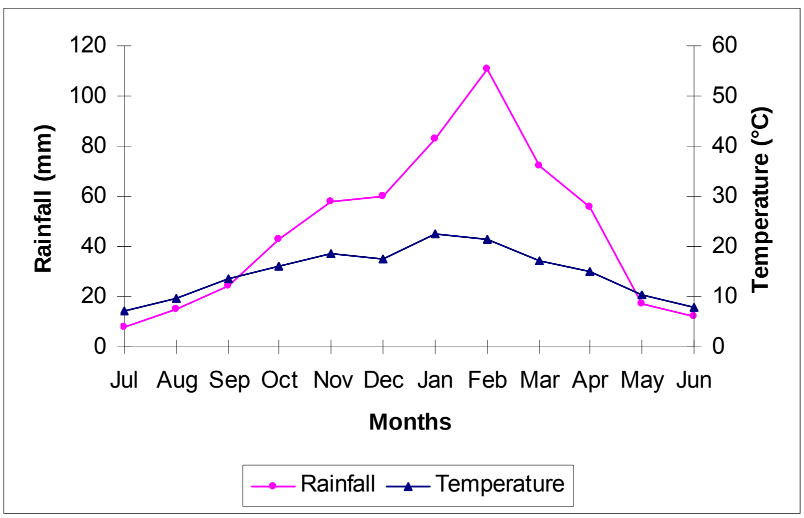


Figure 3.12: Climatic diagram of Bloemfontein.

According to O' Hare (1992) the relatively wet season on such a climatic diagram is where the monthly rainfall line (with scale 1 unit on the vertical axis = 20mm) is above the monthly temperature line (with scale 1 unit on the vertical axis = 10°C). Bloemfontein's wet season therefore tends to begin early in September and ends late April / early May, with maximum rainfall occurring from early to mid-December up until late February / early March.

The mean annual rainfall is 46.6mm which is adequate for good plant growth, but it is unevenly distributed over time and the differences between the average and extreme precipitations are high as shown in Figure 3.12. It is important to also mention that it often happens that light spring rains are followed by long intervals of drought so that the grass which was stimulated to sprout, wilts and dies, and such grass can cause prussic acid poisoning in cattle and sheep (Mostert, 1958).

3.3.3.3 Wind

Wind is important in increasing the evaporating power of the air and therefore in the acceleration of plant transpiration (Mostert, 1958). Furthermore, high and persistent wind speeds may affect plants by abrasion with windborne particles, resulting in elimination of ill-adapted species from such sites and deformation of those persisting there (Kellman, 1975).

Winds in Bloemfontein blow mostly in spring and early summer (Department of Constitutional Development and Planning, 1986). Figure 3.13 below is a year average wind rose of the Bloemfontein area for the period 1993 to 2003.

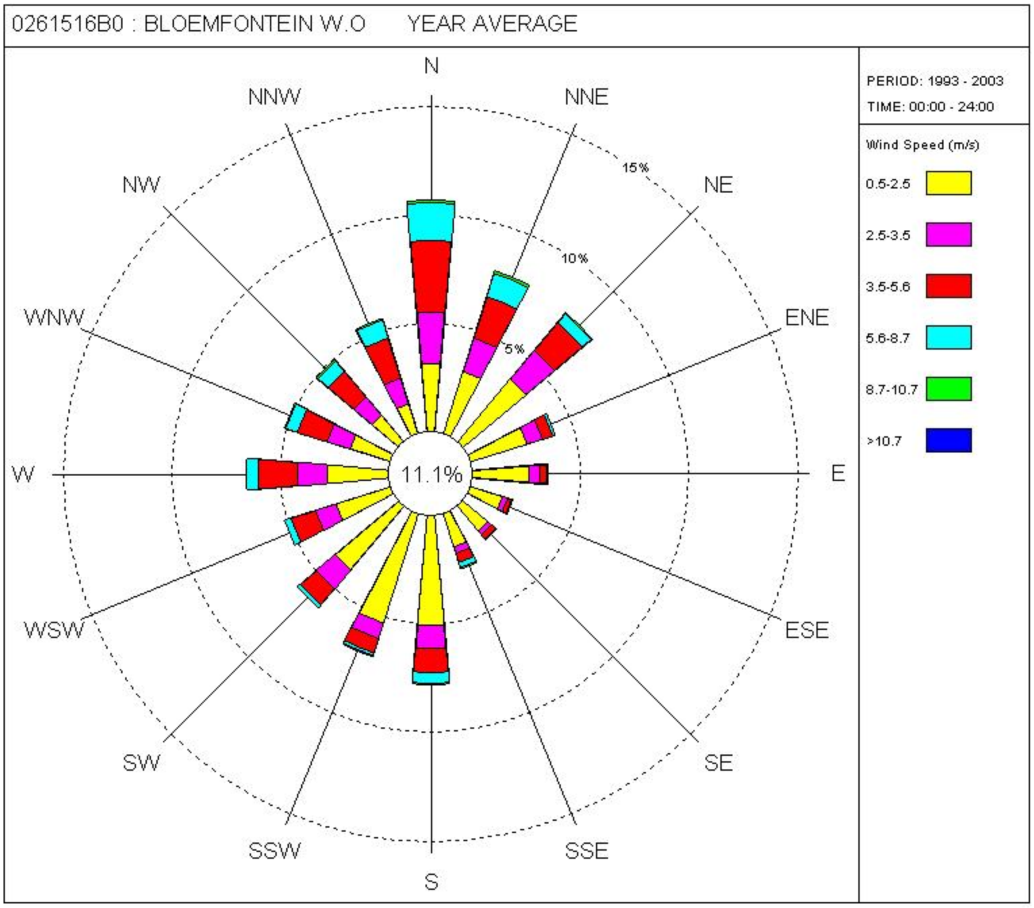


Figure 3.13: Year average wind rose for Bloemfontein for 1993 to 2003 (South African Weather Service 2006).

The wind rose shows that northerly winds are predominant in Bloemfontein, blowing about 11% of the time. They are followed by north, north to north-easterly, north-easterly, north-westerly, south, south to south westerly, south-westerly and westerly winds. Each of these winds blows 6 to 7% of the time at speeds ranging from 5.6 to 8.7m/s. All other winds do not blow for more than 5% of the time. Calm prevails 11.1% of the time.

3.4 General description of the vegetation of Bloemfontein and surrounding areas

A number of vegetation studies around Bloemfontein have previously been done. Examples include Potts and Tidmarsh (1937), Mostert (1958), Du Preez (1979), Rossouw (1983), Malan (1997), and Dingaan (1999).

All these researchers share the view of Rutherford and Westfall (1994) that Bloemfontein is situated in the Grassland Biome. Low and Rebelo (1996) classified the Bloemfontein area as part of the Dry Sandy Highveld Grassland vegetation unit.

More recently Mucina *et al.* (2005) in their vegetation map of South Africa, Lesotho and Swaziland have placed Bloemfontein in the Dry Highveld Grassland Bioregion. This bioregion has three vegetation types, namely Bloemfontein Dry Grassland, Winburg Grassy Shrubland and Bloemfontein Karroid Shrubland (Mucina *et al.* 2005). The UFS campus falls within the Bloemfontein Dry Grassland part of this bioregion.

This is grassland dominated by *Themeda triandra* and *Eragrostis* species with a few Sweet Thorn *Acacia karroo* trees occurring on deep dark clayey soils along water courses (Low and Rebelo, 1996).

There is a presence of karoo elements to the west of Bloemfontein. Low and Rebelo (1996) and Malan (1997) suggest that this is more likely to be outliers of karoo vegetation, rather than a sign of karoo vegetation encroachment. Fuls (1993) also concluded that the karoo vegetation does not spread to the east as predicted by Acocks (1953) and Acocks (1988).

The following description of the plant communities is based on the phytosociological study of open spaces in Bloemfontein by Dingaan (1999). All the vegetation has been affected by human activities to a smaller or larger extent therefore it is not natural in the strict sense of the word. Rather, the word “natural” should be seen in a relative sense. Four broad plant community types were recognized,

i Grassland communities on clayey
ii. Grassland communities on sandy soils
iii. Grassland communities on rocky outcrops
iv. Tree and shrub communities
v. Riparian and wetland communities

3.4.1 Grassland communities on clayey soils

Dingaan (1999) reconized three major grassland communities on clayey soils. They are *Digitaria eriantha-Themeda triandra, Enneapogon cenchroides-Eragrostis lehmanniana*, and *Aristida canecens-Eragrostis lehmanniana* Major Communities*.*

3.4.1.1 *Digitaria eriantha-Themeda triandra* Major Community

It is the most extensive major grassland community on clayey soils. It is mostly found low lying open plains, with soils ranging from moderately dry and shallow (145 mm) to moist and deep (>400 mm).

Grasses dominate this community, with a small number of herbs and shrubs in between at times. *Digitaria erianthia* and *Selago densiflora* are diagnostic of this community, with *Themeda triandra* being dominant (Dingaan, 1999). Four distinct plant communities were recognized in this major community. They are *Panicum coloratum*-*Themeda triandra*, *Digitaria eriantha*-*Cyperus usitatus*, *Digitaria eriantha-Eragrostis chloromelas* and *Sporobolus fimbriatus-Panicum schinzii* Communities (Dingaan, 1999).

3.4.1.2 *Enneapogon cenchroides-Eragrostis lehmanniana* Major Community

It occurs mostly in dry flat areas. It is characterized by gravelly and sometimes rocky soils that are rarely shallow (115 mm), and generally exceed 450 mm.

The diagnostic species are the thorny shrub *Lycium cinereum*, the perennial pioneer grass *Aristida congesta* and the annual grass *Enneapogon cenchroides* while *Themeda triandra* and *Eragrostis lehmanniana* are dominant (Dingaan, 1999). Three plant communities were recognized in this major community. They are *Tagetes minuta*-*Panicum schinzii*, *Melinis repens*-*Eragrostis lehmannia* and *Lycium cinereum*-*Eragrostis lehmanniana* Communities (Dingaan, 1999).

3.4.1.3 *Aristida canescens-Eragrostis lehmanniana* Major Community

This community of grasses and herbs is found in the west of Bloemfontein on moderately deep (>200 mm) soil, and it is totally absent on rocky areas.

The grasses *Brachiaria eruciformis* and *Aristida canescens* are diagnostic, and *Themeda triandra* is dominant (Dingaan, 1999).

3.4.2 Grassland communities on deep sandy soils

Five grassland major communities on deep sandy soils were recognized. They are *Trichoneura grandiglumis-Rhynchosia nervosa, Monsonia angustifolia-Themeda triandra, Eragrostis trichophora-Mariscus capensis, Panicum coloratum-Themeda triandra* and *Eragrostis biflora-Themeda triandra* (Dingaan, 1999).

3.4.2.1 *Trichoneura grandiglumis-Rhynchosia nervosa* Major Community

It occurs on the sides of the Kwaggafontein hills and the grass plains of the Tempe Airfield in the west of Bloemfontein, generally on deep sandy soils. The diagnostic species are the grasses *Trichoneura grandiglumis, Pogonarthria squarrosa, Heteropogon contortus*, and the forbs *Rhynchosia nervosa, Senecio burchellii* and *Pollichia campestris* while *Themeda triandra* and *Eragrostis superba* are dominant (Dingaan, 1999).

3.4.2.2 *Monsonia angustifolia-Themeda triandra* Major Community

It occurs in low lying areas in the north and south of the city. The soils are of the Hutton type ranging from relatively shallow (150 mm) to moderately deep (230 mm). The diagnostic species are *Indigofera alternans* and *Monsonia angustifolia*, and the dominant species is *Themeda triandra* (Dingaan 1999).

3.4.2.3 *Eragrostis trichofora-Mariscus capensis* Major Community

It occurs in the Shannon farming area to the east of the city**.** The soils are mainly moist Bainsvlei which can exceed 400 mm in depth. The diagnostic species include the grass *Eragrostis trichophora*, the herb *Conzya podocephala*, and the sedge *Mariscus congestus* while the dominant species is either *Themeda triandra* or *Aristida congesta* (Dingaan, 1999).

3.4.2.4 *Panicum coloratum-Themeda triandra* Major Community

It occurs to the north of the city on deep Glenrosa and Hutton soils that have small amounts of gravel. *Panicum coloratum*, *Hyparrhenia hirta*, and *Eragrostis curvula* are diagnostic species, and *Eragrostis lehmanniana* and *Themeda triandra* are dominant (Dingaan, 1999).

3.4.2.5 *Eragrostis biflora-Themeda triandra* Major Community

It occurs west of the city on deep Hutton soils that exceed 400 mm in depth at times. The grass *Eragrostis biflora*, the herb *Cyperus rupestris* and the shrubs *Lycium cinereum* and *Pentzia globosa* are diagnostic as well as dominant (Dingaan, 1999).

3.4.3 Grassland communities on rocky outcrops

Five major communities on rocky outcrops were recognized. They are *Eragrostis nindensis-Albuca setosa, Eragrostis trichophora-Aristida-congesta, Heteropogon contortus-Aristida diffusa* sub-species *burkei*, *Asparagus suaveolens-Delosperma pottsii* and *Enneapogon cenchroides-Themeda triandra* Major Communities (Dingaan, 1999).

3.4.3.1 *Eragrostis nindensis-Albuca setosa* Major Community

It occurs on rocky north and west facing hill slopes and valleys. The soil is dry and generally shallow over the rock surfaces, deepening where depressions and rock crevices occur. The grass *Eragrostis nindensis* and the bulbous plants *Ledebouria luteola* and *Albuca setosa* are diagnostic as well as dominant (Dingaan, 1999).

3.4.3.2 *Eragrostis trichophora-Aristida congesta* Major Community

It occurs on rocky east facing slopes where water tends to seep. It is made up of shrubs and grasses growing on the shallow gravel-like soils between the rock outcrops. The diagnostic species are the herb *Sutera caerulea*, the hygrophyte *Tulbaghia leucantha* and the grasses *Eragrostis trichophora* and *Microchloa caffra* (Dingaan, 1999). The grass *Aristida congesta*, the succulent dwarf shrub *Ruschia spinosa*, and the prostrate succulent *Senecio radicans* are abundant (Dingaan, 1999).

3.4.3.3 *Heteropogon contortus-Aristida diffusa* Major Community

It occurs extensively on the tops of hills, on west and north facing slopes, and on the plains below. Rock outcrops here can cover fairly large areas. The soils are dry, shallow and gravel-like, with grasses and dwarf shrubs growing on them. The diagnostic species are *Chascanum pinnatifudum*, *Eragrostis chloromelas*, *Eustachys paspaloides* (Dingaan, 1999). The most abundant species include *Themeda triandra*, *Aristida diffusa* sub-species *burkei*, *Heteropogon contortus* and *Tragus koelerioides* (Dingaan, 1999).

3.4.3.4 *Asparagus suaveolens-Delosperma pottsii* Major Community

It occurs in the deeper and more moisture laden soils of south and south-east facing slopes. Boulders are randomly strewn about in the area.

Crassula lanceolata, *Asparagus suaveolens, Delosperma pottsii* and *Cotyledon orbiculata* are diagnostic as well as abundant (Dingaan, 1999).

3.4.3.5 *Enneapogon cenchroides-Themeda triandra* Major Community

It occurs on dry gravelly soil along the railway lines to the east end and Hamilton industrial areas. The grass *Enneapogon cenchroides* is dominant, and *Themeda triandra* is well represented too (Dingaan, 1999). The diagnostic species are *Enneapogon cenchroides* and the herbs *Salvia verbenaca*, *Argemone ochroleuca*, *Nidorella resedifolia*, *Bidens bipinnata*, and the prostrate dwarf shrub *Atriplex semibaccata* (Dingaan, 1999).

3.4.4 Tree and shrub communities

Two major communities were recognized. They are *Olea europaea* sub-species *africana-Buddleja saligna* and *Euclea crispa* sub-species *ovata-Rhus ciliata* Major community (Dingaaan, 1999).

3.4.4.1 *Olea europaea* sub-species *africana-Buddleja saligna* Community

It occurs on steep hill slopes. The trees are dominated by *Olea europaea* sub-species *africana* and *Buddleja saligna* of 3-10 m height (Dingaan, 1999). Gaps in the tree canopy abound with shorter woody species such as *Cussonia paniculata* and *Euclea crispa* sub-species *crispa* (Dingaan, 1999). The rich undergrowth is made up of species such as the fern *Cheilantes hirta* and the shrublet *Solanum coccineum* (Dingaan, 1999).

3.4.4.2 *Euclea crispa* sub-sp. *ovata-Rhus ciliata* Community

It occurs on south, south east and west facing hill slopes and on plateaus. The soil is fairly deep and rocks are strewn about.

The diagnostic species are *Euclia crispa* sub-species *ovata*, *Heteropogon contortus* and *Tragus koeleroide*s (Dingaan, 1999). The dominant species are *Crassula nudicaulis*, *Rhus ciliata*, *Eustachys paspaloides*, and *Cheilanthes eckloniana* (Dingaan, 1999).

3.4.5 Riparian and wetland communities

Three wetland major communities were recognized. They are *Salix mucronata-Cyperus marginatus, Cyperus longus-Paspalum dilatatum* and *Acacia karroo-Asparagus laricinus* (Dingaaan, 1999).

3.4.5.1 *Salix mucronata-Cyperus marginatus* Major Community

This hydrophytic major community occurs on the bed and on islands within the Modder River. It is strongly associated with deep (>500 mm) dark brown, sandy clay loam soils of pH 7.4-8.3. The willow *Salix mucronata* is very abundant, and on the riverbed, so are the sedges *Pseudoschenus inanis, Cyperus marginatus, Hemarthria altissima* and the erect herb *Persicaria lapathifolia* on the riverbed (Dingaan, 1999).

3.4.5.2 *Cyperus longus-Paspalum dilatatum* Major Community

This major community is hydromesophytic, occurring on flood plains, within and along rivers and streams and around pans and dams. It is associated strongly with moist and moderately deep (>400 mm) sandy clay loam soils of pH 5.38-8.02.

Grasses and sedges are dominant and trees and shrubs are absent. Diagnostic species are *Cyperus longus*, *Rumex lanceolatus* and *Paspalum dilatatum* (Dingaan, 1999).

3.4.5.3 *Acacia karroo-Asparagus laricinus* Major Community

This is generally a major community of mesophytic trees, with some shrubs at times. It is found along small drainage channels and on floodplains of the Modder River. The soils here are deep (up to over 500 mm), clayey or sandy clay loam and are moderately acidic to alkaline.

Near the water courses, greater water availability allows the trees to grow larger and form a closed community, becoming shorter and sparser towards the upper slopes (Mostert, 1958). Trees such as *Ziziphus mucronata* and *Diospyros lycioides* abound, but *Acacia karroo* is the dominant tree species (Dingaan, 1999). Prominent shrubs and dwarf shrubs include *Asparagus cooperi* and *Atriplex semibaccata* (Dingaan, 1999). Where the trees are not dense, grasses and herbs such as *Erharta erecta* and *Tagetes minuta* show increased growth (Dingaan, 1999).

The diagnostic species are *Acacia karroo*, *Tagetes minuta*, *Atriplex semibaccata* and *Asparagus laricinus* (Dingaan, 1999).

CHAPTER 4
METHODS

4.1 Compilation of the species list

A specimen of each plant species found on the campus was collected, dried and preserved in accordance with acceptable herbarium standards. The collection was used to compile a species list to be used as a reference to help identify the plant species in the different vegetation units. The specimens were identified in the Geo Potts Herbarium (BLFU) of the University of the Free State and species names are in accordance with Germishuizen and Meyer (2003). A species list of the naturally occurring and naturalized plant species on the campus was made (Chapter 8).

4.2 Phytosociological study

Phytosociology involves the use of methods for recognizing and defining plant communities, and all such methods are methods of classification (Kent and Coker, 2002). In this study the method used was based on that of the Zurich-Montpellier School developed by Braun-Blanquet in 1928. The purpose of the methodology is to construct a global classification of plant communities. The fundamental concepts and assumptions on which the method is based are shown below in accordance with Kent and Coker (2002).

- Reléves, equivalent to quadrats in terms of vegetation description are located in a careful and deliberate manner so that representative and homogenous samples of the study area's vegetation types may be taken.
- Each species encountered is recorded and its abundance measured using a plant cover scale. See Table 4.1 below.
- Environmental data relating to the reléves are usually recorded as well
- The reléves are put in a table. By sorting and rearranging the reléves and species plant associations are then yielded. The plant association is the basic unit of the Braun-Blanquet classification system (Kent and Coker, 2002). The plant association is therefore a type of plant community.

- The plant community types are then described and discussed often referring to the site character and local environment.
- According to Werger (1974), the Braun-Blanquet method is one of the most significant tools for studying the environment because it

i) is scientifically sound;
ii) fulfills the necessity of classifications at an appropriate level, and
iii) is the most efficient and versatile amongst comparable approaches.

Objections regarding the validity of such methods exist though. These come mainly from individualistic plant ecologists who dispute the idea that distinct assemblages of plants (communities) exist that repeat themselves in space. However, most researchers embrace these methods and they have used them to classify most of the vegetation types in Europe as well as in some other parts of the world (Kent and Coker, 2002).

In South Africa, numerous vegetation studies based on the Zurich-Montpellier School have been conducted. The first studies were done by Van Zinderen-Bakker (1971) on the ravine forests of the eastern Free State while Werger (1973) conducted a phytosociological study of the upper Orange River Valley. Since then the number of such phytosociological studies has increased and spread across the various biomes.

In the Grassland Biome such studies include Behr and Bredenkamp (1988), Eckard (1993a), Coetzee, Bredenkamp and van Rooyen (1995), Dingaan (1999), Muller (2002), Siebert, van Wyk, Bredenkamp and du Plessis (2002), Botha (2003).

In the Forest Biome they include Du Preez and Venter (1990a), McDonald (1993a), Matthews, van Wyk and van Rooyen (1999), Matthews, van Wyk, van Rooyen and Botha (2001), Grobler, Bredenkamp and Brown (2002) and, Cleaver, Brown and Bredenkamp (2004), as well as van Staden and Bredenkamp (2006).

In the Savannah Biome they include Bredenkamp (1986), Bredenkamp, Deutschlander and Theron (1993), Breebart and Deutschlander (1997), Siebert, Matthee and van Wyk (2003), Pienaar (2006).

In the Nama Karoo they include Palmer (1989), Palmer (1991), Pond, Beesley, Brown and Bezuidenhout (2002) as well as van Staden and Bredenkamp (2006).

In the Succulent Karoo Biome they include Smitherman and Perry (1990).

In the Fynbos Biome they include van Wilgen and Kruger (1985), Du Preez (1992), McDonald (1993b), McDonald, Cowling and Boucher (1996) and Cleaver, Brown and Bredenkamp (2004).

It is presently the standardized technique for vegetation classification in South Africa (Bezuidenhout, 1993). The method was considered important to use in this study as it will yield results compatible with those of other researchers in the country. It also forms the basis for the most recent vegetation classification and map of South Africa, Lesotho and Swaziland (VEGMAP) (Mucina, Rutherford and Powrie 2005).

The Braun-Blanquet method can be divided into two phases, the analytical and the synthetic phase.

i) Analytical phase

Homogenous and representative parts of the campus' vegetation were identified. Reléves (sample plots) 16m^2 in size were then sampled to give a picture of the vegetation's floristic composition. The 16 m^2 sample plot sizes were chosen because the area is grassland in line with Bredenkamp and Theron (1978). The sampling technique used was systematic sampling. The size of each open space on the campus was estimated and reléves were then evened out over the area while taking care to keep the location of the reléves from coinciding with any kind of pattern in the vegetation. The total number of reléves in this study was 252 but 30 of them were discarded as they did not conform to any specific pattern, leaving 222 reléves. Species abundance was evaluated using the Braun-Blanquet scale for estimation of plant cover shown below.

Table 4.1: Braun-Blanquet cover scale.

Cover value	Description
R	One or few individuals, rare occurrence
+	Cover less than 1% of total plot area
1	Cover less than 5% of total plot area
2a*	Cover 5-12.5% of total plot area
2b*	Cover 12.5-25% of total plot area
3	Cover 26-50% of total plot area
4	Cover 51-75% of total plot area
5	Cover 76-100% of total plot area

After Bredenkamp, Deutschlander and Theron (1993).

Environmental data such as soil type, percentage area covered by rock and biotic influences such as frequency of mowing were also noted.

ii) Synthetic phase

The floristic data from the analytical phase were used here to classify the vegetation into communities. For this the computer classification programs TURBOVEG (Hennekens, 1996b) and MEGATAB (Hennekens, 1996a) were used. These programs enable swift and effective classification, and they can safely be used to process very large data sets (Du Preez, 1991).

The field data were entered into TURBOVEG (Hennekens, 1996b) so that similar data sets could be grouped together to form a large data set. TWISPAN (Hill, 1979a) was then used to sort and refine these groups based on floristic composition to yield smaller groups.

MEGATAB (Hennekens, 1996a) was then used to sort the vegetation into units. The sorting relies greatly on recognition of diagnostic species and the finalized phytosociological table displays the main synthetic characters of a community (Becking, 1957). Different vegetation groups are identified and by using species as a guideline, several physiognomic units are interpreted (Kent and Coker, 2002; De Frey, 1999; Muller, 2002).

The arrangement of species and relevés in phytosociological tables leads to a comprehensive classification system of syntaxa. This can be used as the basis for further ecological studies. Species act as indicators of the habitat typical of the community and the Zurich-Montpellier approach holds that patterns in the floristic composition correspond with patterns in the environment (Werger, 1974; Kent and Coker, 2002).

The DECORANA ordination algorithm (Hill, 1979b) was used for further analysis to try and establish the relationships between species distribution in space and environmental gradients.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 Introduction

As far as macroclimate as well as to some extent the microclimate are concerned their influences on the various habitats occupied by the various vegetation units are largely uniform. The soils vary from deep sandy Hutton Forms to clayey Valsrivier Forms. On rocky outcrops relatively shallow Glenrosa and Mispah forms dominate. The main influence upon these various habitats is anthropogenic. These anthropogenic impacts create a mosaic of habitats due to previous earthmoving activities such as grading, leveling and dumping of soil in places. At present trampling by vehicles and people as well as grazing pressures in the livestock enclosures contribute to this complex mosaic of various vegetation units.

Classification of the dataset of 222 reléves from the UFS campus in Bloemfontein yielded the following results: 7 major communities, 11 communities and 9 sub-communities. The results are presented in table 5.1 below.

TABLE 5.1: Phytosociological table of the natural vegetation of the campus of the University of the Free State.

Major community nr.	1							2					3	4		5	6	7		
Community nr.		1.1			1.2		1.3		2.1		2.2	2.3		4.1	4.2			71	7.2	7.3
Sub community nr.	1.1.1	1.1.2	1.1.3	1.2.1	1.2.2	1.2.3		2.1.1	2.1.2	2.1.3										
Relevé number	1111111111111111 / 3483422456685885 / 9927779824737409	111 11111 / 534925100 / 382400007	111 1111111 / 2339900025063 / 8247889344483	1 1 / 9097888 / 0397539	56673344444455 / 38988903478 24	7737885666566177378 / 0739087023047323447	11 11 / 42541 / 34848	1111111 / 6777899 / 7089802	11 / 34411 / 72949	11111 / 98641262 / 33307204	2222 2 / 20112223 / 92790800	122212 / 23910190 / 72400487	11122 / 78923	1 11 / 947703	234	222222222 / 444444555 / 456789012	22 / 33 / 23	22 / 33 / 45	222 / 333 / 678	22222 / 34444 / 90123
Database number	4444444444444444 / 2222222222222222 / 4444444444444444 / 4584533556786886 / 3361113268171843	444444444 / 222222222 / 444344444 / 544925101 / 726844441	4444444444444 / 2222222222222 / 4444444444444 / 333001125073 / 268122378827	4444444 / 2222222 / 3444333 / 9008889 / 4731863	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4444444 / 2222222 / 3444443 / 8642262 / 7741648	44444444 / 22222222 / 35555335 / 30222333 / 36134244	44444444 / 22222222 / 33455555 / 33910101 / 16844831	44444 / 22222 / 33333 / 22222 / 12367	444444 / 222222 / 333333 / 111111 / 381247	444 / 222 / 333 / 000 / 678	444444444 / 222222222 / 555555555 / 445555555 / 890123456	44 / 22 / 55 / 33 / 67	44 / 22 / 55 / 33 / 89	444 / 222 / 555 / 444 / 012	44444 / 22222 / 55555 / 44444 / 34567
Number of species per relevé	11111111111851119 / 5336403103 236	11111814 / 070010 4	161718119111 / 5 2 4 48 243	8917119 / 2 11	1799685916171 / 0 2 1 1	1166161469517498711 / 13 0 1 3 22	89111 / 101	9198179 / 5 2	11111 / 10633	18948185 / 9 0	81191151 / 10 13 1	45777914 / 0	73677	366568	864	223332323	11 / 11	57	455	43424
Species group A:																				
Nenax microphylla	1bb111a++11+441+								.b...											
Aristida diffusa	b..4..a.3a.3..3.	+........	..........+.				r....	...a...												
Schkuhria pinnata	1..r....r..r.rr	.r..r....				r...........r.....			+....	r.......										
Species group B:																				
Oenothera stricta	...+.....33.1.3b	....+.b..	.....+1.a.a.	..b....										..rr..						
Triraphis andropogonoides	a..+..1..........	..a5.....	a.1.4.......+			.............a....		.+1....	..r.r	....+...	..a..+..									
Helichrysum zeyheri	..a.....4.......	.1...1+...	.........r.....a.				.1.r.				.......r									
Hypoxis hemerocallidea	+1..r.r...r+..r1	.+....1...	r+.......+....+			..............1...														
Species group C:																				
Eragrostis lehmanniana	.......r..r...1..		+b33353b+5ab	3a44313				....a..				...+....								
Species group D:																				
Cyperus rupestris	...+...a5.........	.a....r4.	.3.....r4.r...	.+3.1..	4bbr5544113331	1	..3.b							.....a						
Species group E:																				
Cynodon dactylon		.......r.r	........r.....	45.5145	54535445511134	15.435b5r4.5345b.54				1.......		....1...								
Dipcadi ciliare	r..............+.	r........	.....1..+..1.	.....+..	.r1..+...1r..+	r.5.11+..r4r....ar+				..1.....			..5..	.5...4						
Species group F:																				
Themeda triandra	ba5b45.44555553555	5.355.5.5	5.3a3ba5555+	.35551.	35b4bb31555554	r5.5.55553....45r55	.54+5													
Panicum coloratum	55155b55..+.3a4.	a5b5b555.	b54554555a5r5	4535554	5555555.55355	55555555.5555a.5553	a.55.			r.......	.+......	....r...								
Indigofera alternans	.b3bb3a.3+1.434.	aa.+1.11.	..b..+..3bb3	..r..1..	.43r..+a1r..+	.3r.1.a.11.+3.bb.a.	.3..r	+......			.1ra.r..									
Tripteris aghillana	.....r...+..a...	1..r.....	+.......+..+...		r1............	.1..+...1.....1.	..a..		...+.											
Hibiscus pusillus	..a..........1..	........r.	r........+r....	....1r..	4.....1+.1.r	...r+.+...a1......	....+													
Berkheya onopordifolia	.........+.....+	r........	......+r..+...	......+	+..........r.	......r.......r.+3	..1..			+.......										
Commelina africana	....r...........	.1.....+.	r.r.+..1......	+.1....+	....1.........	..........b1..+....	.r...			....1...										
Talinum caffrum	..1a.....r......	.1.....1.	......b.b.....	r.a....	.......3...1ar	.r........a+....1.	1.+..								a..					
Oxalis corniculata	.3..3...b.....1..	..43..a..	1.a.3.3a.11a	..4...a	..r........+..	........31.b....1.	1				.r......									
Selago densiflora	1b.11..+a....+...	.+5..1...			..........a...1	1.................	+3.b.						..+..	.a....						
Monsonia angustifolia	..r...+.........r	r+.....+.	......r.r1r.++	+..1..r.	r..+..........	.r.+r.....a13.1r.1r	.r..+			....1...										
Species group G:																				
Eleusine coracana		.........b	..+......+..	.1.....		..1...............	..r..	ba.++1r		..1.....										
Species group H:																				
Brachiaria eruciformis		.....a...						.r....r	b1++r			...+....		r+1+r3						
Species group I:																				
Acacia melanoxylon	...r.r..........			......r.				555555a	13555	155r555r	.....+...	.......+.		.....+						
Trichoneura grandiglumis			........+....					4113...	..r3b	a+....b.	.......r	...5....								
Raphionacme hirsuta	......+.......r..	r........						+r1..1.	..rr+	.r....+r		.....+..								
Geigeria filifolia	..r.+.......+r...	....rr..1.	r..........+		........rr....	.r.+..............	..+..	.b..3..		..b...3.		.......r.								
Lycium pilifolium				....4.a	...4..........	.4...............+		..1.+..	..+.+	......r.	.....r+.									
Species group J:																				
Cynodon hirsutus						................a..					b3....+b3		..1..							
Species group K:																				
Jamesbrittenia atropurpurea						..r...........		bb35a1b	55453	b++55.5.	5b555355	b5a53454								
Schizocarphus nervosus			.........+..r..	...a...		.+........r...		+..b...	a.1r+	.+...1+b	51...1b+	.4.+1...	...+r							
Crabbea acaulis	..........+b1..		1..........+..			...............+		.r..4.+	+535b	r1...1.4	.+.+3...	...1.+..+	...++							
Arctotis venusta	....r.....					......r...		....+r.	...++	+.......	a.......	......1.	+....							
Ruschia hamata						......r...			1	......+.	..+1....	+.....+.	...+.		.r.					
Nidorella hottentotica					.....r.a......				5+1..	.+......	..443...1	5.....5.5								
Solanum supinum		.r.......						.bb...1	....+	4.....4.	....+5.5	..1...1.								
Setaria pumila				1.....+		......b.........1			1....	....r...	......b..									
Species group L:																				
Digitaria eriantha	1..br15.+1.3b41.	+5a4+154b	b4554555515b5					514335b	...1.	4.......	.1.....5	..1..11.								
Aristida congesta	4414.r3b5......r.	.3b.33.4.	1.4......+...4		...+....4.a.4	.................b..	5..4b		1ab.1	......5.	a....4.1	.1.+....		1	44.					
Felicia muricata	..1+.......r.31.a	....+....	...+r...+...	....1.+.	...1...a3...1	..5.4.+.1......4.3	.+r.1	..1....	.+...	r...+...	433133a.	.3......	+....							
Tragus koelerioides	4a3...a11.....r..	......b.a.	r.+.....a.+..		.........b....	.1........1..1....	...11	.r.....	...r..	+....a..	.+......	......1+								
Eriospermum cooperi	+..+...r.r....r..	.+r1...r.	+.........r...r	...+...		..........r.r..r..r.	1....	+bb4aaa	..+1b	1r4..a..	..4.b..1				..r					
Ipomoea oenotherae	..........4....	.+.......		..r....					..r..	r.+...3.	..1.....	......+.1a								
Senecio burchellii	.1......1.....+..	.+.......		1..r...					..r..	1.+...+.		11								
Lycium hirsutum	.......+........		.a..1......	.1.....	...b..........		...ar				......5.			1						
Elephantorrhiza elephantina	4a..............	..a...b...					1..4.													
Species group M:																				
Conyza podocephala	.+.......1...+.b	.......r.	...++.1.......	.....r.	r.............	+.....r...........	...1.			5			54355							
Chloris virgata				.1....r.	.1............	1.................	..1..				.....a..		33.+3							
Species group N:																				
Eragrostis superba	a3.35r4b1.......	.3bbba.3.	..4....3.+.5	3r...1.	a....1.ba.31.	....31.++3.bb.1a..b	+31b5	....3.r	.rra.	b.b31..b	b3555..b	..3.5+33	r..15							
Salvia verbenaca			...r.........	.....1.		r...1..........r				+.......	...a.+.a	..a.1+..	13..r							
Sutera caerulea	..+........		.......r.....			.................r.			+....	...1....	+....a..	+.......	r....		+..					
Species group O:																				
Chenopodium album			....+.......						b....	+.......			...+.	a4.aaa	+1r		11		.b4	
Salsola kali						...............a...	..a..		...a.					...+r.	++.					
Species group P:																				
Urochloa panicoides	....+........				.a............						...1+...			.a1..a						
Rumex crispus						4.................								+.3..a						
Species group Q:																				
Gomphrena celosioides				.....r.								.3......		..r...	aba					
Plantago lanceolata			.........r..			................a..								..r.r.	+a+		.1			
Species group R:																				
Chamaesyce inaequilatera					....a.........				.r...				..1r+	.a.+.a	+..					
Species group S:																				
Chasmatophyllum musculinum						.r......		.+.....								++1bb+13b				
Oropetium capense						.r.....		.+.....								.1rbr.1.+				
Eragrostis nindensis																1.+r+1+1+				
Species group T:																				
Ciclospermum leptophyllum			......r......					....1..									ab			
Bromus catharticus																	b+			
Oenothera rosea																	1+			
Lepidium capense																	+1			
Sonchus oleraceus																	++			
Emex australis																	1.			
Stellaria media																	3.			
Species group U:																				
Phragmites australis																	55	55		
Cyperus sexangularis																	.3	r3		
Oxalis depressa																	r5	.b		
Species group V:																				
Ficinia nodosa						b.........												55	14b	5.b15
Pseudognaphalium oligandrum																	+.	5.	.a4	1a...
Eleocharis limosa																		.5	5..	.55.3
Species group W:																				
Cuscuta campestris																		r5		
Species group X:																				
Persicaria lapathifolia																	.r	.1	33a	
Atriplex semibaccata																			.a4	
Species group Y:																				
Persicaria decipiens																			4..	55541
Leptochloa fusca																				+.+.+

Insignificant species with an occurrence of less than 4 have been omitted

5.2 Classification

The hierarchical classification of the 7 major communities is as follows

1. *Themeda triandra-Panicum coloratum* Major Community
1.1 *Digitaria eriantha-Oenothera stricta* Community
1.1.1 *Nenax microphylla-Themeda triandra* Sub-community
1.1.2 *Helichrysum zeyheri-Eragrostis superba* Sub-community
1.1.3 *Triraphis andropogonoides-Eragrostis lehmanniana* Sub-community
1.2 *Cynodon dactylon-Dipcadi ciliare* Community
1.2.1 *Eragrostis lehmanniana- Cynodon dactylon* Sub-community
1.2.2 *Cyperus rupestris- Cynodon dactylon* Sub-community
1.2.3 *Eragrostis superba-Cynodon dactylon* Sub-community
1.3 *Themeda triandra-Eragrostis superba* Community

2. *Jamesbrittenia atropurpurea-Crabbea acaulis* Major Community
2.1 *Acacia melanoxylon-Jamesbrittenia atropurpurea* Community
2.1.1 *Eleusine coracana-Acacia melanoxylon* Sub-community
2.1.2 *Brachiaria eruciformis-Acacia melanoxylon* Sub-community
2.1.3 *Eragrostis superba-Acacia melanoxylon* Sub-community
2.2 *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community
2.3 *Nidorella hottentotta-Jamesbittenia atropurpurea* Community

3. *Chloris virgata-Aristida congesta* Major Community

4. *Chenopodium album-Salsola kali* Major Community
4.1 *Brachiaria eruciformis-Salsola kali* Community
4.2 *Gomphrena celosioides-Aristida congesta* Community

5. *Chasmatophyllum musculinum-Oropetium capense* Major Community

6. *Phragmites australis-Bromus carthaticus* Major Community

7. *Ficinia nodosa-Eleocharis limosa* Major Community

7.1. *Ficinia nodosa-Phragmites australis* Community

7.2 *Ficinia nodosa-Persicaria lapathifolia* Community

7.3 *Ficinia nodosa-Leptochloa fusca* Community

5.3 Description of the plant communities

1. *Themeda triandra-Panicum coloratum* Major Community

This major community's western boundary is from the southwestern corner of the campus alongside Koos van Der Walt Street right up to and including the four Agricutural Research Centre's livestock enclosures in the north that were used at times for grazing.

Figure 5.1: Part of the *Themeda triandra-Panicum coloratum* Major Community west of Shimla Park sports facility.

The eastern boundary is from south of the FARMOVS Complex up to the open area immediately west of the SASOL Library and Mabaleng Buildings. The soils in this area are of the Hutton (deeper soils) and Glenrosa forms (shallow soils on sandstone outcrops and dolerite sills). As far as anthropogenic impacts are concerned, this grassland is mowed once a year except on the roadsides where it is mowed once a month. In the south, foot trails have opened up in the vegetation, most probably as a result of frequent trampling by students walking from the Universitas suburb to lectures and *vise versa*.

Dingaan, Du Preez and Venter (*in press*) described a similar major community namely the *Themeda triandra-Panicum coloratum* Major Community which also occurs on Hutton and Glenrosa soil forms.

The diagnostic species of this *Themeda triandra-Panicum coloratum* Major Community (Species group F, Table 5.1) include the grasses *Themeda triandra, Panicum coloratum,* the forbs *Indigofera alternans, Tripteris aghillana, Hibiscus pusillus, Berkheya onopordifolia, Commelina africana, Talinum caffrum, Oxalis corniculata, Selago densiflora, Monsonia angustifolia* and (Species group G, Table 5.1) *grass Eleusine coracana.*

This major community has a few woody plant species. These woody plants include *Elephantorrhiza elephantina*, *Lycium hirsutum* and the dwarf karroid shub *Felicia muricata* (Species group L, Table 5.1).
Other prominent species in this major community include the perennial grasses *Digitaria eriantha, Aristida congesta* (Species group L), *Cynodon dactylon* (Species group E), *Eragrostis superba* (Species group N), *Aristida diffusa* (Species group A), and *Eragrostis lehmanniana* (Species group C). The xerophytic sedge *Cyperus rupestris* (Species group D) is also quite abundant.

An average of 10 species per relevé was recorded for this major community (Table 5.1).

This major community can be sub-divided into three communities. They are the *Digitaria eriantha-Oenothera stricta*, *Cynodon dactylon-Dipcadi ciliare* and *Themeda triandra-Eragrostis superba* Communities. The first two are sub-divided into three sub-communities each.

1.1 *Digitaria eriantha-Oenothera stricta* Community

This community is found in the largely open area south and west of FARMOVS on Glenrosa soils. It also occurs in the four livestock enclosures on the western boundary of the campus and in the open area just east of these enclosures where the Hutton soil form is prominent.

The area is mowed once a year except on the roadsides where it is mowed once a month. In the enclosures, livestock is kept for periods of the year. Along the boundaries of these enclosures a double row of *Rhus lancea* trees was planted as shade for the animals. The disturbed areas under the planted *Rhus lancea* trees were not sampled during this survey.

The diagnostic species group is Species group B (Table 5.1). The species are the grass *Triraphis andropogonoides*, the exotic forb *Oenothera stricta*, perennial dwarf shrub *Helichrysum zeyheri* and the geophyte *Hypoxis hemerocallidea.* The climax grass *Digitaria eriantha* (Species group L) and the forb *Conyza podocephala* (Species group M) occur quite frequently in this community, with the latter having mostly high cover values (Table 5.1).

The *Digitaria eriantha-Oenothera stricta* Community is divided into three sub-communities namely the *Nenax microphylla-Themeda triandra*, *Helichrysum zeyheri-Eragrostis superba* and *Triraphis andropogonoides-Eragrostis lehmanniana* Sub-Communities.

An average of 11.54 species per reléve was recorded for this community (Table 5.1).

1.1.1 *Nenax microphylla-Themeda triandra* Sub-community

This sub-community is found northwest of the campus in the Agricultural Research Centre's four livestock enclosures as well as in the open area east of these enclosures. The dominant soil form in this area is of the Hutton form. A few individuals of goat, sheep or springbok are kept in these enclosures on an irregular basis. These enclosures are used by researchers of the Agricultural Section of the Faculty of Natural and Agricultural Sciences. The grazing pressure can be relatively high in some instances and this usually results in disturbance of the vegetation in these enclosures.

The diagnostic species of this sub-community is Species group A (Table 5.1). The disturbance in these enclosures is reflected by the high cover abundance values of the pioneer grass *Aristida diffusa* and the presence of the exotic forb *Schkuhria pinnata*. The other diagnostic species is *Nenax microphylla* (Species group A, Table 5.1).

The dominant species in this sub-community are the grasses *Themeda triandra and Panicum coloratum* and the forb *Indigofera alternans,* all of which are in Species group F. Other Species with a noteworthy presence are the grasses *Digitaria eriantha, Aristida congesta, Tragus koelerioides* (Species group L), and *Eragrostis superba* (Species group N). Other species with a noteworthy presence in this sub-community are the forbs *Oenothera stricta* (Species group B) and *Selago densiflora* (Species group F), dwarf shrub *Felicia muricata* (Species group L), and the tuberons *Hypoxis haemerocallidea* (Species group B) and *Eriospermum cooperi* (Species group L) (Table 5.1).

An average of 11.9 species per relevé was recorded for this sub-community (Table 5.1).

1.1.2 *Helichrysum zeyheri-Eragrostis superba* Sub-community

This sub-community is found to the south and west of FARMOVS on Glenrosa and Hutton soils. It is also present in the livestock enclosures on Hutton soil. It is less disturbed in some places as indicated by the absence of pioneer species such as *Aristida diffusa* (Species group A), and *Tragus koeleroides* (Species group L) (Table 51).

This sub-community does not have a diagnostic species group, but the relative high constancy of the grass *Eragrostis superba* (Species group N) and the absence of the species of Species groups A and C (Table 5.1) as well as *Felicia muricata* (Species group L), help to define it. *Helichrysum zeyheri* (Species group B) is rather poorly represented but can still be regarded as diagnostic.

Other prominent species present in this sub-community are the grasses *Themeda triandra, Panicum coloratum* (Species group F), *Digitaria eriantha, Aristida congesta,* (Species group L), and *Eragrostis superba* (Species group N).

The forbs *Indigofera alternans, Selago densiflora* (Species group F), and bulb *Eriospermum cooperi* (Species group L) are all noteworthy species (Table 5.1).

An average of 10.4 species per relevé was recorded for this sub-community (Table 5.1).

1.1.3 *Triraphis andropogonoides-Eragrostis lehmanniana* Sub-community

This sub-community is found south of the FARMOVS Complex on Glenrosa soil as well as in the area between the tennis courts and the western fence of the campus on Hutton soil. The habitat is similar to that of the previously described sub-community (*Helichrysum zeyheri-Eragrostis superba* Sub-community) but it occurs on relatively deeper soils that retain soil moisture better.

The diagnostic species is the sub-climax grass *Eragrostis lehmanniana* (Species group C, Table 5.1).

An average of 11.8 species per relevé was recorded for this sub-community (Table 5.1).

1.2 *Cynodon dactylon-Dipcadi ciliare* Community

The *Cynodon dactylon-Dipcadi ciliare* Community occurs on the Hutton soil form in the open area between Shimla Park sports facility and the campus' western fence and in the area from immediately west of the SASOL Library and Mabaleng buildings up to immediately east of the UFS rugby team's hostel. This grassland is mowed once a year except on the roadsides where it is mowed once a month, see Figure 5.2 below.

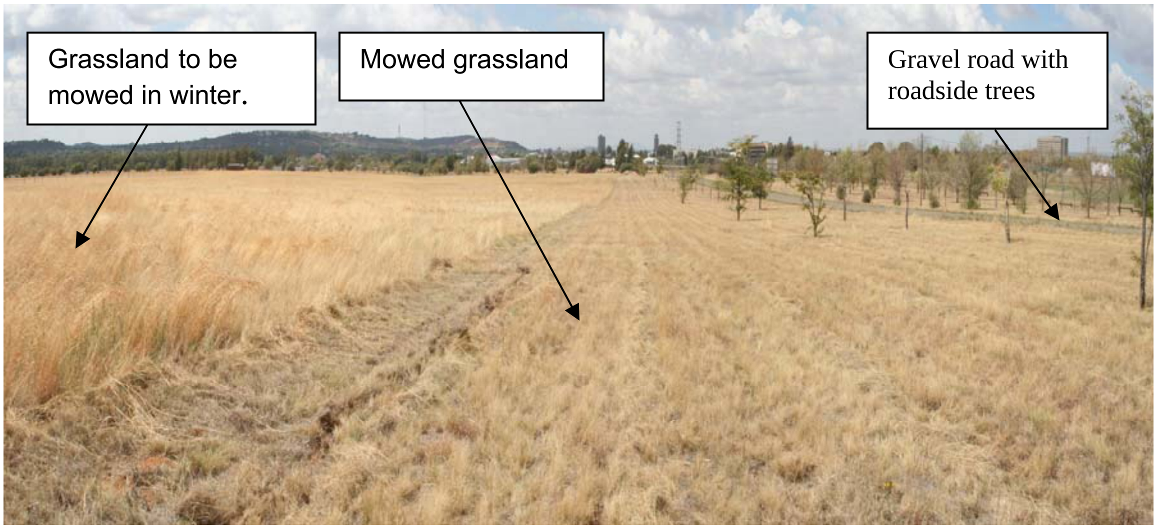


Figure 5.2: Area where *Cynodon dactylon-Dipcadi ciliare* Community occurs showing roadside mowing.

It is found also in the sections of the area between the western tennis courts and the western fence of the campus.

The diagnostic species group is Species group E (Table 5.1). The species are the pioneer grass *Cynodon dactylon* and the geophyte *Dipcadi ciliare.* The climax grass *Digitaria eriantha* (Species group L) as well as the species of Species group B are all absent from this community (Table 5.1).

The *Cynodon dactylon-Dipcadi ciliare* Community is divided into three sub-communities namely the *Eragrostis lehmanniana-Cynodon dactylon* Sub-community, the *Cyperus rupestris-Cynodon dactylon* Sub-community, and the *Eragrostis superba-Cynodon dactylon* Sub-community.

An average of 8.5 species per relevé was recorded for this community.

1.2.1 *Eragrostis lehmanniana-Cynodon dactylon* Sub-community

This sub-community is found on Hutton soil in the open area between Shimla Park sports facility and the campus' western fence.

The area is much more disturbed than the already described sub-communities. The impacts are mainly anthropogenic. Most of them are caused by earth-moving activities (grading, dumping, and levelling of soil). This sub-community can be regarded as transitional between the *Triraphis andropogonoides-Eragrostis lehmanniana* Sub-community and the *Cynodon dactylon-Dipcadi ciliare* Community. It lacks the diagnostic species of Species group B, but *Eragrostis lehmanniana* (the diagnostic species of the *Triraphis andropogonoides-Eragrostis lehmanniana* Sub-community (Species group C) is very dominant.

This sub-community does not have a diagnostic species group, but the relatively high constancy of the grass *Eragrostis lehmanniana* (Species group C) and the absence of the plants belonging to Species group A (Table 5.1) as well as the presence and high cover values of the grass *Cynodon dactylon* (Species group E), help to define it.

Other prominent species present in this sub-community are the grasses *Themeda triandra, Panicum coloratum* (Species group F), and *Eragrostis superba* (Species group N). There are no forb species worth mentioning in this sub-community (Table 5.1).

An average of 9.57 species per relevé was recorded for this sub-community (Table 5.1).

1.2.2 *Cyperus rupestris-Cynodon dactylon* Sub-community

This sub-community occurs on Hutton soils in the open area west of the SASOL Library and Mabaleng buildings. This grassland is also heavily affected by human activities such as regular mowing, and soil disturbance, see Figure 5.3 below.

Figure 5.3: Soil disturbance in the area of the *Cyperus rupestris-Cynodon dactylon* Sub-community.

This sub-community also has no diagnostic species group, but the absence of *Eragrostis lehmanniana* (Species group C) and the relatively high constancy of the sedge *Cyperus rupestris* (Species group D) differentiate this sub-community from the others.

Other prominent species present in this sub-community are the grasses *Themeda triandra, Panicum coloratum* (Species group F), *Aristida congesta* (Species group L) and *Eragrostis superba* (Species group N). A few forbs are worth mentioning. They are *Indigofera alternans, Hibiscus pusillus, Talinum caffrum* (Species group F), and *Felicia muricata* (Species group L) (Table 5.1).

An average of 8.4 species per relevé was recorded for this sub-community (Table 5.1).

1.2.3 *Eragrostis superba-Cynodon dactylon* Sub-community

The *Eragrostis superba-Cynodon dactylon* Sub-community occurs on deep Hutton soils in the open area west of the SASOL Library and in the open area east of the UFS rugby players' hostel. This grassland is also heavily affected by human activities such as regular mowing and soil disturbances.

This sub-community also does not have a diagnostic species group, but the absence of *Eragrostis lehmanniana* (Species group C) and *Cyperus rupestris* (Species group D) differentiate this sub-community from the others.

Prominent species also present in this sub-community are the grasses *Themeda triandra, Panicum coloratum* (Species group F), and *Eragrostis superba* (Species group N). Prominent forbs are *Indigofera alternans, Hibiscus pusillus, Monsonia angustifolia* (Species group F), and *Felicia muricata* (Species group L) (Table 5.1).

An average of 8.16 species per relevé was recorded for this sub-community (Table 5.1).

1.3 *Themeda triandra-Eragrostis superba* Community

This community is found on Hutton soil in the area between the western tennis courts and the campus' western fence as well as in the northwestern and the southwestern livestock enclosures. This area is mowed once a year except on the road sides. Inside the livestock enclosures no mowing is done but frequent grazing by goats, sheep and occasionally springbok occurred until around March 2005.

This community is characterized by the absence of *Eragrostis lehmanniana* (Species group C), *Cynodon dactylon* and *Dipcadi ciliare* (Species group E) as well as the presence of Cyperus rupestris (Specis group D).

The dominant species in this community are the grasses *Themeda triandra, Panicum coloratum* (Species group F) and *Aristida congesta* (Species group L). Other species that occur with usually high values are the grass *Eragrostis superba* (Species group N), the forb *Selago densiflora* (Species group F) the dwarf shrub and *Felicia muricata* (Species group L) (Table 5.1).

An average of 9.8 species per relevé was recorded for this community (Table 5.1).

2. *Jamesbrittenia atropurpurea-Crabbea acaulis* Major Community

This major community is found on Hutton soil in the northwest of the campus inside the southwestern livestock enclosure and in the open area east of it.

It is also present on Mispah soils in the open area north of it where sandstone outcrops occur. Furthermore, it also occurs on relatively shallow Hutton soils in the area between the western tennis courts and the campus' western fence as well as in the open area west of the SASOL Library and Mabaleng buildings. It occurs on Glenrosa soil inside the Rag Park (Joolkol), Valsrivier soil immediately west of the warehouses northeast of the SASOL Library, on Shortlands soil in the open area south of the UFS Dutch Reformed Church and finally on Valsriviers soil in the open area west of the SK5 cafeteria.

These areas were in the past, as well as today, subjected to various degrees of disturbance. Mowing is done once a year except in the southwestern livestock enclosure, in the open area south of the campus' Dutch Reformed Church and west of SK5 cafeteria and Khayalami Hostel where mowing is done once a month as well. Vehicles also destroy the vegetation in places.

Figure 5.4: *Jamesbrittenia atropurpurea-Crabbea acaulis* Major Community immediately west of the warehouses located north of the SASOL Library. In between the planted roadside trees mowing is done once a month.

Dingaan, Du Preez and Venter (*in press*) described a similar major community namely the *Trichoneura grandiglumis-Rhynchosia nervosa* Major Community which also occurs on Hutton and Glenrosa soil forms.

The diagnostic species for this *Jamesbrittenia atropurpurea-Crabbea acaulis* Major Community occur in Species group K (Table 5.1).

They do not include any grass species, but the geophyte *Schizocarphus nervosus*, and forbs *Jamesbrittenia atrupurpurea, Crabbea acaulis, Arctotis venusta, Ruschia hamata, Nidorella hottentotica, Solanum supinum,* and *Sutera pumila* can be noted.
The dominant species of this major community are *Jamesbrittenia atropurpurea* (Species group K) and *Eragrostis superba* (Species group N).

This major community has a few woody plant species. These woody plants include the exotic *Acacia melanoxylon* (planted to create shade along roads throughout this grassland as well as along the campus borders to screen it from the surrounding suburbs), and *Lycium pilifolium* (Species group I) (Table 5.1).

Other prominent species in this major community include the perennial grasses *Trichoneura grandiglumis* (Species group I), *Cynodon hirsutus* (Species group J), *Digitaria eriantha, Aristida congesta* (Species group L), and *Eragrostis superba* (Species group N). Prominent forbs include the geophytes *Raphionacme hirsuta* (Species group I) and *Eriospermum cooperi* (Species group L), and the forb species of Species group K (Table 5.1).

An average of 8.87 species per relevé was recorded for this major community (Table 5.1).

This major community can be sub-divided into three communities. They are the *Acacia melanoxylon-Jamesbrittenia atropurpurea* Community, *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community and the *Nidorella hottentotta-Jamesbittenia atropurpurea* Community. Only the *Acacia melanoxylon-Jamesbrittenia atropurpurea* Community is sub-divided into three sub-communities.

2.1 *Acacia melanoxylon-Jamesbrittenia atropurpurea* Community

This community is found on Hutton soil in the northwest of the campus inside the southwest livestock enclosure, in the open area east of it and on sandstone outcrops further to the northwest where the shallow soil is Mispah.

It is again found on Hutton soils in the northeast of the campus in the area between the western tennis courts and the campus' western fence. These areas are mowed once a year except in the livestock enclosures.

The community's diagnostic species group is Species group I which consists of the pioneer grass *Trichoneura grandiglumis*, exotic tree *Acacia melanoxylon*, the geophyte *Raphionacme hirsuta*, and the toxic forb *Geigeria filifolia* and the karroid shrub *Lycium pilifolium.*

An average 10.15 species per relevé was recorded for this community.

The *Acacia melanoxylon-Jamesbrittenia atropurpurea* Community is divided into three sub-communities namely the *Eleusine coracana-Acacia melanoxylon* Sub-community, the *Brachiaria eruciformis-Acacia melanoxylon* Sub-community, and the *Eragrostis superba-Acacia melanoxylon* Sub-community.

2.1.1 *Eleusine coracana-Acacia melanoxylon* Sub-community

This sub-community is found on moist areas which are regularly irrigated. The sub-community occurs on sites along the roads where *Acacia melanoxylon* trees were planted as well as in the seepage area downstream of the earth-walled dam west of FARMOVS. The soil there is of the Mispah form. In this area mowing is done once a year.

The diagnostic species of this sub-community is *Eleusine coracana* (Species group G (Table 5.1). The high cover–abundance of *Acacia melanoxylon* (Species group I), as well as the presence of the grass *Digitaria eriantha* and the geophyte *Eriospermum cooperi* (Species group L) help to differerentiate this sub-community from the others in Table 5.1.

Other prominent species present in this sub-community are the tree *Acacia melanoxylon* (Species group I), the grass *Trichoneura grandiglumis*, the geophyte *Raphionacme hirsuta,* the forbs *Geigeria filifolia* (Species group I)*, Jamesbrittenia atropurpurea,* and *Solanum supinum* (Species group K) (Table 5.1).

An average of 9.87 species per relevé was recorded for this sub-community (Table 5.1).

2.1.2 *Brachiaria eruciformis-Acacia melanoxylon* Sub-community

This sub-community is found on Hutton soil in the open area west of the SASOL Library and Mabaleng as well as southwest of the campus in the area between the western tennis courts and the western fence of the campus. These areas are mowed once a year. These areas were recently subjected to soil disturbances such as grading and leveling of soil.

The sub-community's diagnostic species is the annual grass *Brachiaria eruciformis* of Species group H in Table 5.1. In this sub-community other prominent species present are the tree *Acacia melanoxylon* (Species group I), the grass *Trichoneura grandiglumis* (Species group I), *Aristida congesta* (Species group L), and *Eragrostis superba* (Species group N), the geophyte *Raphionacme hirsuta* (Species group I), and *Schizocarphus nervosus* (Species group K)*,* the forbs *Jamesbrittenia atropurpurea, Crabbea acaulis, Nidorella hottentotica* (Species group K) (Table 51).

An average of 12.6 species per relevé was recorded for this sub-community (Table 5.1).

2.1.3 *Eragrostis superba-Acacia melanoxylon* Sub-community

This community is found on Hutton soil in the area between the western tennis courts and the western fence of the campus, in the southwestern livestock enclosure and in the open area east of the enclosures. Mowing is once a year except in the livestock enclosures.

This sub-community also does not have a diagnostic species group, but the absence of *Eleusine coracana* (Species group G) and *Brachiaria eruciformis* (Species group H) differentiates this sub-community from the others (Table 51).

In this sub-community other prominent species present are the tree *Acacia melanoxylon* (Species group I), the grass *Trichoneura grandiglumis* (Species group I), and *Eragrostis superba* (Species group N), the geophyte *Raphionacme hirsuta* (Species group I), the forbs *Jamesbrittenia atropurpurea, Schizocarphus nervosus, Crabbea acaulis,* (Species group K) and Eriospermum cooperi (Species group L) (Table 51).

An average of 8.86 species per relevé was recorded for this sub-community (Table 5.1).

2.2 *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community

This is a degraded community occurring on Glenrosa soils inside the Rag Park and on Shortlands soils in the open area just south of the campus' Dutch Reformed Church.

These areas are mowed once a year. Trampling occurs in these areas during the annual Rag Festival and the area south of the campus's Dutch Reformed Church is used for parking cars by students.

The community's diagnostic species group is Species group J which consists of the pioneer grass *Cynodon hirsustus.* Other diagnostic species are *Tripteris aghillana* (Species group F), and *Felicia muricata* (Species group L) (Table 5.1).

In this community other prominent species present are the grass *Aristida congesta* (Species group L), and *Eragrostis superba* (Species group N), the geophytes *Schizocarphus nervosus* (Species group K), and *Eriospermum cooperi* (Species group L), the forbs *Jamesbrittenia atropurpurea,* and *Crabbea acaulis,* (Species group K) (Table 5.1).

The *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community is not sub-divided into any sub-communities.

An average of 9.75 species per relevé was recorded for this community (Table 51).

2.3 *Nidorella hottentotta-Jamesbittenia atropurpurea* Community

Degradation of the vegetation, due to trampling by people and vehicles is the major impact in this community. It occurs on Glenrosa soils immediately west of the warehouses northeast of the library and on Valsrivier soils in the open area west of the Khayalami Hostel.

These areas are also mowed once a year except on the roadsides where mowing is once per month.

The highly degraded state of this community is reflected in the low number of species per relevé (Table 5.1), and the lack of a distinct species group.

Other prominent species present in this community are the grass *Eragrostis superba* (Species group N), the geophytes *Schizocarphus nervosus* (Species group K), the forbs *Jamesbrittenia atropurpurea, Crabbea acaulis, Nidorella hottentotica,* (Species group K), and Salvia verbenaca (Species group N) (Table 5.1).

The *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community is not sub-divided into sub-communities.

An average of 6.63 species per relevé was recorded for this community (Table 5.1).

3. *Chloris virgata-Aristida congesta* Major Community

This major community is found in the southeast of the campus in the open area bounded in the east by Khayalami hostel and SK5 cafeteria while in the west it is bounded by the Pellies Park sports field.

Figure 5.5: *Chloris virgata-Aristida congesta* Major Community damaged by pavement construction and frequent trampling.

The soil there is Valsrivier. Trampling by people and vehicles is the major cause of the degradation of this community. Mowing in these areas is done once a month in summer.

Dingaan, *et al*. (*in press*) described a similar major community namely the *Enneapogon cenchroides - Themeda triandra* Major Community which also occurs on disturbed soils.

The diagnostic species for this *Chloris virgata-Aristida congesta* Major Community include the grass *Chloris virgata*, and the prostrate forbs *Conyza podocephala* (Species group M) and *Chamaesyce inaquilatera* (Species group R) (Table 5.1).

Other prominent species in this major community include the grass *Eragrostis superba,* the forb *Salvia verbenaca and Sutera caerulea* (Species group N) (Table 5.1).

An average of 6 species per relevé was recorded for this major community (Table 5.1). This major community can not be sub-divided into communities.

4. *Chenopodium album-Salsola kali* Major Community

This major community is found in the southeast of the campus in the open area bounded in the east by Khayalami hostel and SK5 cafeteria while in the west it is bounded by the eastern berm of the Pellies Park sports field. The soil found there is of Valsrivier form. This area is mowed once a month. Near the berm the vegetation occasionally receives water when the sprinklers spray water beyond the field.

Dingaan, Du Preez and Venter (*in press*) described a similar major community namely the *Enneapogon cenchroides-Themeda triandra* Major Community which also occurs on disturbed soils.

The diagnostic species for this *Chenopodium album-Salsola kali* Major Community are those in Species group O, (Table 5.1). They are two exotic pioneers namely, *Chenopodium album* and *Salsola kali.*

Other prominent species in this major community include the protrate forb *Chamasyce inaequilatera* (Species group R) (Table 5.1).

An average of 5.77 species per relevé was recorded for this major community (Table 5.). The *Chenopodium album-Salsola kali* Major Community is divided into two communities namely the *Brachiaria eruciformis-Salsola kali* and the *Gomphrena celosioides-Aristida congesta* Communities.

4.1 *Brachiaria eruciformis-Salsola kali* Community

This community is found on the eastern berm of Pellies Park sports field and in the area around the foot of the berm.

The soil there is of Valsrivier type and this area is mowed once a month.

The diagnostic species of *Brachiaria eruciformis-Salsola kali* Community are the annual grasses *Brachiaria eruciformis* (Species group H), *Urochloa panicoides* (Species group P), the annuals *Chenopodium album* (high cover-abundance values) (Species group O), and *Rumex crispus* (Species group P) (Table 5.1).

This community's highly degraded state is reflected in the low average number of species recorded per relevé of 5.66 (Table 5.1).

4.2 *Gomphrena celosioides-Aristida congesta* Community

As with the *Brachiaria eruciformis-Salsola kali* Community, this community is found on the eastern berm of Pellies Park sports field and in the area around the foot of the berm. It is also found on Valsrivier soils and mowing is once a month.

The diagnostic species of this community are the pioneer *Aristida congesta* (Species group L), the exotic forbs *Gomphrena selosioides* and *Plantago lanceolata* (Species group Q) (Table 5.1).

The presence of so many exotic pioneers as well as the low average number of species per relevé (6) is an indication of this community's highly degraded state (Table 5.1).

Other notable species present in this community are the exotic pioneers *Chenopodium album* and *Salsola kali* (Species group O) (Table 5.1).

5. *Chasmatophyllum musculinum-Oropetium capense* Major Community

This major community is found in the open area northwest of the campus on sandstone outcrops.

The soil there is a very shallow Mispah of a depth that is less than 20mm. The shallowness of the soil and the sandstone substrate does not allow water to remain for long periods in this habitat. Evaporation and runoff are the main causes of water loss. The plants growing in this unique habitat are specially adapted to survive these arid conditions. Dingaan and Du Preez (2002) described a similar vegetation type namely the *Oropetium capense–Eragrostis nindensis* Sub-community which also occurs on dry, shallow soils of doleritic origin.

The diagnostic species for this *Chasmatophyllum musculinum-Oropetium capense* Major Community (Species group S, Table 5.1), include the grasses *Eragrostis nindensis,* and *Oropetium capense,* and the prostrate succulent Mesemb *Chasmatophyllum musculinum.*

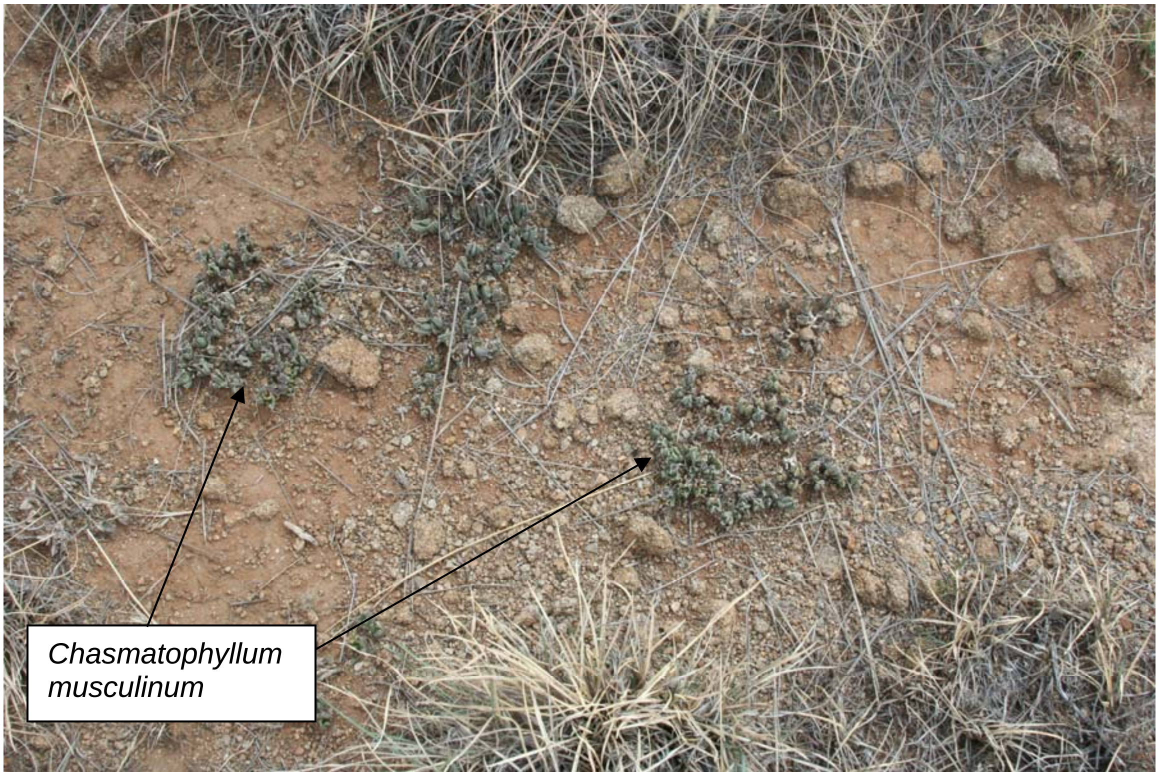


Figure 5.6: Portion of the *Chasmatophyllum musculinum-Oropetium capense* Major Community.

No other plants occur in this specific habitat and the very low average of 2.55 species per relevé recorded is an indication of the specific habitat requirements of this habitat.

6. *Phragmites australis-Bromus catharticus* Major Community

This major community is found at the earth walled dam 200m west of the FARMOVS Complex. The soils found there are of Valsrivier and Bainsvlei forms. This wetland usually has a lot of water during the rainy season due to storm water run-off whereas during the dry winter months it is usually dry.

Figure 5.7: *Phragmites australis-Bromus catharticus* Major Community on wetland near FARMOVS Complex.

Dingaan, *et al*. (2001) described a similar major community namely the *Cyperus longus-Paspalum diltatum* Major Community which also occurs on flood plains and along rivers, streams and dams.

The diagnostic species of this major community (Species group T, Table 5.1), include the grass *Bromus catharticus,* the forbs *Ciclospermum leptophyllum, Oenothera rosea, Lepidium capense, Sonchus oleraceus, Emex australis, Stellaria media,* as well as *Chenopodium album* of Species group O.

Other plants present in this major community are the reed *Phragmites australis* forming very dense monotypic stands, *Cyperus sexangularis* and *Oxalis depressa* (Species group U) (Table 5.1).

An average of 11 species per relevé was recorded for this major community (Table 5.1)

7. *Ficinia nodosa-Eleocharis limosa* Major Community

This is a major community found at the two earth walled dams northeast and northwest of the netball courts and at the earth walled dam 200m west of the FARMOVS Complex. The soils there are of the Bainsvlei form.

Figure 5.8: Earth-walled dam northeast of the netball courts where the *Ficinia nodosa-Eleocharis limosa* Major Community occurs.

This dam has a small catchment and always dries up in autumn.

Figure 5.9: Earth walled dam northwest of the netball courts also with the *Ficinia nodosa-Eleocharis limosa* Major Community.

This dam also has a small catchment and always dries up in autumn. Dingaan, *et al*. (2001) described a similar major community namely the *Cyperus longus-Paspalum diltatum* Major Community which also occurs on flood plains and along rivers, streams and dams.

The diagnostic species for this major community (Species group V, Table 5.1), consist of two sedge species namely *Ficinia nodosa,* and *Eleocharis limosa* as well as the forb *Pseudognaphalium oligandrum.*

Other plants present in this major community are species restricted to the following three different communities, namely the *Ficinia nodosa-Phragmites australis* Community, the *Ficinia nodosa-Persicaria lapathifolia* Community and the *Ficinia nodosa-Leptochloa fusca* Community (Table 5.1).

An average of 4.3 species per relevé was recorded for this major community (Table 5.1).

7.1 *Ficinia nodosa-Phragmites australis* Community

This community is found at the earth walled dam 200m west of the FARMOVS Complex where the soil is of Bainsvlei form.

The diagnostic species of this sub-community are *Phragmites australis, Cyperus sexangularis, Oxalis depressa* (Species group U) and the holo-parasite *Cuscuta campestris* (Species group W) (Table 5.1).

Other prominent species present in this community are the sedge species *Ficinia nodosa,* and *Eleocharis limosa* as well as the forb *Pseudognaphalium oligandrum* (Species group V) (Table 5.1).

An average of 6 species per relevé was recorded for this community (Table 5.1).

7.2 *Ficinia nodosa-Persicaria lapathifolia* Community

This community is found at the earth walled dam northeast of the netball courts. The soil there is of Bainsvlei form. This community is restricted to the shallow waters near the inlet of the dam.

The diagnostic species of this community are *Chenopodium album* (Species group O), *Persicaria lapathifolia* and *Atriplex semibaccata* (Species group X) (Table 5.1).

Other prominent species present in this community are the sedge species *Ficinia nodosa,* and *Eleocharis limosa* as well as the forb *Pseudognaphalium oligandrum* (Species group V) (Table 5.1).

An average of 4.66 species per relevé was recorded for this community (Table 5.1).

7.3 *Ficinia nodosa-Leptochloa fusca* Community

This community is found at the earth walled dam north-east as well as at the one north-west of the netball courts. The soil there is of Bainsvlei form.

This community occurs in the deeper parts of the dam where water remains the longest. These plants can also handle water-saturated soils for very long periods.

The diagnostic species of this community are the forb *Persicaria decipiens* and the grass *Leptochloa fusca [Diplachne fusca]* (Species group Y) (Table 5.1).

An average of 3.4 species per relevé was recorded for this community (Table 5.1).

5.4 DECORANA ordination

The distribution of the sample plots along the first and second axes of the DECORANA ordination is given in Figure 5. 10.

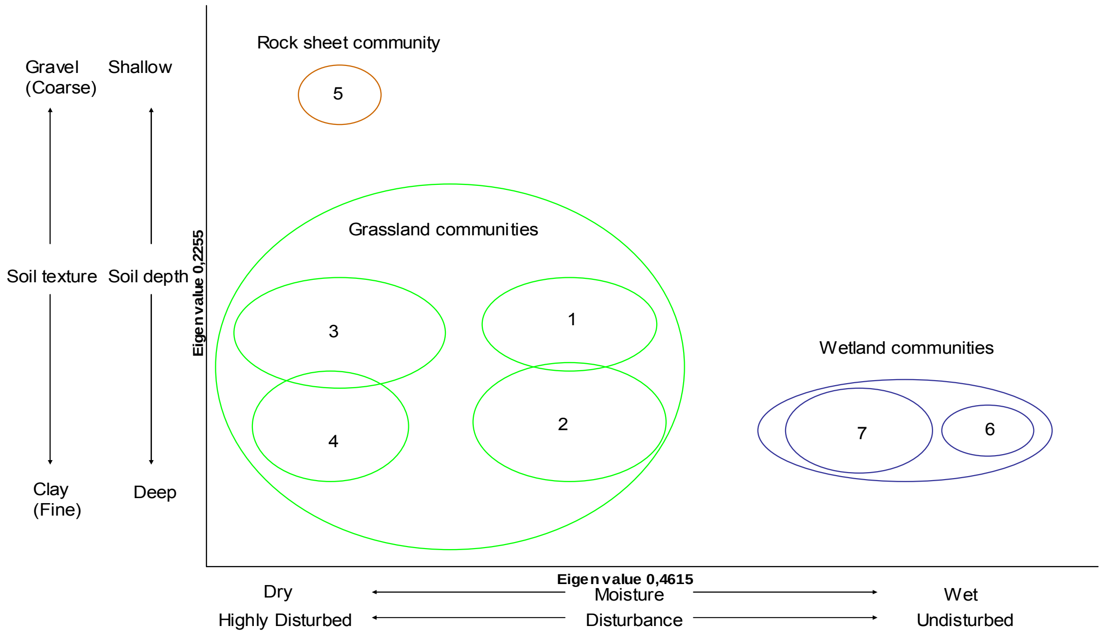


Figure 5.10: Sample plot distribution against environmental variables

The environmental gradients on the horizontal axis are moisture and degree of disturbance. The vertical axis represents the environmental gradients namely soil depth and soil texture.

Major Communities 1 to 5 are positioned to the left of the ordination diagram. This indicates the disturbed and dry habitats with varying soil depth, and soil texture. The wetland major communities (Major Communities 6 and 7) are positioned to the right of the ordination diagram. Although these major communities are occupying wetlands created by humans, they reflect a large degree of stability. They are typical of wetlands on stream banks, and earth-walled dams where irregular flooding of the habitat occurs.

The second axis reflects soil related gradients. Major Community 5 represents the succulent community on very shallow soils on sandstone rock sheets. The soil texture here is very coarse compared to the habitat of the other major communities (1 to 4) on the opposite side of the gradient.

The DECORANA ordination corresponds well with the phytosociological classification (Table 5.1).

CHAPTER 6
URBAN BIOTOPE MAPPING

6.1 Introduction

Land use intensification in Europe has caused loss of biotope diversity and is threatening wild plant and animal species (Sukopp and Weiler, 1988). The protection of wild plants and animals requires conservation of their communities as well as their habitats. Before any nature conservation strategy is implemented it is advisable to first conduct a survey of all the species and biotopes.

In light of this, biotope mapping has been conducted since the 1970s in Germany. Its original focus was the inventory of natural and semi-natural ecosystems e.g. moors, water bodies, forests and biotopes that developed under the influence of agricultural land use practices e.g. heaths and litter meadows (Sukopp and Weiler, 1988). In urban areas biotope mapping was considered superfluous (Sukopp and Weiler, 1988; Putter, 2004).

Over time however biotope mapping came to be applied in cities, and not only in Germany but in other countries too, for example in Denmark (Attwell, 2000), Sweden (Löfvenhaft, Björn and ihse, 2002) and in New Zealand (Freeman and Buck, 2003). Putter (2004) states that biotope mapping has now been conducted in 175 cities in Germany. This was to facilitate urban nature conservation so that urban residents could have direct contact with elements of their environment (Sukopp and Weiler, 1988).

According to Sukopp and Weiler (1988) urban biotopes are important for the following reasons:

i) for species protection (as refuges, dispersal centres and corridors);
ii) they help provide a sense of place;
iii) for recreation;
iv) as informal play grounds for children;
v) as demonstration and experimental areas for educational purposes;
vi) for ecological research;

vii) as bio-indicators for environmental change and pollution;

viii) for environmental protection and environmental health e.g. noise attenuation;

ix) for moderating microclimate, curbing air pollution and intercepting rainfall to improve infiltration (Millard, 2004).

In Europe urban biotope mapping is used to present information on urban vegetation units to decision-makers in an easily accessible and understandable format (Cilliers, *et al*. 2004).

Biotope mapping can be done using the selective method or the comprehensive method (Sukopp and Weiler, 1988). In the selective method only the biotopes that are considered as important to conserve are studied. In an urban context areas of this sort would be those with a high vegetation cover and a low level of human impact such as forests, shrubs, old ruderal vegetation, extensively used meadows and abandoned or extensively used allotments (Cilliers, *et al*. 2004). They are also those biotopes showing a typical spectrum of species on a specific site (e.g. typical species of ruderal vegetation or of secondary forests) and/or a high variation in vegetation age and structure and/or development over a long time.

Comprehensive biotope mapping is not limited to selected biotopes. Rather its aim is to inventory all the habitats associated with the various land use types in built-up areas, for example settlements, industrial sites and wastelands (Sukopp and Weiler, 1988; Cilliers, *et al*. 2004).

Since it is usually not possible to conduct highly detailed studies over an entire city area, sample areas of each land use type are chosen and examined in detail to try and identify all the biotope types (Sukopp and Weiler, 1988). This is called comprehensive representative mapping (Sukopp and Weiler, 1988; Cilliers, *et al*. 2004). The biotopes considered worthy of conservation are chosen based on the results of this sampling.

Compared to selective mapping, comprehensive mapping has the disadvantage that it needs much more money, time and qualified personnel (Sukopp and Weiler, 1988). Cilliers *et al*. (2004) state that despite this it provides a more detailed basis for further interpretation concerning issues such as evaluation of different biotope types as dispersal corridors, the selection of plants for open space planning and the documenting of changes in vegetation after a follow up investigation.

In addition to vegetation mapping based on floristic and phytosociological surveys selected animal species such as breeding birds (Sukopp, 1988), bats, amphibians, reptiles, butterflies, beetles, dragonflies, spiders and wild bees can be done by both mapping methods (Cilliers, *et al*. 2004). The aim of this is to identify other areas such as bare ground, which is not important for plant conservation but is valuable for protection of various animal groups (Cilliers, *et al*. 2004).

6.2 Urban biotope mapping in South Africa

During 2001-2002 urban biotope mapping was done for the first time in South Africa in the Potchefstroom Municipal area by two German exchange students Rost and Röthig (Putter, 2004). A simplified version of the kind of biotope mapping keys used in Germany was first prepared. This key was then adapted to South African cities, thus it has some specific and detailed biotope types such as those of the various residential areas that significantly affect existing natural vegetation which are not common in European cities (Cilliers, *et al*. 2004). See Table 6.1 below.

Table 6.1: Mapping key for biotope types.

Major biotope types	**Specific biotope types**	**Further detail**
1. Central city (commercial / residential)		
2. Residential areas	2.1 Blocks of flats	2.11 Closed (no / small gardens, 70-100% sealed) 2.1.2 Open (larger gardens, <60% sealed)
	2.2 Townhouses (> one unit per plot, one small garden/unit)	
	2.3 Large single houses, park-like gardens (trees, shrubs, lawns, flowerbeds)	2.31 Large gardens, (<30% sealed) 2.32 Small gardens (30-50 sealed)
	2.4 Small single houses, basic	2.41 Sealed areas <50%

	services, small gardens (few trees, shrubs, small lawns)	2.42 Sealed areas >50%
	2.5 Small single houses, reduced basic services (water, sewage), gardens small/absent)	2.5.1 Permanent houses with electricity 2.5.2 Temporary houses without electricity
3. Commercial areas	3.1 Predominantly sealed surfaces >70%	
	3.2 Lesser sealed surfaces (<70%) with intensively managed public open spaces	
	3.3 Lesser sealed (<70%) with extensively managed open spaces, including small waste grounds	
4. Industrial areas	4.1 Predominantly sealed surfaces (>70%)	
	4.2 Lesser sealed surfaces (<70%), with intensively managed open spaces	
	4.3 Lesser sealed surfaces (<70%), with extensively managed or unmanaged open spaces, including small waste grounds	
5. Managed open spaces	5.1 Intensively managed public parks (mowing >10x times/year)	5.1.1 For passive recreation 5.1.2 For active recreation (with playing apparatus, trim park)
	5.2 Extensively managed public parks (mowed usually 3-4 times/year)	5.2.1 For passive recreation 5.2.2 For active recreation (with playing apparatus, trim park)
	5.3 Private park-like open spaces (gardens of University, College, Agricultural College)	
	5.4 Sports fields and grounds	5.41 Predominantly sealed surfaces (>ca. 70%) (tennis courts, athletics and hockey fields with synthetic surfaces)
		5.42 Lesser sealed surfaces (<ca. 70%) (soccer, rugby, cricket) 5.4.3 Informal sports fields (mainly soccer, basket, and netball) on bare ground.
	5.5 Cemeteries	
	5.6 Campsites	
	5.7 Botanical garden	
6.Man-made water bodies	6.1 Lake (dam)	
	6.2 Ponds	
	6.3 Channels	
7. Traffic areas	7.1 Railway areas	
	7.2 Roads	7.2.1 Main road/highways with green verges (including traffic circles and islands) 7.2.2 Local roads with street trees 7.2.3 Local roads without green verges

		7.2.4 Unsealed local roads (dirt roads) 7.2.5 Parking areas 7.2.6 Footpaths
	7.3 Airstrip and hangars	
8. Agricultural areas	8.1 Crop fields	
	8.2 Sowed pastures	
	8.3 Vegetable gardens	
9. Plantations	9.1 Eucalyptus dominated plantations	
	9.2 Others	
10. Natural and semi-natural areas (usually not mowed)	10.1 Wetlands	10.1.1 Rivers 10.1.2 Streams 10.1.3 Marshes and vleis 10.1.4 Channelized rivers and streams
	10.2 Grasslands (less than 10% woody species)	10.2.1 Sandy grasslands 10.2.2 Rocky grasslands 10.2.3 Clayey grasslands
	10.3 Woodlands	10.3.1 Dominated by trees 10.3.2 Dominated by shrubs
11. Disposal sites and ditches	11.1 Household disposal and building rubble sites	
	11.2 Industrial disposal sites	
	11.3 Gravel ditches	
12. Waste grounds	12.1 Annual and biennial communities	
	12.2 Perennial communities	
13. Special land use types	13.1 Military areas	
	13.2 Schools (ornamental gardens & sports fields)	

(Putter, 2004).

Below are the evaluation criteria that they used to determine the worthiness of biotope types for conservation purposes.

Table 6.2 Criteria for evaluating worthiness of biotope types for conservation purposes.

Evaluation Criteria		**1**	**2**	**3**	**4**
Species richness (plant species)	x1	<60	61-80	81-100	>100
Area (m^2)	x 1	100-200	200-500	500-1000	>1000
Sealed area (%)	x1	100-75	75-50	50-25	<25
Networking of biotopes	x1	None/ isolated	Few	Moderate	High

Protected plant species Red List (Hilton-Taylor, 1996))	x1	None	Insufficiently known + no longer threatened	Rare+ Indeterminants	Endangered + vulnerable
Plant structural diversity	x1	1 Level	2 Levels	3 levels	Mosaic
Age	x 1	0-2	2-10	10-50	>50
Estimated expenses of restoring this biotope	x 2	Low	Average	High	Not restorable
Indigenous Plants (Arnold and de Wet, 1993)	x 3	0-10	10-30	30-50	>50
Declared Weeds and Invaders (Henderson, 2001)	x 1	>10	2-10	0-2	0

(Putter, 2004)

The values scored by each biotope in the evaluation criteria of Table 6.2 above were then added to compute the worthiness of the biotope for conservation. The sum of worthiness for each biotope was then subjected to the ranking system given below by Putter (2004)

Sum of worthiness:
13-22 points → Low ecological value
23-32 points → Moderate ecological value
33-42 points → High ecological value
43-52 points → Very high ecological value

The idea of having table 6.2 also came from Germany but most of the specific evaluation criteria and their different levels were customized for South African conditions (Cilliers, *et al*. 2004).

Cilliers *et al*. 2004 concluded that the technique is suitable for use in South Africa and that urban biotope mapping exercises in other cities in South Africa should take place.

Putter (2004) conducted a vegetation dynamics study on some of the biotopes identified by Rost and Röthig in the city of Potchefstroom. He too concluded that the technique is suitable for usage in South Africa although the key may need to be refined to cope with the heterogeneity of certain biotope types.

Some of the biotopes in the biotope mapping key described by Putter (2004) were found to have very little relevance on the UFS campus in Bloemfontein because they are biotopes one would find in cities such as landfill sites, industrial areas and plantations. For this reason the key was customised for the situation on the campus.

Table 6.3: Biotope and land use mapping key for the Bloemfontein campus of the UFS.

Major biotope types	**Specific biotope types**	**Further detail**
1.Built up area of the campus	1.1 Buildings and adjacent car parks, lawns and ornamental gardens	
2. Managed open spaces (excluding lawns)	2.1 Intensively managed open spaces (mowed more than 10 times/year)	2.1.1 For active recreation e. g, golf, rugby, soccer and cricket fields 2.1.2 For passive recreation e.g. taking walks
	2.2 Extensively managed open spaces (mowed less than 3 times/year)	2.2.1 For active recreation 2.2.2 For passive recreation
	2.3 Planted groves of trees	
	2.4 Nursery	
	2.5 Sealed sports grounds (e.g. tennis, basketball, netball courts with synthetic surfaces)	
3. Man-made water bodies	3.1 Dams	
4. Traffic areas	4.1 Roads	4.1.1 Gravel roads 4.1. 2 Tar roads and paved footpaths
5. Research area	5.1 Grain fields	
	5.2 Orchards and	

	vegetable gardens	
	5.3 Natural pasture	
	5.4 Research area buildings	
6. Disposal sites	6.1 Soil dumping sites	

In this study the biotopes that were regarded as worthy of conducting the phytosociological study on were the less managed open spaces and the wetlands. The reason is that these biotopes are considered more natural since human effort plays a relatively smaller role in determining the makeup of their plant communities.

Figure 6.1 below shows the biotopes and land use types identified on the UFS campus in Bloemfontein during this study.

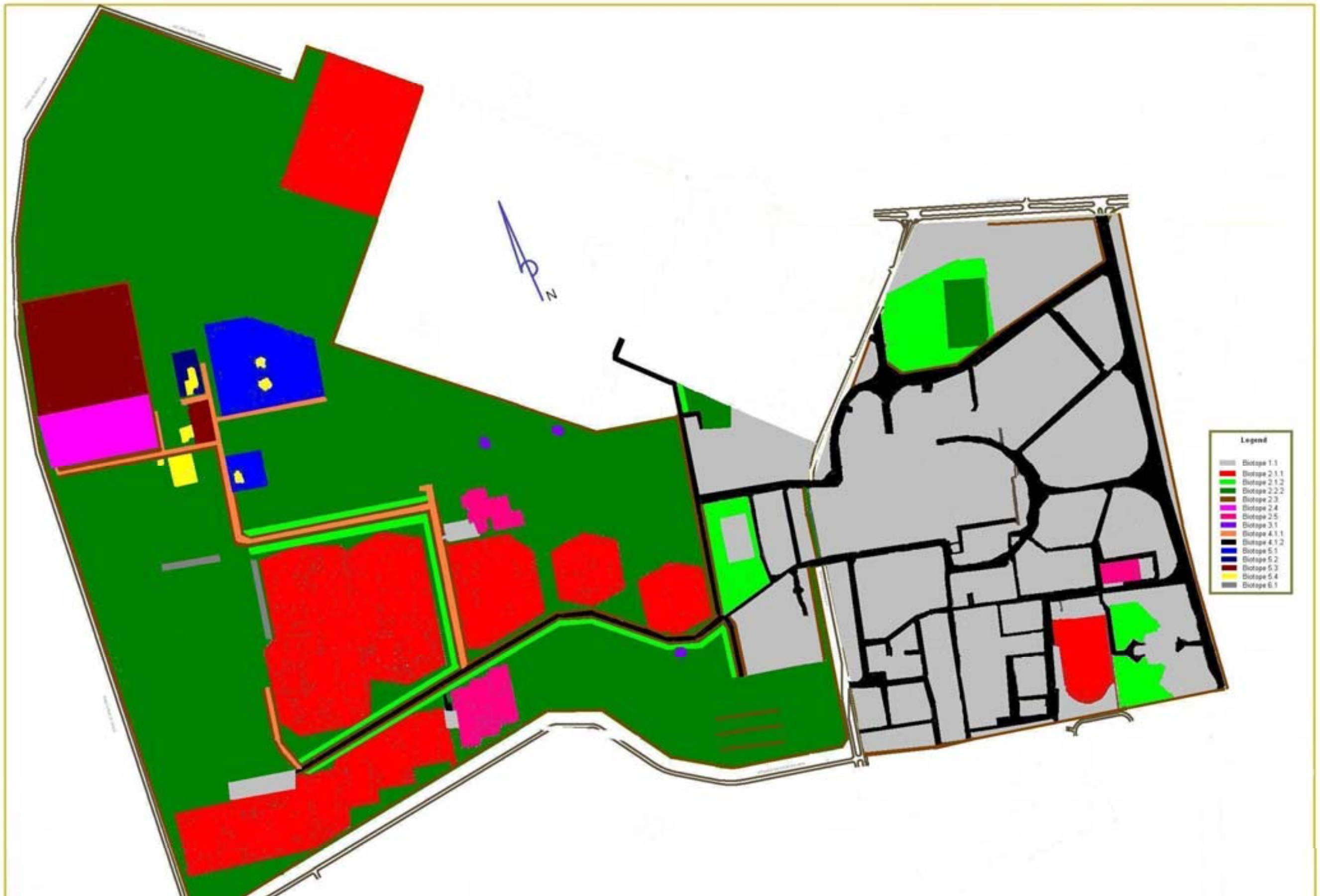


Figure 6.1: Computer Aided Drawing of biotopes identified on UFS campus in Bloemfontein

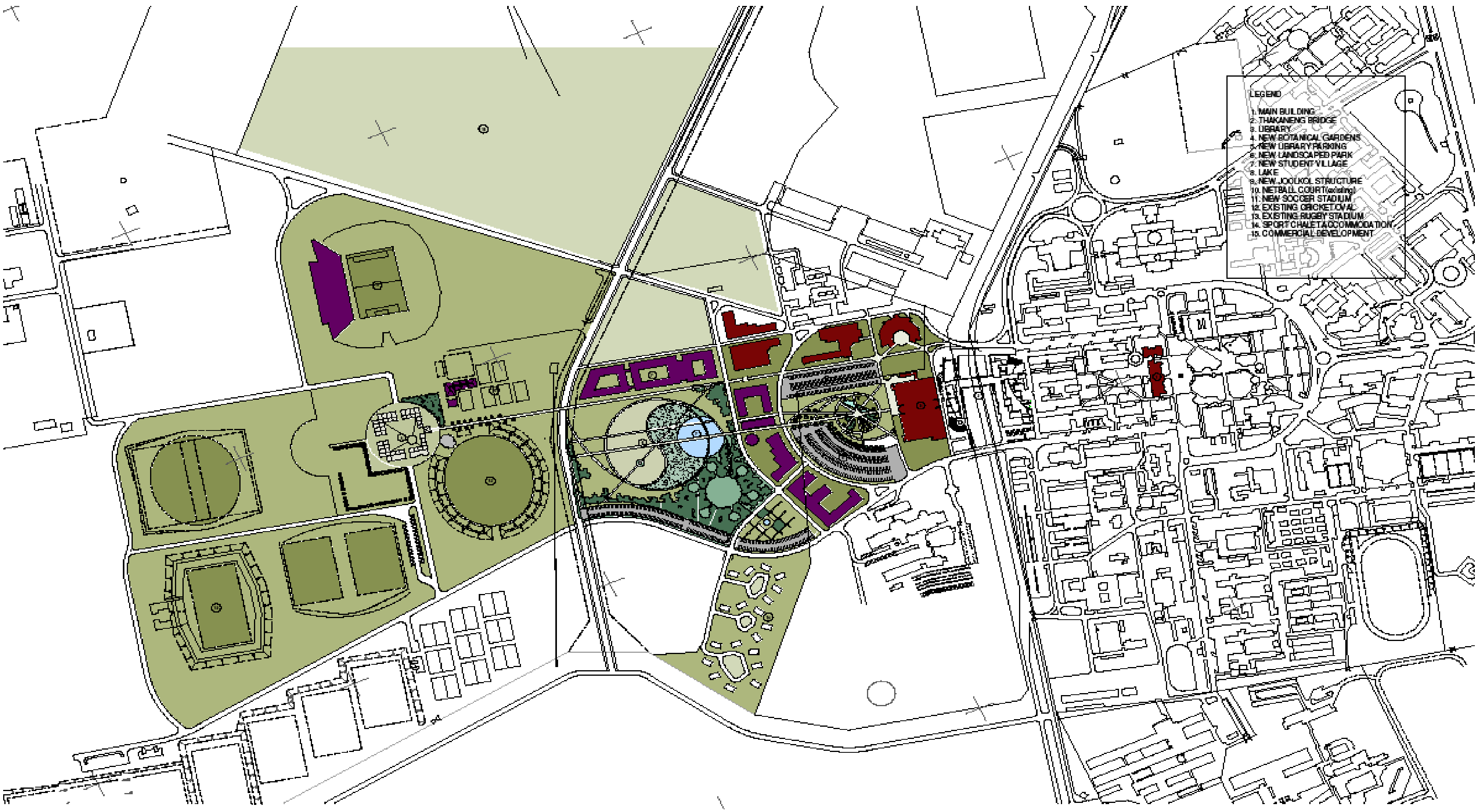
It is clear from Figure 6.1 that the biotopes covering the larger parts of the campus are the:

- built-up area mainly on the eastern side of the campus (shaded light grey) with its many lawns, ornamental gardens and planted trees between buildings and along tar roads,
- the extensively managed open spaces mainly in the middle and to the west (shaded light and dark green) and the
- frequently mowed and irrigated sports fields mainly in the west of the campus (shaded orange).

It is clear that the less managed open spaces at present still occupy a significant portion of the western part of the campus although some of these plant communities have been significantly disturbed by human activities as explained in Chapter 5 and exemplified in Figure 6.2 below.

Figure 6.2: Open area between the UFS Dutch Reformed Church and the Agriculture building. The *Cynodon hirsutus-Jamesbrittenia atropurpurea* Community in this area has recently being cleared in order to build a tarred parking area.

Figure 6.3 below shows the recently compiled development masterplan for the western parts of the campus.



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This plan indicates that large parts of the natural vegetation present in 2007 are going to be give way to development in future.

After construction of the proposed library parking area (5), student village (7) and sport chalet accommodation (14) the vegetation that will remain immediately adjacent to these facilities will very likely be turned into lawns and ornamental gardens together with the proposed landscaped park (6) as is presently the case in the eastern parts of the campus. The new soccer stadium (11) is likely to be managed like the already existing sports fields which differ from lawns mainly in that lawns are not used for active recreation.

These lawns, sports fields and ornamental gardens are characterized by plant communities that are maintained artificially (e.g. frequent mowing, weeding and irrigation with large amounts of water) so they were not studied in detail. Poynton and Roberts (1985) point out that such artificially maintained open spaces are of high amenity value but have very little biogeographical value as they no longer have the natural habitat settings that would help indigenous species use them as connecting corridors for dispersal between habitat islands. This is very undesirable because urbanization and other human activities have already caused destruction to large parts of the Grassland Biome as was explained in Chapter 1.

The amounts of water (which has to be paid for) used to nurture these lawns and sports fields also raises questions relating to social and environmental justice in light of the fact that South Africa is a water short country of rainfall that is only slightly above half of the world’s average and many of its citizens do not have access to a water supply of adequate quantity and quality (Department of Water Affairs and Forestry, 1997).

Also the future of the wetland located near the FARMOVS Complex is uncertain as the proposed sport chalet accommodation (14) is situated in its vicinity. If this wetland is destroyed to make way for the facility the various bird species living there will lose their nesting and roosting area. If the facility is built too close to it the birds may be scared away by the perpetual presence of humans nearby.

CHAPTER 7
CONCLUSIONS

The aims of this study were to:

(i) Survey, classify, describe, and ecologically interpret the various indigenous plant communities of the UFS campus in Bloemfontein;

(ii) Apply the biotope mapping technique to the campus.

The systematic sampling technique of vegetation survey used in this study proved to be effective. For classification of the phytosociological data the following software packages were used:

- TURBOVEG (Hennekens, 1996a) which is a database for entering phytosociological data into the computer, processing it so that similar data sets are grouped together to form a larger data set and then presenting it.

- TWINSPAN (Hill, 1979a) which is a numerical classification program for sorting and refining the data set to yield smaller groups based on floristic composition.

- MEGATAB (Hennekens, 1996a) which is a visual editor for phytosociological tables was then used to further sort the vegetation and this yielded 7 major communities, 11 communities and 9 sub-communities.

The vegetation units were described based on the presence and abundance of the species that make them up, and the environmental conditions observed where the vegetation units are located were refered to. Furthermore the DECORANA ordination algorithm (Hill, 1979b) was used to correlate the vegetation units with certain environmental variables. The DECORANA ordination corresponds very well with the phytosociological classification. The environmental variables that were found to play an important role in determining plant community distribution in space were anthropogenic disturbance, moisture availability as well as soil depth and texture.

Of the 7 major communities identified in the study area, 5 came from the grassland. Some of them were found to be similar to some that were described during previous vegetation studies in the Bloemfontein area for example Dingaan, *et al*. (2001). The other 2 major communities were wetland communities from the campus's earth walled dams and they also were similar to some of the plant communities described during previous vegetation studies of the Bloemfontein area, for example in Dingaan, *et al*. (in press).

In addition to the vegetation survey, classification and description, biotope mapping was also successfully conducted on the Bloemfontein campus of the UFS. The biotope map shows that the eastern parts of the campus are built up to a large extent and that most of the vegetation there is far from natural as it is maintained by humans nurturing it at high cost. In the western parts of the campus the biotope map shows that extensively managed plant communities occupy a significantly larger area than in the east. These communities are considered more natural as anthropogenic factors play a much smaller role in their existence. However the proposed developments for the western part of the campus present the threat of significant synanthroposation for these plant communities in future.

The biotope map of the UFS campus in Bloemfontein provides important information about vegetation unts in a manner that decision makers at the campus should find easy to relate to and use. In order for ecologically sound land use management to be achieved in future the following recommendations are made:

(i) Before proposal 5, 7 and 14 are implemented all protected plants (e.g. *Schizocarphus nervosus* and *Brunsvigia radulosa*) occurring on the campus should be transplanted to where they will be safe as these developments will require prior clearing away of vegetation. The same applies to development proposal 15 but it will not be dealt with here as it is situated outside the campus fence where the UFS administration has no authority. The sports chalet accommodation that is to be built in the vicinity of the earth-walled dam near the FARMOVS Complex should be located at least 50m from the earth-walled dam to avoid scaring away the birds that live there.

(ii) Vegetation dynamics studies on the campus should be conducted to determine the extent to which the intensity of management of the ornamental gardens, lawns and sports fields should be reduced so that they acquire a level of naturalness that is satisfactory from a biogeographical point of view. These studies should incorporate sociological investigations to establish the extent to which the intensity of management may be reduced without causing people to start feeling that these open spaces are no longer satisfying amenity needs.

The results of such studies can then be used to manage the campus' open spaces in a manner that meets biogeographical needs as well as amenity needs and saves precious water.

(iii) Urban biotope mapping based on phytosociological studies followed by vegetation dynamics studies that incorporate sociological aspects should be conducted for the whole Bloemfontein municipal area and other increasingly urbanizing municipal areas in the Grassland Biome. The results of such studies can then be used to achieve urbanization that is ecologically sound and that simultaneously meets amenity needs in the Grassland Biome.

CHAPTER 8

SPECIES LIST

The following list is made up of the plant species recorded and collected on the UFS main campus in Bloemfontein during this study. This list has 45 families, 130 genera and 173 species. Exotic species are marked with an asterix (*). The dicotyledonous families encountered on the campus outnumbered the monocotyledonous ones; however the monocotyledonous Poaceae had the most genera, followed by the dicotyledonous Asteraceae. The dicotyledonous families have been listed before the mocotyledonous ones.

Table 7.1: A synopsis of families with more than 3 genera.

	Family	Genus	Species
Dicotyledons	**Asteraceae**	21	29
	Brassicaceae	3	4
	Convolvulaceae	4	5
	Fabaceae	9	11
	Malvaceae	4	4
	Polygonaceae	3	4
	Solanaceae	4	6
Monocotyledons	**Cyperaceae**	3	4
	Hyacinthaceae	6	6
	Poaceae	22	34

Table 7.2: A synopsis of genera with more than three species

	Family	Genera	Species
Dicotyledons	**Asteraceae**	Senecio	4
	Verbenaceae	Verbena	3
Monocotyledons	**Asparagaceae**	Asparagus	3
	Poaceae	Eragrostis	5

DICOTYLEDONS

ACANTHACEAE

Barleria L.

B. macrostegia Nees

Blepharis Juss.

B. integrifolia (L.f.) E.Mey. ex Shinz var. integrifolia

Crabbea Harv.
C. acaulis N.E.Br.

AMARANTHACEAE
***Alternantera** Forssk.
*A. nodiflora R.Br.
*A. pungens Kunth
*****
Gomphrena L.
*G. celosioides Mart.

ANACARDIACEAE
Rhus L.
R. ciliata Licht. ex Schult.
R. lancea L.f.

APOCYNACEAE
***Araujia** Brot.
*A. sericifera Brot.

Raphionacme Harv.
R. dyeri Retief and Venter
R. hirsuta (E.Mey.) R.A.Dyer ex E.Phillips

***Nerium** L.
*N. oleander L.

ASTERACEAE
Arctotis L.
A. venusta Norl.

Amphiglossa DC.
A. triflora DC.

Berkheya Ehrh.
B. onopordifolia (DC.) O.Hoffm. ex Burtt Davy var. onopordifolia
B. pinnatifida (Thunb.) Thell. subsp. pinnatifida

Bidens L.
*B. pilosa L.
*B. bipinnata L.

Conyza Less.
*C. bonariensis (L.) Cronquist
C. podocephala DC.

Felicia Cass.
F. muricata (Thunb.) Nees subsp. muricata

Gazania Gaertn.
G. krebsiana Less. subsp. Serulata (DC.) Roessler

Geigeria Griess.
G. filifolia Mattf.

Hertia Less.
H. pallens (DC.) Kuntze

Helichrysum Mill.
H. zeyheri Less.

Lactuca L.
L. inermis Forssk.

Nidorella Cass.
N. hottentotica DC.

Osteospermum L.
O. muricatum E. Mey ex DC. subsp muricatum.

Pentzia Thunb.
P. globosa Less.
P. incana (Thunb.) Kuntze

Pseudognaphalium Kirp.
P. oligandrum (DC.) Hilliard & B.L.Burtt

***Schkuhria** Roth
*S. pinnata (Lam.) Cabrera

Senecio L.
S. burchellii DC.
S. hastatus L.
S. ruwenzoriensis S. Moore
S. speciosus Willd.

Sonchus L.
*S. oleraceus L.
S. nanus Sond. ex Harv.

***Tagetes** L.
*T. minuta L.

***Taraxacum** F.H.Wigg.
*T. officinale Weber

Tripteris Less.
T. aghillana DC. var. aghillana

BRASSICACEAE
***Capsella** Medik.
*C. bursa-pastoris (L.) Medik.

Lepidium L.
L. africanum (Burm.f.) DC. subsp. africanum
L. capense Thunb.

Sisymbrium L.
S. thelungii O.E.Schulz

BUDDLEJACEAE
Buddleja L.
B. saligna Willd.

CELTIDACEAE
Celtis L.
*C. sinensis R.Br.

CAMPANULACEAE
Wahlenbergia Schrad. ex Roth
W. undulata (L.f.) A.DC.

CARYOPHYLLACEAE
***Stellaria** L.
*S. media (L.) Vill.

CHENOPODIACEAE
Atriplex L.
A. semibaccata R.Br. var. typica Aellen

Chenopodium L.
*C. album L.

Salsola L.
*S. kali L.

CONVOLVULACEAE
Convolvulus L.
*C. arvensis L.

Cuscuta L.
*C. campestris Yunck.

Dichondra J.R.Forst. & G.Forst.
D. micrantha Urb.

Ipomoea L.
I. oblongata E.Mey. ex Choisy
I. oenotheroides (L.f.) Raf. ex Hallier f.

CRASSULACEAE
Crassula L.
C. lanceolata (Eckl. & Zeyh.) Endl. ex Walp. subsp. tranvaalensis (Kunze) Tölken
C. nudicaulis L. var. nudicaulis

DIPSACACEAE
Scabiosa L.
S. columbaria L.

EUPHORBIACEAE
Chamaesyce Gray
C. inaequilatera (Sond.) Soják
C. species

FABACEAE
Acacia Mill.
A. karroo Hayne
*A. melanoxylon R.Br.

Elephantorrizha Benth.
E. elephantina (Burch.) Skeels

Indigofera L.
I. alternans DC. var alternans

Lotononis (DC.) Eckl. & Zeyh.
L. listii Polhill

***Medicago** L.
*****M. laciniata (L.) Mill. var. laciniata
*M. polymorpha L.

***Melilotus** Mill.
*****M. alba Desr.

Melolobium Eckl. & Zeyh.
M. candicans (E.Mey.) Eckl. & Zeyh.

Rhynchosia Lour.
R. totta (Thunb.) DC. var. totta

Trifolium L.
T. africanum Ser. var. africanum

GERANIACAE
Monsonia L.
M. angustifolia E.Mey. ex A.Rich.

Pelargonium L'Hér.
P. aridum R.A Dyer

LAMIACEAE
Salvia L.
S. verbenaca L.

MALVACEAE
Hibiscus L.
H. pussilus Thunb.

***Malva** L.
*M. parviflora L. var. parviflora

Pavonia Cav.
P. burchellii (DC.) R.A.Dyer

***Sphaeralcea** A.St.-Hil.
*S. bonariesis (Cav.) Griseb.

MESEMBRYANTHEMACEAE
Chasmatophyllum Dinter & Schwantes
C. musculinum (Haw.) Dinter & Schwantes

Delosperma N.E.Br. emend.
D. cooperi (Hook. f.) L.Bolus

Ruschia Schwanthes
R. hamata (L.bolus) Schwantes

MOLLUGINACEAE
Limeum L.
L. aethiopicum Burm. subsp. aethiopicum var. aethopicum

NYCTAGINACEAE
Boerhavia L.
*B. erecta L.

OLEACEAE
Olea L.
O. europaea L. subsp. africana (Mill.) P.S. Green

Menodora Humb. & Bonpl.
M. africana Hook.

ONAGRACEAE
***Oenothera** L.
*O. rosea L'Hér. ex Aiton
*O. stricta Ledeb. ex Link subsp. stricta

OXALIDACEAE
Oxalis L.
*O. corniculata L.
O. depressa Eckl. & Zeyh.

PAPAVERACEAE
***Argemone L.**
*A. ochroleuca Sweet subsp. Ochroleuca

PLANTAGINACEAE
Plantago L.
P. lanceolata L.

POLYGONACEAE
Persicaria (L.) Mill.
P. decipiens (R.Br.) Wilson
*P. lapathifolia (L.) Gray

Emex Campd.
E. australis Steinh.

Rumex L.
*R. crispus L.

PORTULACACEAE
Talinum Adans.
T. caffrum (Thunb.) Eckl. & Zeyh.

RUBIACEAE
Kohautia Cham. & Schltdl.
K. amatymbica Eckl. and Zeyh.

Nenax Gaertn.
N. microphylla (Sond.) Salter

SCHROPHULARIACEAE
Aptosimum Burch. ex Benth.
A. indivisum Burch. ex Benth.

Jamesbrittenia Kuntze
J. atropurpurea (Benth.) Hilliard subsp. atropurpurea

Selago L.
S. densiflora Rolfe

SOLANACEAE
***Cestrum** L.
*C. laevigatum Schltdl.

***Datura** L.

*D. stramonium L.

Lycium L.

L. horridum Thunb.
L. pilifolium C.H. Wright

Solanum L.

S. retroflexum Dunal
S. supinum Dunal var. supinum

STERCULIACEAE
Hermannia L.

H. coccocarpa (Eckl. & Zeyh.) Kuntze
H. comosa Burch. ex DC.

TAMARICACEAE
Tamarix L.

*T. ramosissima Ledeb.

VAHLIACEAE
Vahlia Thunb.

V. capensis (L.f.) Thunb. subsp. Capensis

VERBENACEAE
Verbena L.

*V. aristigera S.Moore
*V. bonariensis L.
*V. brasiliensis Vell.

ZYGOPHYLLACEAE
Tribulus L.

T. terrestris L.

MONOCOTYLEDONS

AMARYLLIDACEAE
Brunsvigia Heist

B. radulosa Herb.

ASPARAGACEAE
Asparagus L.

A. africanus Lam.
A. cooperi Baker
A. laricinus Burch.

ASPHODELACEAE
Aloe L.
A. grandidendata Salm-Dyck

Bulbine Wolf
B. abissinica A.Rich.
B. frutescens (L.) Wiild.

COMMELINACEAE
Commelina L.
C. africana

CYPERACEAE
Cyperus L.
C. rupestris Kunth var. rupestris
C. sexangularis Nees

Ficinia Schrad.
Ficinia nodosa (Rottb.) Goetgh., Muasya & D.A. Simpson

Scirpoides Ség.
S. dioecus (Kunth) Browning

ERIOSPERMACEAE
Eriospermum Jacq. ex Willd.
E. cooperi Baker var. cooperi

HYACINTHACEAE
Dipcadi Medik.
D. ciliare (Zeyh. ex Harv.) Baker

Drimia Jacq.
D. elata Jacq.

Eucomis L'Hér.
E. autumnalis (Mill.) Chitt. subsp. clavata (Baker) Reyneke

Ledebouria Roth
L. luteola Jessop

Massonia Thunb. ex Houtt.
M. jasminiflora Burch. ex Baker

Schizocarphus Van der Merwe.
S. nervosus (Burch.) Van der Merwe

HYPOXIDACEAE
Hypoxis L.
H. rigidula Baker var.rigidula

IRIDACEAE
Moraea Mill.
H. pallida (Baker) Goldblatt

POACEAE
Aristida L.
A. adscensionis L.

A. congesta Roem. & Schult. subsp. congesta

***Arundo** L.
***A. donax L.

Brachiaria (Trin.) Griseb.
B. eruciformis (Sm.) Griseb.

Bromus L.
*B. carthaticus Vahl

Chloris Sw.
C. virgata Sw.

Cynodon Rich.
C. dactylon (L.) Pers.
C. hirsutus Stent

Digitaria Haller
D. argyrograpta (Nees) Stapf
D. eriantha Steud.

Eleusine Gaertn.
E. coracana (L.) Gaertn. subsp. africana (Kenn.-O'Byrne) Hilu & de Wet

Elionurus Kunth ex Willd.
E. muticus (Spreng.) Kuntze

Enneapogon Desv. ex P.Beauv.
E. cenchroides (Roem. & Schult.) C.E.Hubb.
E. scoparius Stapf

Eragrostis Wolf
E. biflora Hack. ex Schinz
E. chloromelas Steud.
E. echinochloidea Stapf
E. obtusa Munro ex Ficalho & Hiern
E. superba Peyr.

Melinis P.Beauv.
M. nerviglumis (Franch.) Zizka

Panicum L.
P. coloratum L. var. coloratum
P. stapfianum Fourc.

Paspalum L.
P. distichum L.

Pennisetum Rich.
*****P. clandestinum Hochst. ex Chiov.

Phragmites Adans.
P. australis (Cav.) Steud.

Setaria P.Beauv.
S. pumila (Poir.) Roem. & Schult.
S. sphacelata (Schumach.) Moss var. torta (Stapf) Clayton

Themeda Forssk.
T. triandra Forssk.

Tragus Haller
T. koelerioides Asch.
T. racemosus (L.) All.

Trichoneura Andersson
T. grandiglumis (Nees) Ekman

Triraphis R.Br.
T. andropogonoides (Steud.) E.Phillips

Urochloa P.Beauv.
U. mosambicensis (Hack.) Dandy
U. panicoides P.Beauv.

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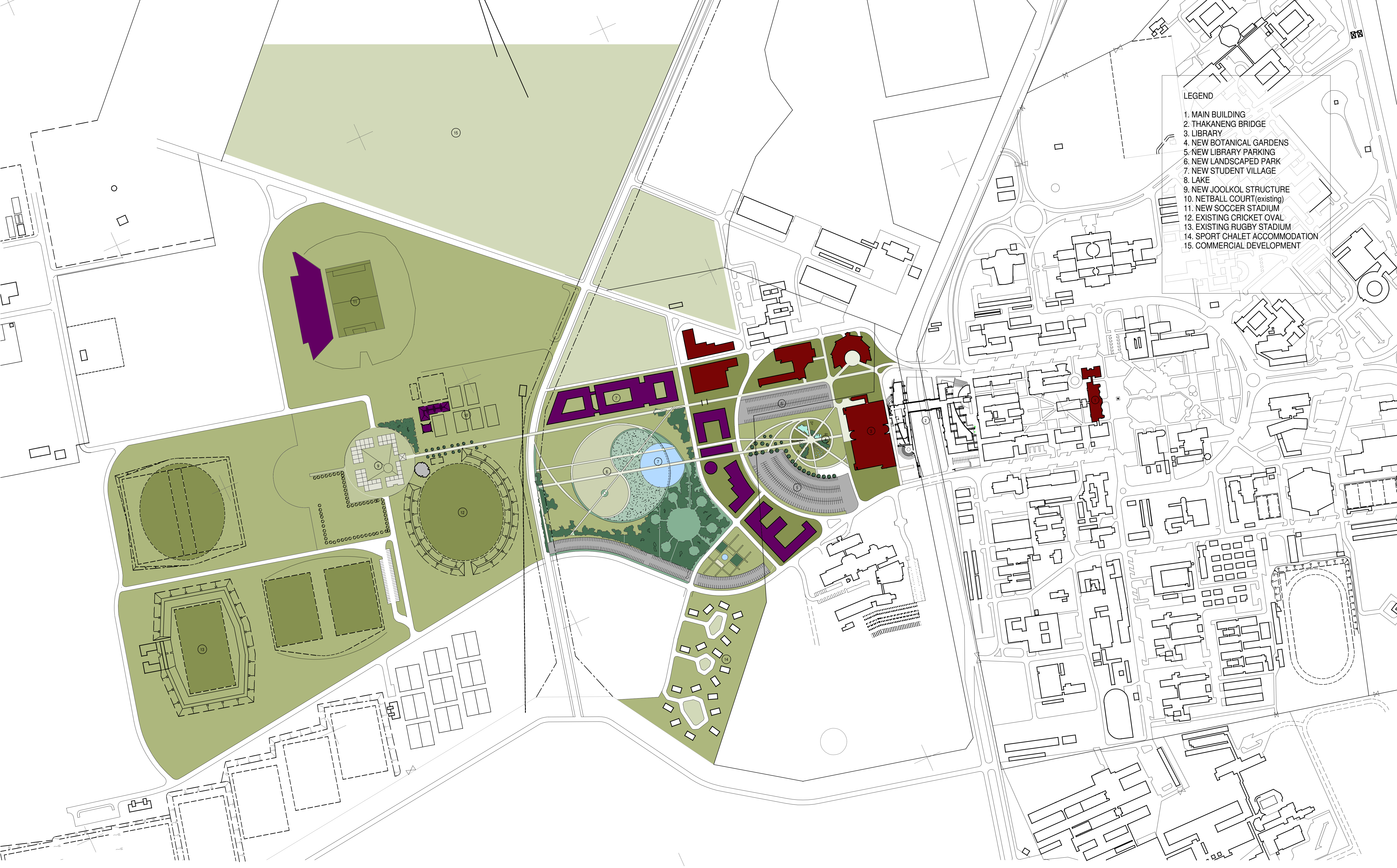

UNIVERSITY OF THE FREE STATE: DEVELOPMENT PROPOSALS FOR THE WEST CAMPUS

DIE ROODT PARTNERSHIP
ARCHITECTS AND TOWNPLANNERS

TABLE 5.1: Phytosociological table of the natural vegetation of the campus of the University of the Free State.

Sub community nr.	1.1.1	1.1.2	1.1.3	1.2.1	1.2.2	1.2.3	1.3	2.1.1	2.1.2	2.1.3	2.2	2.3	3	4.1	4.2	5	6	7.1	7.2	7.3
Major community nr.	1							2					3	4		5	6	7		
Community nr.	1.1			1.2			1.3	2.1			2.2	2.3		4.1	4.2			7.1	7.2	7.3
Relevé number	1111111111111111	111 11111	111 111111	1 1		1	11 11	1111111	11	11111	2222 2	122212		1 11		222222222	22	22	222	22222
	3483422456685885	534925100	233990025063	9097888	5667334444455	7737885666566177378	42541	8777899	34411	98641262	20112223	23910190	11122	1 11		444444555	33	33	333	34444
	9927779824737409	382400007	824788934483	0397539	3898890347824	0739087023047323447	34848	7089802	72949	33307204	92790800	72400487	78923	947703	234	456789012	23	45	678	90123
Database number	4444444444444444	444444444	444444444444	4444444	4444444444444	4444444444444444444	44444	4444444	44444	44444444	44444444	44444444	44444	444444	444	444444444	44	44	444	44444
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	4444444444444444	444344444	444444444444	3444333	3333333333333	3333333333333433333	44344	4444444	33344	33444443	35555335	33455555	33333	333333	333	555555555	55	55	555	55555
	4584533556786886	544925101	333001125073	9008889	5778444445555	7838896666567177379	42642	9788999	44512	98642262	30222333	33910101	22222	111111	000	445555555	33	33	444	44444
	3361113268171843	726844441	268122378827	4731863	7232234781268	4173421467481767881	78282	1423246	16383	77741648	36134244	16844831	12367	381247	678	890123456	67	89	012	34567
Number of species per relevé	1111111111851119	111111814	161718119111	8917119	1799685916171	1166161469517498711	89111	9198179	11111	18948185	81191151	45777914	73677	366568	864	223332323	11	57	455	43424
	5336403103 236	070010 4	5 2 4 48 243	2 11	0 2 1 1	13 0 1 3 22	101	5 2	10633	9 0	10 13 1	0					11			
Species group A:																				
Nenax microphylla	1bb111a++11+441+	....	....	....	....	....	.....	....	.b...	....	....	....	.....	......	...	....	..	..	...	.....
Aristida diffusa	b..4..a.3a.3..3.	+........	..........+.	....	....	....	r....	...a...	.....	....	....	....	.....	......	...	....	..	..	...	.....
Schkuhria pinnata	1..r.....r..r.rr	.r..r....	....	....	....	r.............r....	.....	....	+....	r.......	....	....	.....	......	...	....	..	..	...	.....
Species group B:																				
Oenothera stricta	...+.....33.1.3b	....+.b..	.....+1.a.a.	...b...	....	....	.....	....	.....	....	....	....	.....	..rr..	...	....	..	..	...	.....
Triraphis andropogonoides	a..+..1.........	..a5.....	a.1.4......+	....	....	..............a....	.....	.+1....	..r.r	....+...	..a..+..	....	.....	......	...	....	..	..	...	.....
Helichrysum zeyheri	..a.......4.....	.1..1+...	........r..a	....	....	....	.1.r.	....	.....	....	.......r	....	.....	......	...	....	..	..	...	.....
Hypoxis hemerocallidea	+1..r.r...r+..r1	.+...1...	r+......+..+	....	....	...........1.......	.....	....	.....	....	....	....	.....	......	...	....	..	..	...	.....
Species group C:																				
Eragrostis lehmanniana	......r..r...1..	....	+b33353b+5ab	3a44313	....	....	.....	...a...	.....	....	..+.....	....	.....	......	...	....	..	..	...	.....
Species group D:																				
Cyperus rupestris	...+..a5........	.a....r4.	.3....r4.r..	.+3.1..	4bbr554411331	1	.3.b.	....	.....	....	....	....	.....	.....a	...	....	..	..	...	.....
Species group E:																				
Cynodon dactylon	....	......r.r	......r.....	45.5145	5453544551134	15.435b5r4.5345b.54	.....	....	1....	....	..1.....	....	.....	......	...	....	..	..	...	.....
Dipcadi ciliare	r..............+	r........	....1..+..1.	...+...	.r1..+...1r.+	r.5.11+..r4r....ar+	.....	....	.1...	....	....	....	.5...	.5...4	...	....	..	..	...	.....
Species group F:																				
Themeda triandra	ba5b45.445555355	5.355.5.5	5.3a3ba5555+	.35551.	35b4bb3155554	r5.5.55553....45r55	.54+5	....	.....	....	....	....	.....	......	...	....	..	..	...	.....
Panicum coloratum	55155b55..+.3a4.	a5b5b555.	b5455455a5r5	4535554	5555555.55355	55555555.5555a.5553	a.55.	....	r....	.+......	...r....	....	.....	......	...	....	..	..	...	.....
Indigofera alternans	.b3bb3a.3+1.434.	aa.+1.11.	..b..+..3bb3	..r.1..	..43r..+a1r.+	.3r.1.a.11.+3.bb.a.	.3..r	+......	.....	....	....	....	.....	......	...	....	..	..	...	.....
Tripteris aghillana	....r...+..a....	1..r.....	+......+.+..	....	r.1..........	...1..+....1......1	..a..	....	..+..	....	.1ra.r..	....	.....	......	...	....	..	..	...	.....
Hibiscus pusillus	..a...........1.	.......r.	r.......+r..	...1r..	4......1+.1.r	...r+.+....a1......	....+	....	.....	....	....	....	.....	......	...	....	..	..	...	.....
Berkheya onopordifolia	..........+....+	r........	......+r..+.	......+	+.........r..	..........r....r.+3	..1..	....	+....	....	....	....	.....	......	...	....	..	..	...	.....
Commelina africana	...r............	.1.....+.	r.r.+..1....	+.1...+	....1........	...........b1..+...	.r...	....	.....	...1....	....	....	.....	......	...	....	..	..	...	.....
Talinum caffrum	..1a.....r......	.1.....1.	....b.b.....	r.a....	......3...1ar	.r.........a+....1.	1.+..	....	.....	....	....	....	.....	......	a..	....	..	..	...	.....
Oxalis corniculata	.3..3...b.....1.	..43..a..	1.a.3.3a.11a	..4...a	.r........+..	........31.b.....1.	1	....	.....	....	.r......	....	.....	......	...	....	..	..	...	.....
Selago densiflora	1b.11..+a...+...	.+5..1...	....	....	........a...1	1..................	+3.b.	....	.....	....	....	....	..+..	.a....	...	....	..	..	...	.....
Monsonia angustifolia	..r...+........r	r+.....+.	....r.r1r.++	+.1..r.	r..+.........	.r.+r.....a13.1r.1r	.r..+	....	.....	...1....	....	....	.....	......	...	....	..	..	...	.....
Species group G:																				
Eleusine coracana	....	........b	..+.....+...	.1.....	....	..1................	..r..	ba.++1r	.....	.1......	....	....	.....	......	...	....	..	..	...	.....
Species group H:																				
Brachiaria eruciformis	....	....a....	....	....	....	....	.....	.r....r	b1++r	....	....+...	....	.....	r+1+r3	...	....	..	..	...	.....
Species group I:																				
Acacia melanoxylon	...r.r..........	....	....	......r	....	....	.....	555555a	13555	155r555r	....+...	.......+	.....	.....+	...	....	..	..	...	.....
Trichoneura grandiglumis	....	....	........+...	....	....	....	.....	4113...	..r3b	a+...b..	.......r	...5....	.....	......	...	....	..	..	...	.....
Raphionacme hirsuta	....+.........r.	r........	....	....	....	....	.....	+r1..1.	..rr+	.r...+r.	....	....+...	.....	......	...	....	..	..	...	.....
Geigeria filifolia	..r.+......+r...	...rr..1.	r..........+	....	.........rr..	.r.+...............	..+..	.b..3..	.....	.b...3..	....	.......r	.....	......	...	....	..	..	...	.....
Lycium pilifolium	....	....	....	....4.a	..4..........	..4...............+	.....	..1.+..	..+.+	....r...	...r+...	....	.....	......	...	....	..	..	...	.....
Species group J:																				
Cynodon hirsutus	....	....	....	....	....	................a..	.....	....	.....	....	b3...+b3	....	..1..	......	...	....	..	..	...	.....
Species group K:																				
Jamesbrittenia atropurperea	....	....	....	....	....	..r................	.....	bb35a1b	55453	b++55.5.	5b555355	b5a53454	.....	......	...	....	..	..	...	.....
Schizocarphus nervosus	....	....	.......+..r.	..a....	....	..+.........r......	.....	+..b...	a.1r+	.+...1+b	51...1b+	.4.+1...	...+r	......	...	....	..	..	...	.....
Crabbea acaulis	...........+b1..	....	1.........+.	....	....	...........+.......	.....	.r..4.+	+535b	r1...1.4	.+.+3...	...1.+.+	...++	......	...	....	..	..	...	.....
Arctotis venusta	....r...........	....	....	....	....	......r............	.....	....+r.	...++	+.......	a.......	......1.	+....	......	...	....	..	..	...	.....
Ruschia hamata	....	....	....	....	....	......r............	.....	....	1	....+...	..+1....	+....+..	...+.	......	r..	....	..	..	...	.....
Nidorella hottentotica	....	....	....	....	......r.a....	....	.....	....	5+1..	.+......	..443..1	5....5.5	.....	......	...	....	..	..	...	.....
Solanum supinum	....	.r.......	....	....	....	....	.....	.bb...1	....+	4.....4.	....+5.5	.1...1..	.....	......	...	....	..	..	...	.....
Setaria pumila	....	....	....	1.....+	....	...........b......1	.....	....	1....	....r...	....b...	....	.....	......	...	....	..	..	...	.....
Species group L:																				
Digitaria eriantha	1..br15.+1.3b41.	+5a4+154b	b455455515b5	....	....	....	.....	514335b	...1.	4.......	.1....5.	.1..11..	.....	......	...	....	..	..	...	.....
Aristida congesta	4414.r3b5.....r.	.3b.33.4.	1.4....+...4	....	...+....4.a.4	................b..	5..4b	....	1ab.1	.....5..	a....4.1	1.+.....	.....	....1.	44.	....	..	..	...	.....
Felicia muricata	..1+......r.31.a	.....+...	...+r..+....	....1.+	..1....a3...1	..5.4.+.1.......4.3	.+r.1	..1....	.+...	r...+...	433133a.	.3......	+....	......	...	....	..	..	...	.....
Tragus koelerioides	4a3...a11.....r.	.....b.a.	r.+....a.+..	....	.........b...	.1.........1..1....	...11	.r.....	...r.	+....a..	.+......	......1+	.....	......	...	....	..	..	...	.....
Eriospermum cooperi	+..+...r.r....r.	.+r1...r.	+.......r..r	..+....	....	..........r.r..r..r	1....	+bb4aaa	..+1b	1r4..a..	..4.b..1	....	.....	......	..r	....	..	..	...	.....
Ipomoea oenotherae	..............4.	.+.......	....	...r...	....	....	.....	....	...r.	r.+...3.	..1.....	...+.1a.	.....	......	...	....	..	..	...	.....
Senecio burchellii	.1.....1.....+..	.+.......	....	.1..r..	....	....	.....	....	...r.	1.+...+.	..+.....	...+.11.	.....	......	...	....	..	..	...	.....
Lycium hirsutum	.......+........	....	.a..1.......	..1....	...b.........	....	...ar	....	.....	....	....5...	....	.....	....1.	...	....	..	..	...	.....
Elephantorrhiza elephantina	4a..............	..a..b...	....	....	....	....	1..4.	....	.....	....	....	....	.....	......	...	....	..	..	...	.....
Species group M:																				
Conyza podocephala	.+.......1...+.b	.......r.	...++.1.....	......r	r............	+.....r............	...1.	....	.....	5	....	....	54355	......	...	....	..	..	...	.....
Chloris virgata	....	....	....	.1....r	.1...........	1..................	...1.	....	.....	....	.....a..	....	33.+3	......	...	....	..	..	...	.....
Species group N:																				
Eragrostis superba	a3.35r4b1.......	.3bbba.3.	..4....3.+.5	3r....1	a....1.ba.31.	....31.++3.bb.1a..b	+31b5	....3.r	.rra.	b.b31..b	b3555..b	..3.5+33	r..15	......	...	....	..	..	...	.....
Salvia verbenaca	....	....	...r........	.....1.	....	r...1.............r	.....	....	.....	+.......	...a.+.a	..a.1+..	13..r	......	...	....	..	..	...	.....
Sutera caerulea	..+.............	....	......r.....	....	....	..................r	.....	....	+....	...1....	+....a..	+.......	r....	......	.+.	....	..	..	...	.....
Species group O:																				
Chenopodium album	....	....	....+.......	....	....	....	.....	....	b....	+.......	....	....	...+.	a4.aaa	+1r	....	11	..	.b4	.....
Salsola kali	....	....	....	....	....	................a..	..a..	....	.a...	....	....	....	.....	...+r.	++.	....	..	..	...	.....
Species group P:																				
Urochloa panicoides	....+...........	....	....	....	..a..........	....	.....	....	.....	....	...1+...	....	.....	.a1..a	...	....	..	..	...	.....
Rumex crispus	....	....	....	....	....	4..................	.....	....	.....	....	....	....	.....	+.3..a	...	....	..	..	...	.....
Species group Q:																				
Gomphrenia celosioides	....	....	....	....r..	....	....	.....	....	.....	....	....	.3......	.....	..r...	aba	....	..	..	...	.....
Plantago lanceolata	....	....	..........r.	....	....	................a..	.....	....	.....	....	....	....	.....	..r.r.	+a+	....	1.	..	...	.....
Species group R:																				
Chamaesyce inaequilatera	....	....	....	....	....a........	....	.....	....	.r...	....	....	....	..1r+	.a.+.a	+..	....	..	..	...	.....
Species group S:																				
Chasmatophyllum musculinum	....	....	....	....	....	.r.................	.....	.+.....	.....	....	....	....	.....	......	...	++1bb+13b	..	..	...	.....
Oropetium capense	....	....	....	....	....	.r.................	.....	.+.....	.....	....	....	....	.....	......	...	.1rbr.1.+	..	..	...	.....
Eragrostis nindensis	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	1.+r+1+1+	..	..	...	.....
Species group T:																				
Ciclospermum leptophyllum	....	....	......r.....	....	....	....	.....	...1...	.....	....	....	....	.....	......	...	....	ab	..	...	.....
Bromus carthaticus	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	b+	..	...	.....
Oenothera rosea	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	1+	..	...	.....
Lepidium capence	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	+1	..	...	.....
Sonchus oleraceus	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	++	..	...	.....
Emex australis	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	1.	..	...	.....
Stellaria media	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	3.	..	...	.....
Species group U:																				
Phragmites australis	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	55	55	...	.....
Cyperus sexangularis	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	.3	r3	...	.....
Oxalis depressa	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	r5	.b	...	.....
Species group V:																				
Ficinia nodosa	....	....	....	....	....	b..................	.....	....	.....	....	....	....	.....	......	...	....	..	55	14b	5.b15
Pseudognaphalium oligandrum	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	+.	5.	.a4	1a...
Eleocharis limosa	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	..	.5	5..	.55.3
Species group W:																				
Cuscuta campestris	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	..	r5	...	.....
Species group X:																				
Persicaria lapathifolia	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	.r	.1	33a	.....
Atriplex semibacatta	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	..	..	.a4	.....
Species group Y:																				
Persicaria decipiens	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	..	..	4..	55541
Leptochloa fusca	....	....	....	....	....	....	.....	....	.....	....	....	....	.....	......	...	....	..	..	...	+.+.+

Insignificant species with an occurrence of less than 4 have been omitted