KLOOFENDAL NATURE RESERVE

Part 1:

ECOLOGICAL EVALUATION

Ekotrust cc
CK 90/10465/23

Prepared by Ekotrust cc
Dr Noel van Rooyen
Prof Gretel van Rooyen

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Contents

EXECUTIVE SUMMARY

The aim of the study was to conduct a habitat evaluation and prepare an ecological management plan for the Kloofendal Nature Reserve (KDNR). The study includes a vegetation study (classification and mapping), veld condition assessment, grazing/browsing capacity, recommendations on wildlife species and stocking densities, a protocol for a monitoring program and the first baseline monitoring data.

The reserve is situated in southern Gauteng, on the western boundary of the City of Johannesburg Metropolitan Municipality and covers an area of approximately 128 ha. The landscape consists of hills, rocky ridges, valleys, kloofs, plains, drainage lines and rivers and altitude ranges from a low of approximately 1640 m in the north to about 1790 m above sea level in the south. Quartzite and ferruginous shale of the Hospital Hill Subgroup cover most of the reserve, while in the northeastern parts the reserve is underlain by shale and quartzite of the Orange Grove Formation. The KDNR falls in the Ib41e Land Type indicating that exposed rock, stones or boulders cover more than 80% of the area.

The regional climate is described as summer rainfall with very dry winters. Mean annual rainfall for stations in the vicinity of KDNR ranges from 690 – 868 mm and extreme maximum and minimum temperature measured over a period of 29 years in the region were 36.1°C (December) and -5.6°C (June) respectively.

On the biome level, the KDNR falls in the Savanna Biome (Rutherford & Westfall 1986) and in particular in the Central Bushveld Bioregion (Mucina & Rutherford 2006). Mucina & Rutherford (2006) mapped the KDNR as part of the Gold Reef Mountain Bushveld (SVcb9). This vegetation type occurs along rocky quartzite ridges of the Magaliesberg and other west-east trending ridges in the south of Gauteng. This vegetation type is considered as "least threatened" with some 22% statutorily conserved (NEM:BA 2011, Mucina & Rutherford 2006). About 15% is transformed mainly by cultivation and urban and built-up areas. However, according to the National list of threatened ecosystems in the National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEM:BA 2011) and the GDARD Conservation plan (Version 3 of 2011), the KDNR is situated in the Roodepoort Reef Mountain Bushveld (GP 8). This ecosystem is considered as "critically endangered" with only about 12% of this vegetation type protected and approximately 29% of the system already transformed.

The approach followed during the present vegetation survey was firstly to stratefy the satellite images into relatively homogeneous units on the basis of vegetation, colour, texture and topography. Each plant species present in a plot was noted and assigned a cover abundance value and various environmental factors were noted at each site. A total of 50 plots were sampled. Vegetation data were analysed by means of specialized computer programs and 12 plant communities were distinguished. These vegetation units are described

and mapped in this report. The communities could be grouped into five groups viz. rocky outcrop communities, grassland, open bushveld, dense bushveld and forest and degraded communities.

The veld condition and grazing capacity (Grazer Unit/Browser Unit method, GU/BU method) of KDNR were determined. The veld condition index of the different plant communities ranged from 24% (very poor) to 48% (moderate) with a mean of 36% (poor). About 55% of the KDNR was in moderate condition, while 45% of the reserve was in poor condition. From a grazing point of view the veld in the reserve was therefore not in a good condition. However, the poor to moderate veld condition does not necessarily reflect poor veld management on the reserve, but is the consequence of the sour, unpalatable grass species composition that is typical of the Highveld grasslands. These grass species thrive under high rainfall conditions and leached sandy soils, usually derived from quartzite or sandstone. It is recommended that the veld condition of the different communities be monitored regularly. Initially, monitoring should be done annually to build up a database and to establish whether the veld is improving with new management initiatives.

The Grazer Unit/Browser Unit method resulted in a mean ecological and economic grazing capacity of 5.1 ha/LAU and 7.1 ha/LAU respectively. The GU/BU Unit method value was therefore within the range of the Agricultural Research Council but more conservative than the methods of Danckwertz (1989) and Moore & Odendaal (1987), but not as conservative as the value derived by the Rainfall/Wildlife biomass equation of Coe *et al.* (1976).

The selection of which wildlife species that could be introduced to KDNR will depend on the requirements and objectives of JCPZ for the reserve. Two examples of stocking densities are provided in this report: (a) using the full capacity of the reserve and a diversity of wildlife; and (b) understocking with a limited number of species. The latter option is similar to the *status quo*, but red hartebeest and springbok have been added.

Bush encroachment was a problem in some communities on KDNR. The main problem dwarf shrub species were *Seriphium plumosum* and *Lopholaena coriifolia*. The highest dwarf shrub densities occur in community 2 (*Lopholaena coriifolia* – mean of 3300 individuals per ha), community 6 *(Seriphium plumosum* – mean of 2350 individuals per ha) and community 7 *(Seriphium plumosum* – mean of 2400 individuals per ha).

Shrub densities were high in communities 6, 7, 8 and 9. The dominant shrub species appeared to be *Searsia pyroides*, *Diospyros lycioides, Acacia caffra* (new name *Senegalia caffra*), *Leucosidea sericea, Searsia lancea* and *Afrocanthium* spp. A comparison of the historical aerial photograph of 1941 with a recent satellite image clearly indicates the areas where extensive densification has occurred and could indicate areas where control measures could be implemented.

Thirty-four Category 1b alien invasive species were recorded in the KDNR during the current

survey and an additional 13 species were recorded by other collectors. These numbers include the three Category 2 species because they are not cultivated for economic purposes and no permit has been issued for them; and four Category 3 species in riparian areas. In total the Category 1b species contribute approximately 10% of the total number of plant species on the reserve. Most of the Category 1b species were not common in the KDNR, except for *Cotoneaster franchetii, Acacia mearnsii, Acacia melanoxylon, Solanum mauritianum* and *Eucalyptus camaldulensis.*

Communities 1, 3, 4 and 5 had low numbers of alien invasive species, whereas communities 2, 6, 7, 8 and 9 had intermediate number of alien invasive species. The highest number of Category 1b species was encountered in communities 10, 11 and 12. Because the riparian community (community 10) is also regarded as ecologically sensitive, this community should be targeted for control operations.

Fire is an essential component of South African grasslands and savannas. Some general guidelines regarding fire management for KDNR has been provided in this report. More detail on fire management is provided in Part 2 (Ecological Management Plan).

In total 312 indigenous and 68 alien species were recorded in the 2014 survey on KDNR. In Appendix A a list the collections/reports by the Friends of Kloofendal Nature Reserve and the study by IMR Garratt were also incorporated. According to Appendix A, 457 species have been recorded (identifications not necessarily confirmed) on the reserve to date, with 86 of these species being alien (19% of all species). In total 47 of the 457 species were Category 1b declared invasive species according to the 2014 list of NEM:BA.

Several biodiversity parameters were calculated for each of the communities: species richness, species evenness, Shannon-Wiener index of diversity and Simpson's index of diversity. Overall, the rocky outcrop communities were the most diverse and the disturbed communities had the lowest diversity.

Only two Red Data species with a status higher than 'least concern' have been recorded in KDNR: *Boophone disticha (*declining) and *Hypoxis hemerocallidea (*declining). Species mentioned in the Gauteng Nature Conservation Bill as rare plant species of Gauteng and recorded in KDNR included: *Adromischus umbraticola, Cineraria austrotransvaalensis* and *Prunus africana.* According to the databank of GDARD concerning rare plant species of Gauteng, the following Red/Orange listed plant species are of importance in the region and have been recorded from the quarter degree grid 2627BB in which KDNR is situated: *Alepidea attenuata, Aloe peglerae, Boophone disticha, Bowiea volubilis* subsp. *volubilis, Brachycorythis conica* subsp. *transvaalensis, Callilepis leptophylla, Cineraria austrotransvaalensis, Delosperma leendertziae, Eucomis autumnalis, Habenaria barbertoni, Holothrix randii, Hypoxis hemerocallidea, Ilex mitis* var. *mitis, Melolobium subspicatum* and *Pearsonia bracteata.*

Pittosporum viridiflorum and *Prunus africana* were the only protected tree species recorded in KDNR, whereas CITES (Appendix II) species found on the reserve were *Aloe arborescens, Aloe greatheadii* subsp. *davyana, Aloe marlothii, Aloe peglerae (*GDARD list*), Aloe verecunda, Anacampseros subnuda* and *Prunus africana.*

Threatened and protected species (draft TOPS list of March 2013) of the National Environmental Management: Biodiversity Act (No. 10 of 2004), which could possibly occur in KDNR are: *Aloe peglerae* (Endangered), *Bowiea volubilis* subsp. *volubilis (*Vulnerable) and *Prunus africana (*Vulnerable).

Sensitive areas on KDNR include the entire Wilgespruit and the associated riparian vegetation as well as the rocky ridge (community 1). These areas should receive attention in terms of alien plant invasive species and soil erosion (donga formation). The clusters of *Protea roupelliae* and the central rocky ridge have been indicated as sentitive.

TERMS OF REFERENCE

Conduct a habitat evaluation and prepare an ecological management plan for Kloofendal Nature Reserve (KDNR) in Gauteng province.

1. Initial preparation

Obtain all relevant maps (topocadastral, geology, land types), satellite images, climatic data (rainfall, temperature, relative air humidity and cloudiness), as well as information on the infrastructure and natural environment of the area concerned. The topographical, geological and land type information is used to stratify the satellite images of the area into relatively homogeneous units on the basis of physiography and vegetation cover.

2. Vegetation and habitat survey

Survey the stratified units and record all identifiable plant species, as well as habitat features, e.g. geology, topography, aspect, slope, soil texture and rock cover. Classify the data by means of the TURBOVEG, MEGATAB and JUICE computer programs and describe and map the different plant communities. Determine the structure of the main plant communities in terms of canopy cover and density of the woody strata. Quantitatively survey the grass species composition to assess veld condition in order to calculate the grazing capacity of each plant community. Measure the aboveground grass biomass, with the aid of a disc pasture meter, for the calculation of the grazing capacity and for a fire management program. Report on alien plant species and identify possible encroacher/invasive indigenous plant species. Compile a preliminary plant species checklist for KDNR.

3. Grazing and browsing capacity

Determine the grazing and browsing capacity for KDNR under long-term mean annual rainfall conditions as well as for above and below mean annual rainfall. Recommend wildlife numbers and ratios of grazers and browsers for KDNR, based on habitat suitability, current veld condition, grazing and browsing capacity and animal behaviour.

5. Management plan

Provide management recommendations and guidelines for aspects such as rangeland restoration, control of bush encroachment, use of fire, alien plant control, water provision and tick control. Identify ecologically sensitive areas and/or problem areas in need of special management or rehabilitation, e.g. wetlands, bush encroached, eroded and degraded areas. The management plan has been prepared as Part 2 of the current ecological evaluation.

GENERAL INFORMATION

Project: Ecological management plan of Kloofendal Nature Reserve, Gauteng

Total area covered by the property: 128 ha

Report prepared by:

Ekotrust cc
Dr Noel van Rooyen DSc; Pr.Sci.Nat.; GSSA
Prof Gretel van Rooyen PhD; Pr.Sci.Nat.
272 Thatchers Fields
Lynnwood 0081
Tel/Fax: 012 348 9043
Mobile: 082 882 0886
E-mail: noel@ekotrust.co.za
www.ekotrust.co.za

Report prepared for:

Conservation Management Department
Johannesburg City Parks and Zoo

For attention:

Bishop Ngobeli
Manager: Protected Areas
Mobile: 083 981 0272
Tel. 011 943 3578
011 042 8856

REGULATIONS GOVERNING THIS REPORT

Appointment of specialist

Ekotrust cc was commissioned by Johannesburg City Parks and Zoo to prepare an ecological management plan of the Kloofendal Nature Reserve, Gauteng province.

Company profile:

Name of Company: Ekotrust cc
(Registration number: CK90/05465/23)
Sole Member: Dr Noel van Rooyen
Founding date: 1990

Ekotrust cc specializes in habitat evaluation, vegetation classification and mapping, floristic diversity assessments, rare species assessments, alien plant assessments and management, wildlife management, wildlife production and economic assessments, veld condition assessment, bush encroachment, fire management, carrying capacity, wildlife numbers and ratios.

Declaration of independence

I, Noel van Rooyen, declare that:

- I am a member of Ekotrust cc: (CK90/05465/23);
- I act as an independent specialist consultant in the fields of ecology, botany and wildlife management;
- I regard the information contained in the report to be objective, true and correct within the framework of assumptions and limitations; and
- I do not have any business, financial, personal or other interest in the activity of the client other than fair remuneration for work performed.

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The observations, findings, recommendations and conclusions provided in the current report are based on the compiler's best scientific and professional knowledge and other available information. If new information should become available Ekotrust cc reserves the right to modify aspects of the report. This report (hard copy and/or electronic) must not be amended or extended without the prior written consent of the author. Furthermore, any recommendations, statements or conclusions drawn from or based on this report must make reference to the report. If these recommendations, statements or conclusions form part of a main report relating to the current investigation, this report must be included in its entirety (as an Appendix).

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Scope and purpose of report

The scope and purpose of the report are summarised in the "Terms of Reference" section of this report.

Dr Noel van Rooyen

Date: 31 December 2014

CHAPTER 1

INTRODUCTION

The mandate of Johannesburg City Parks and Zoo (JCPZ) has been defined as: '*The provision, preservation and management of open spaces, biodiversity, environmental and conservation services through education, research, direct conservation action and recreation with a focus on the zoo, parks and cemeteries*'. In delivering on its mandate JCPZ has set itself the vision to create '*a green, clean, conserved and active world-class, African city*'. To achieve this vision their mission is '*to develop, maintain and conserve public open spaces, cemeteries and animal life for present and future generations*'. JCPZ recognizes their environmental responsibility and is committed to:

- create and conserve a natural environment that is rich in biodiversity and is managed and maintained according to sound ecological principles;
- promote environmental awareness and responsibility amongst all stakeholders through training, development, education and communication;
- incorporate environmental considerations into all operational activities, processes, policies and strategies of JCPZ; and
- develop, maintain and implement an environmental management system (EMS) based on ISO 14001 standards (www.jhbcityparks.com accessed 2 June 2014).

Furthermore, the City of Johannesburg has prepared a 'Biodiversity Strategy and Action Plan 2015' to '*conserve and manage biodiversity and the city's environmental heritage to ensure the delivery of sustainable and equitable ecological goods and services to the citizens of Johannesburg, now and in the future*.' The guiding principles of the biodiversity strategy that are relevant to the current ecological evaluation of the Kloofendal Nature Reserve have been summarized in BOX 1 (City of Johannesburg 2009).

The primary management objective of the Kloofendal Nature Reserve is biodiversity conservation. In order to best achieve this objective, Joburg City Parks & Zoo have expressed the need for clear guidelines on how to proceed with regards to long-term veld management and the possible introduction of additional wildlife. Ideally a conservation area should be managed to be self-sustaining, while the quality and diversity of the resources should not be allowed to deteriorate, as this would inevitably lead to ecosystem degradation and lower productivity. The primary purpose of vegetation and wildlife management should be to maintain the inherent biodiversity of the region to ensure that the continued capacity of the area to support life is not compromised.

BOX 1: Guiding principles of the Biodiversity Strategy and Action Plan (City of Johannesburg 2009)

- The natural ecological spaces should be kept in their natural condition, remain intact and function optimally. These spaces provide valuable ecological goods and services to the City and intervention can reduce their value.
- Build institutional capacity and develop partnerships with society (community structures, CBOs and NGOs). Develop and encourage networks and learning within the city departments.
- Biodiversity is a common, shared good (or public asset) and the City should take collective responsibility for the ecological goods and services provided by biodiversity.
- Engage local communities for the conservation and management of the remaining natural areas in order to harness existing local knowledge and raise awareness of biodiversity issues.
- Ecological processes are not confined to city administrative boundaries and wards and are connected throughout the city (for example, rivers systems and ridges). Various policies and strategies support this interconnected and integrative approach such as the Open Space System, C-Plan of GDARD, Catchment Management Policy, Wetlands audit, ridges policy and so forth.
- Align with other plans and initiatives being undertaken by the city, NGOs or communities (for example, alien plant control, owl boxes and bat boxes at schools).
- Use best available science and knowledge for urban biodiversity and principles of sustainable development.
- Balance public interest and private interests of property owners.
- Promote the city's Open Space Framework (OSS) and ecological network (including ecosystem goods and services) as the context to which urban development must be tailored.
- Use innovative approaches to protecting and integrating biodiversity into city management.

Management of a wildlife reserve includes control, protection, conservation, maintenance and rehabilitation of the area in a manner that is consistent with environmental principles and legislation.

The identification and description of vegetation units across the landscape form the basis of scientifically based environmental and veld management plans and are critical first steps in building a framework for ecosystem management planning. A vegetation map is essential:

- to assess the veld condition of each plant community;
- to determine the grazing and browsing capacity of the area;
- to evaluate the extent of bush encroachment;
- to assess the extent of alien plant invasion;
- to identify sensitive habitats and rare flora and fauna; and
- to evaluate the suitability of the habitats for herbivores that occur naturally in the region.

The objectives of the habitat evaluation of KDNR were to provide a sound foundation for the preparation of an ecological (vegetation and wildlife) management plan of the reserve, which will:

- enable viable and sustainable wildlife conservation and utilisation based on sound veld management and wildlife management principles;

- to maintain the integrity and diversity of the natural habitats and their associated biota; and
- to allow human use of the area consistent with the first two goals.

The report therefore aims to:

- classify, describe and map the vegetation types of KDNR;
- assess the veld condition;
- determine the grazing and browsing capacity for grazing and browsing herbivores that are suitable for the region;
- recommend a stocking density for KDNR and ratios of grazers to browsers based on habitat suitability;
- to provide background on aspects of vegetation and wildlife management that are relevant for KDNR;
- to provide an ecological management plan with specific recommendations; and
- to provide a protocol for the monitoring of the vegetation dynamics on KDNR.

CHAPTER 2

PHYSICAL ENVIRONMENT

2.1 Location

The KDNR is situated in Gauteng on the western boundary of the City of Johannesburg Metropolitan Municipality (Figures 1, 2 & 3). The amphitheatre in the reserve is at approximately 26° 07' 51" S; 27° 52' 52" E. The KDNR falls in the topocadastral map 2627BB Roodepoort and covers an area of approximately 128 ha.

The Kloofendal Nature Reserve holds a special place in Joburg's 'City of Gold' history. It was the first place on the Witwatersrand where gold was discovered in 1884 by the Struben brothers. They called the mine the Confidence Reef Mine, but unfortunately the gold ran dry after a single year. The remains of the mine were declared a national monument, now a provincial heritage site, in 1984. The two stamp mills that the Struben brothers used in their search for gold were returned to the reserve in 2009 by the Friends of Kloofendal.

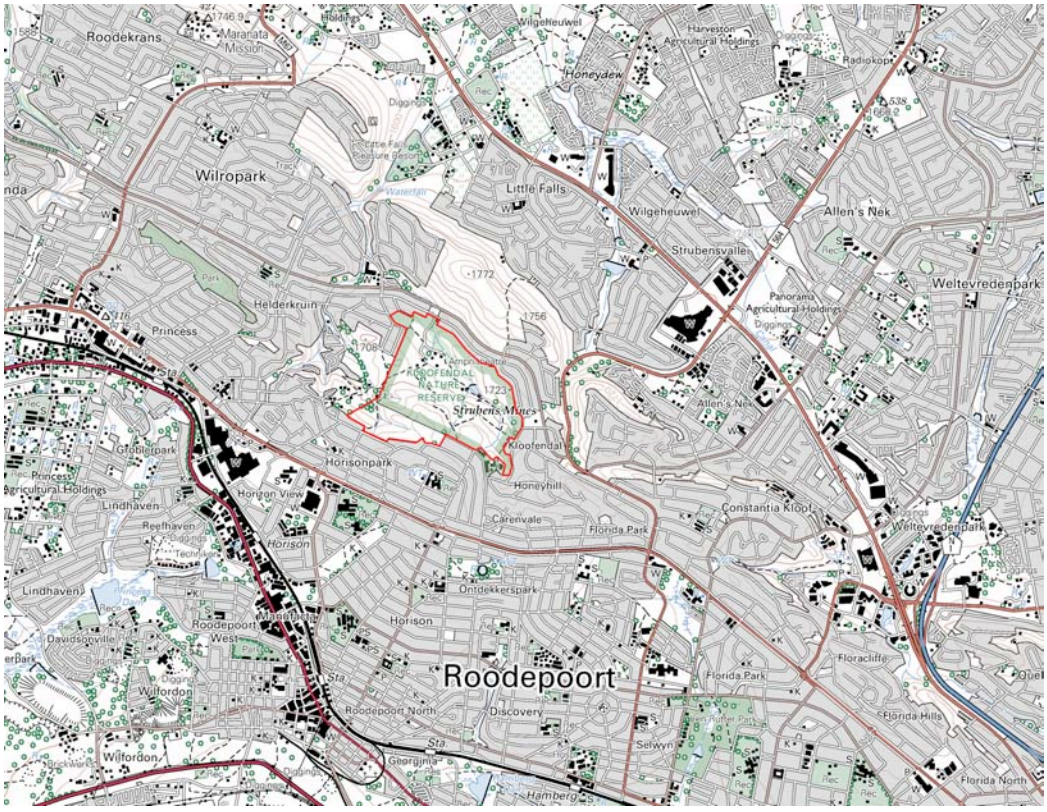

Figure 1. Topocadastral map of Kloofendal Nature Reserve (red outline) and surrounding areas indicating the location of the reserve (Topocadastral map 2010).

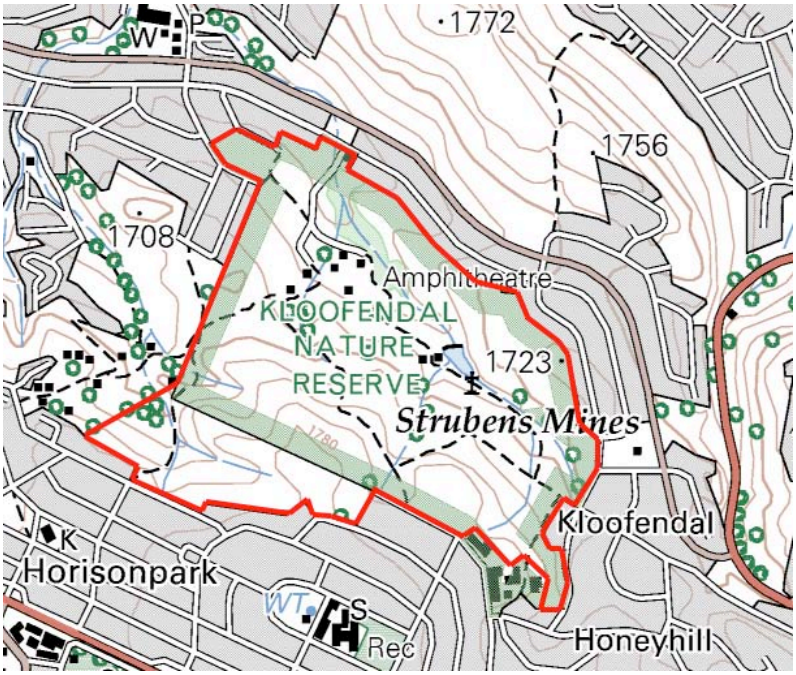

Figure 2. Topocadastral map of Kloofendal Nature Reserve (Topocadastral map 2010).

Figure 3. Satellite image of Kloofendal Nature Reserve (red line indicates the boundary).

2.2 Terrain morphology and drainage

The landscape consists of hills, rocky ridges, valleys, kloofs, plains, drainage lines and rivers (Figures 1, 2 & 3). The reserve lies in the A21E catchment zone of the Limpopo primary catchment region and is drained northwards by the Wilgespruit and its tributaries towards the Crocodile River. The altitude ranges from a low of approximately 1640 m in the north to about 1790 m above sea level in the south, a difference of 150 m in altitude (Figure 2).

2.3 Climate

2.3.1 Regional climate

The regional climate is described as summer rainfall with very dry winters (Mucina & Rutherford 2006). The annual precipitation may range from 600 mm to about 750 mm, with a mean of 666 mm. The mean annual precipitation coefficient of variation is 27%, which indicates a fair amount of variation in rainfall from year to year. The mean annual temperature of 16.4°C indicates a transition between a cool-temperate and warm-temperate climate. Frequent frost occurs in the lowlands in winter on approximately 26 days per year, but less on the higher ridges and hills. According to Kuschke & Malherbe (2014), dry and wet seasons tend to cluster together and extended droughts may come into effect from 2018 onwards.

2.3.2 Rainfall

The mean annual rainfall for stations in the vicinity of KDNR ranges from 690 – 868 mm with a mean of 737 mm (Table 1; Erasmus 1987, Weather Bureau 1988, 1998). The mean annual rainfall for Roodepoort Municipality is 720 mm while at Roodekrantz, northwest of the KDNR, it is 868 mm. At Krugerdorp to the west, Randfontein to the southwest, Florida to the south and Golden Harvest to the northwest rainfall ranges from 710 to 733 mm (Erasmus 1987, Weather Bureau 1988, 1998).

The rainy season at Roodepoort is predominantly in summer from October to April, when about 92% of the mean annual rainfall is measured, with a peak in January. The driest months are June, July and August (Table 1; Figure 4). The maximum rainfall measured in 24 hours at Krugerdorp rainfall station was 116 mm in January, while the highest maximum rainfall measured per month, was 440 mm in January (Table 2; Weather Bureau 1988, 1998). The annual rainfall may vary from 427 mm to 1056 mm during dry and wet rainfall cycles respectively (Table 2). For five out of 10 years the annual rainfall will be 703 mm or less and annual rainfall less than 526 mm could be expected once in 10 years (Table 3).

Table 1. Mean monthly and yearly rainfall for a number of rainfall stations in the region (Erasmus 1987)

Month	**Roodepoort (MUN)**	Randfontein (GM)	Krugersdorp	Luipaardsvlei	Roodekrantz	Florida	Golden Harvest
Jan	**131**	126	146	127	143	120	151
Feb	**107**	98	110	110	127	113	116
Mar	**91**	88	92	82	117	86	90
Apr	**49**	46	54	41	42	34	27
May	**21**	20	18	20	24	22	17
June	**7**	7	5	7	9	8	2
July	**10**	10	5	10	14	13	9
Aug	**7**	8	14	8	11	12	11
Sept	**20**	21	20	20	21	25	14
Oct	**61**	63	67	59	66	67	54
Nov	**112**	106	109	107	127	108	100
Dec	**113**	113	113	108	142	123	117
Year	**720**	710	724	690	868	717	733

Roodepoort (Mun): Station number, 0475/669; Coordinates, 26°09' South 27°53' East; Altitude, 1742 m;
Randfontein (GM): Station number, 0475/370; Coordinates, 26°10' South 27°43' East; Altitude, 1765 m;
Krugersdorp: Station number, 0475/456; Coordinates, 26°06' South 27°47' East; Altitude, 1710 m;
Luipaardsvlei: Station number, 0475/517; Coordinates, 26°07' South 27°48' East; Altitude, 1760 m;
Roodekrantz: Station number, 0475/576; Coordinates, 26°05' South 27°50' East; Altitude, 1660 m;
Florida: Station number, 0475/730A; Coordinates, 26°10' South 27°55' East; Altitude, 1585 m;
Golden Harvest: Station number, 0475/785; Coordinates, 26°04' South 27°58' East; Altitude, 1500 m.

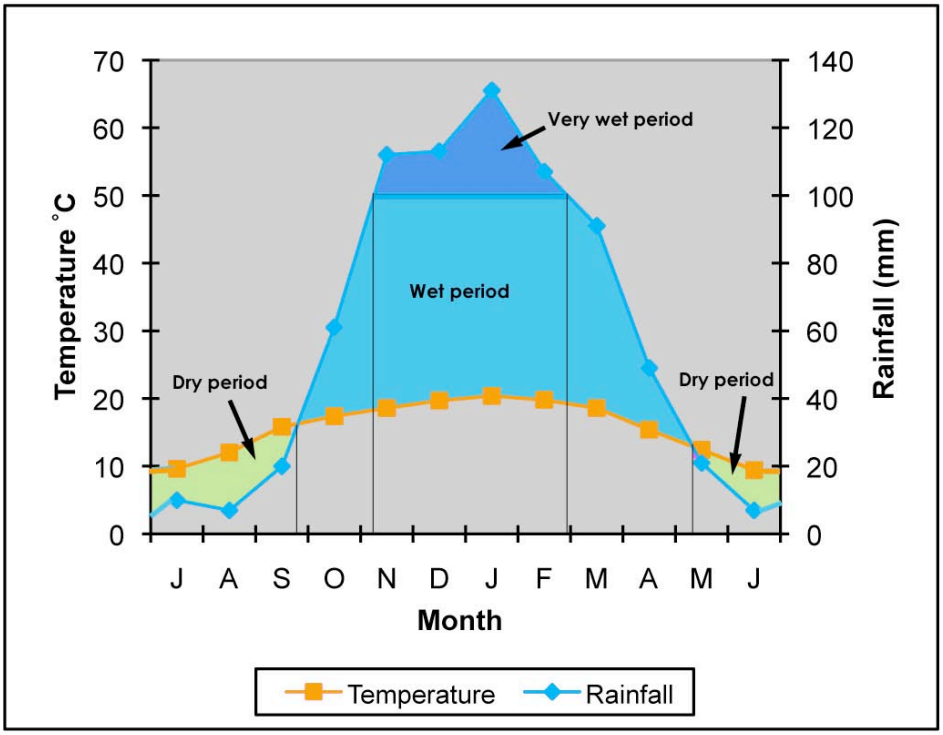

Figure 4. Climate diagram for the Kloofendal Nature Reserve region based on data from Roodepoort (rainfall) and Krugersdorp (temperature) weather stations. Dry period = rainfall below temperature curve.

Table 2. Maximum rainfall (mm) in 24 hours, highest monthly maximum and lowest monthly minimum rainfall at Krugersdorp rainfall station 0475/456 8; 26° 06' South; 27° 46' East; 1699 m altitude (29 years)(Weather Bureau 1998)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
*Max	116	60	104	49	112	29	23	26	57	57	63	57	116
*High	440	204	227	145	124	43	31	57	122	163	210	210	1056
*Low	30	24	13	5	0	0	0	0	0	15	27	29	427

*Max = maximum rainfall recorded over 24 h
*High = highest monthly maximum rainfall (mm) (and highest annual rainfall)
*Low = lowest monthly minimum rainfall (mm) (and lowest annual rainfall)

Table 3. Rainfall data for Roodepoort rainfall station (0475/669; 26° 09' South; 27° 53' East; 1742 m altitude (75 years)(Erasmus 1987))

	Jan	Feb	Mrt	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
*Max	526	402	255	196	155	118	128	83	99	163	257	297	1127
9	232	185	165	100	52	21	32	23	49	113	192	190	937
8	187	151	131	76	36	10	16	11	34	89	157	156	849
7	158	128	110	60	26	5	7	5	25	73	134	134	791
6	135	111	94	49	19	2	3	3	18	62	116	117	745
5	116	96	80	40	13	0	0	0	13	52	101	102	703
4	99	83	67	31	9	0	0	0	8	43	87	89	664
3	83	70	56	24	5	0	0	0	5	35	74	76	625
2	66	57	44	17	1	0	0	0	1	27	60	63	581
1	47	40	30	9	0	0	0	0	0	18	44	47	526
*Min	27	0	0	0	0	0	0	0	0	0	14	19	432
Mean	131	107	91	49	21	7	10	7	20	61	112	113	720

*Max = highest rainfall recorded over 75 years
*Min = lowest rainfall recorded over 75 years
First column 1 to 9: e.g. 5 means that in 5 out of 10 years the rainfall will be 116 mm or less in January; or for 5 out of 10 years the annual rainfall will be 703 mm or less (last column)

2.3.3 *Temperature*

The mean annual temperature at Krugersdorp is 15.7°C (Table 4). The mean daily maximum for January is 26.1°C and for July it is 16.9°C. The mean daily minimum for January is 14.6°C and for July it is 2.4°C. The extreme maximum and minimum temperature measured over a period of 29 years were 36.1°C (December) and -5.6°C (June) respectively. There is a possibility that frost may occur any time from April to October (Table 4).

2.3.4 *Percentage relative humidity, cloud cover, thunder, hail & fog*

The humidity at 08:00 ranges from 55% in September to 75% in February and March (Table 5). The humidity at 14:00 ranges from 31% in August to 53% in February. Cloud cover at 14:00 is the highest during January, and the lowest in August. Thunder is heard for some 30 days per year, the most frequently in November, while hail can occur year-round except in June and July, with a peak in October and November. Fog occurs mostly in June and September, while snow was recorded in May and June (Table 5).

Table 4. Temperature data (°C) for Krugersdorp rainfall station (0475/456 8; 26° 06' South; 27° 46' East; 1699 m altitude (29 years) (Weather Bureau 1988, 1998))

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
*Mean	20.4	19.8	18.6	15.4	12.4	9.4	9.6	12.0	15.8	17.4	18.6	19.7	15.7
*Max	26.1	25.5	24.3	21.3	19.1	16.3	16.9	19.4	22.9	24.0	24.6	25.7	22.2
*Min	14.6	14.2	12.9	9.4	5.6	2.4	2.4	4.7	8.7	10.9	12.5	13.7	9.3
*E Max	36.1	34.0	32.4	29.3	26.5	23.0	23.2	27.0	30.7	32.3	32.7	33.7	36.1
*E Min	6.6	4.8	2.1	-1.4	-2.3	-5.6	-5.0	-4.9	-2.5	0.3	3.6	3.3	-5.6

*Mean = mean daily temperature per month and mean annual temperature
*Max = Mean daily maximum temperature per month
*Min = Mean daily minimum temperature per month
*E max = extreme maximum temperature recorded over 29 years
*E min = extreme minimum temperature recorded over 29 years

Table 5. Relative air humidity (%), cloud cover (in eights), thunder, hail, fog and snow at Johannesburg (Joubert Park) rainfall station (0476/072 9; 26° 12' South; 28° 03' East; 1753 m altitude (37 years)(Weather Bureau 1988, 1998))

Months	% Relative air humidity		Cloud cover		Thunder	Hail	Fog	Snow
	8:00	14:00	8:00	14:00				
Jan	72	52	3.8	4.7	4.1	0.2	0.2	0.0
Feb	75	53	3.4	4.5	3.5	0.5	0.2	0.0
Mar	75	50	3.3	4.5	3.2	0.4	0.0	0.0
Apr	72	49	2.9	3.8	1.8	0.2	0.1	0.0
May	64	39	1.6	2.0	0.9	0.1	0.1	0.1
Jun	65	37	1.4	1.4	0.3	0.0	0.3	0.2
Jul	62	36	1.2	1.3	0.0	0.0	0.1	0.0
Aug	58	31	1.3	1.2	0.4	0.1	0.0	0.0
Sept	55	32	1.4	1.7	1.4	0.4	0.4	0.0
Oct	60	39	2.8	3.5	3.9	0.8	0.1	0.0
Nov	67	46	3.7	4.4	5.4	0.7	0.1	0.0
Dec	69	49	3.4	4.1	4.5	0.4	0.1	0.0
Year	66	43	2.5	3.1	29.4	3.8	1.7	0.3

2.4 Geology

The northeastern parts of the KDNR are characterised by shale and quartzite (Ro) of the Orange Grove Formation of the Hospital Hill Subgroup, West Rand Group and Witwatersrand Supergroup (Figure 5, Geological Survey 1986). Most of the remainder of the reserve is characterised by quartzite and ferruginous shale (Rh) of the Hospital Hill Subgroup, West Rand Group, Witwatersrand Supergroup. Two fault lines cut through sections of the reserve. The faulting has resulted in the otherwise continuous quartz ridges being broken up into separate blocks on rocky outcrops.

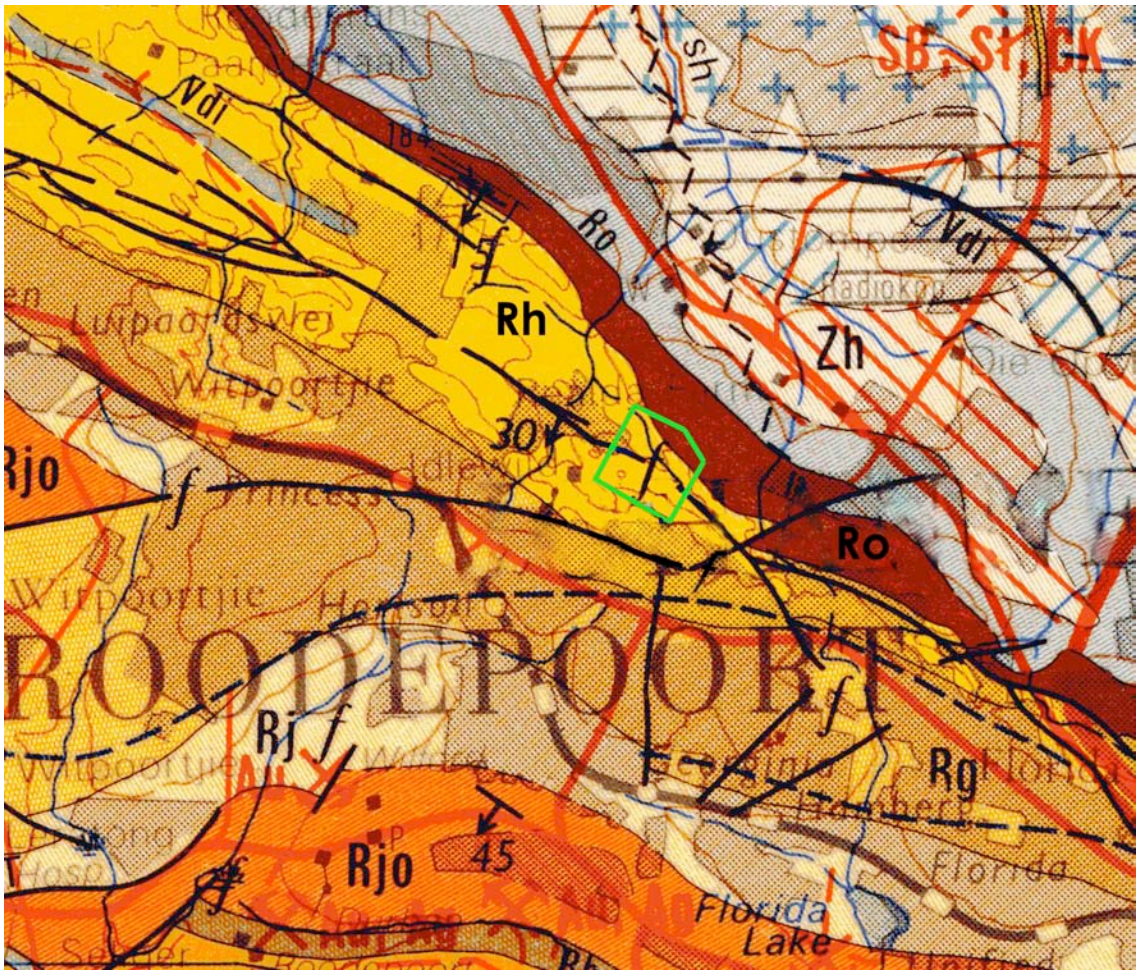

Figure 5. Geology of the Kloofendal Nature Reserve region based on the Geological Survey (1986) map. The green line indicates the approxiate boundary of the KDNR. Explanations of codes are provided in the text.

2.5 Land types and soils

Land types are areas with a uniform climate, terrain form and soil pattern. A terrain unit within a land type is any part of the land surface with homogeneous form and slope. Examples of terrain units are crest, scarp, midslope, footslope, valley bottom and floodplain. One (1) represents a crest, 2 = scarp, 3 = midslope, 4 = footslope and 5 = valley bottom. A scarp is usually steeper than 70°.

The KDNR falls in the Ib41e Land Type (Figure 6, Land Type map 1979). The Ib Land Type refers to exposed rock, stones or boulders covering more than 80% of the area. Terrain units 1, 2, 3, 4 and 5 occur in the Ib41 landscape and cover 26%, 7%, 52%, 10% and 5% of the area respectively. The slopes range from 0 - 8% in terrain unit 1; >100% in terrain unit 2, 7 - 15% in terrain unit 3; 5 - 9% in terrain unit 4; and 0 - 2% in terrain unit 5. Rocks cover up to 58% of

terrain unit 1; 86% of terrain unit 2; 72% of terrain unit 3; 20% of terrain unit 4; and 14% of terrain unit 5. The soil depth varies from 100 – 1200+ mm. The soil texture of Land Type Ib41 varies from medium textured loamy sand to loam soils, with the clay content of the A-horizon ranging from 10 - 20% and up to 25% in the B-horizon. Mispah and Glenrosa soil forms dominate the area, with some Hutton and Clovelly soil forms occurring in lowland areas.

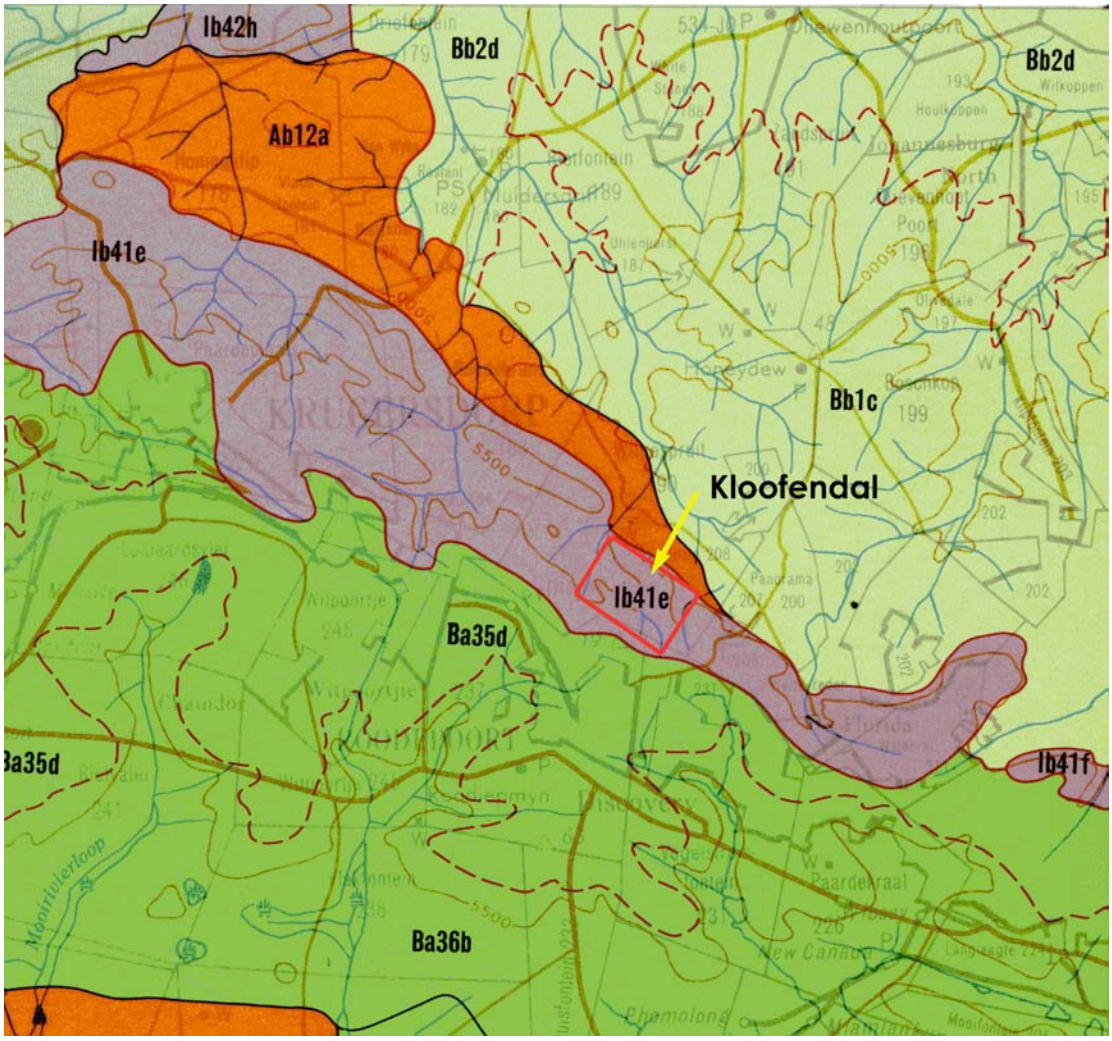

Figure 6. Land Types of the Kloofendal Nature Reserve and adjacent region. The red line indicates the approximate boundary of the reserve (Land type map 1979).

2.6 Ridges, rivers and wetlands

According to the GDARD Conservation plan (version 3 of 2011), KDNR is located on one of the five major ridge systems in Gauteng (Figure 7) and the ridge policy of the province applies to this area (Pfab 2001). The Roodepoort/Krugersdorp quartzite ridge is classified as a Class 3 ridge, which means from 35 to 65% of the ridge is already transformed by urban development. The quartzite ridges of Gauteng are limited in distribution but contain floristic

elements of grassland and savanna, as well as a Drakensberg element.

The richness and diversity of flora and fauna are significantly higher in geomorphological heterogeneous habitats such as ridges due to differences in aspect, slope, altitude, soil and hydrological conditions. Fourty-two percent of Gauteng's Red Data and 41% of endemic plant species of Gauteng are confined to the ridges in the province (Pfab 2001). The protection of ridges therefore contributes significantly to the conservation of biodiversity in Gauteng. Natural ridges also provide opportunities for recreation and education.

The Wilgespruit and its associated wetland run through the reserve (Figure 7). Many streams originate on ridges in Gauteng and control inputs of water into wetlands.

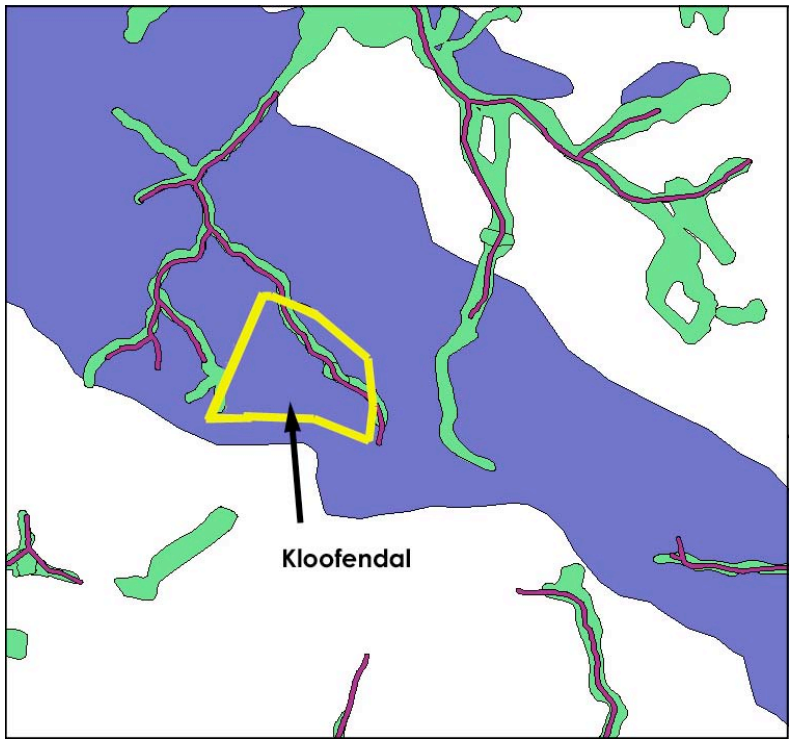

Figure 7. The location of Kloofendal Nature Reserve in terms of the ridges (blue), rivers (red) and wetlands (green) of the GDARD Conservation plan (version 3, 2011).

Large parts of the Roodepoort Reef as indicated in Figure 7 (blue area) are already transformed (green area, Figure 8) but most of the KDNR is classified as untransformed (white area, Figure 8).

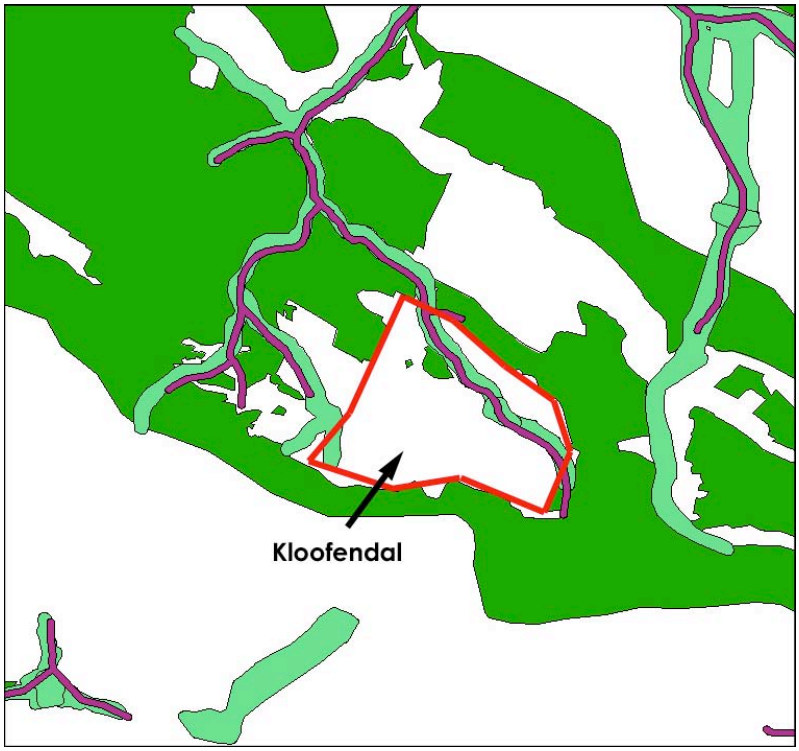

Figure 8. The location of Kloofendal Nature Reserve on the Roodepoort ridge in terms of transformation according to the GDARD Conservation plan (version 3, 2011).

CHAPTER 3

METHODS

3.1 Approach

For proper and efficient surveying of an area, an ecological stratification of the KDNR on the basis of terrain morphology and vegetation cover was made in advance. This stratification was used to determine the position and number of sample plots, and was the basis for identifying habitat types and to produce a vegetation map. Satellite images of the KDNR were obtained first and these images were stratified into relatively homogeneous vegetation/terrain units.

3.2 Vegetation surveys

The vegetation surveys were done in March 2014 and 50 plots were surveyed. An assessment of the dominant plant species and habitat features, e.g. topography, geology, rocky outcrops, rock cover, soil texture, soil depth, soil colour, slope and aspect were made at each sample plot.

The detailed vegetation survey consisted of recording all the identifiable trees, shrubs, grasses, sedges, ferns, forbs, geophytes, succulents and alien (exotic) plant species within each sample plot. Each species was allocated a percentage canopy cover value, which is required for the classification and description of the plant communities. The canopy cover estimates were according to the following scale used in the Braun-Blanquet approach:

- Plus (+) means a canopy cover/abundance estimate of less than 1%;
- 1 means a canopy cover of 1 – 5%;
- 2a means a canopy cover value of >5 to 12%;
- 2b means a canopy cover value of >12 – 25%;
- 3 means a canopy cover value of >25 – 50%;
- 4 means a canopy cover value of >50 – 75%; and
- 5 means a canopy cover value of >75%.

An estimate of the total vegetation cover (%) was made for different strata: tall trees (>6 m), small trees (3 m – 6 m), shrubs (<3 m), as well as the herbaceous layer (grasses and forbs). The density (individuals per ha) of the tall trees (>6 m), small trees (3 – 6 m), shrubs (<3 m) and dwarf shrubs (<1 m) was determined by counting individuals in several 25 m^2 or 100 m^2 quadrats at a few selected sample plots.

A step point-survey (50 points per sample plot) of the herbaceous layer (grasses and forbs)

was made to determine the frequency (%) of grass species. This point survey provides an indication of the dominance or importance of each grass species (Mentis 1981).

The disc pasture meter (Trollope & Potgieter 1986, Zambatis *et al.* 2006) was used to determine the herbaceous biomass (grasses and forbs). Twenty-five disc height readings were taken per sample plot.

3.3 Data analyses

3.3.1 Classification of vegetation into plant communities

A classification of the vegetation data was done with the TURBOVEG, MEGATAB and JUICE computer programs (Hennekens & Schaminee 2001, Tichy *et al.* 2011). The description of the plant communities included the tall tree, small tree, shrub, grass and forb (herbaceous) layers, including the geophytic, succulent, ferns and alien species recorded. All plant taxa recorded in the sample plots were listed in the checklist (see Appendix A). The location of the plant communities has been indicated on the accompanying vegetation map. The vegetation structure of the plant communities was described in terms of canopy cover, density and height of the woody species.

3.3.2 Calculation of veld condition and grazing capacity

The approach that was followed was based on the method that was described in detail by Bothma, Van Rooyen & Van Rooyen (2004). The plant species composition of the grasses and forbs in a community was obtained from the step-point survey. The grass and forb species were then classified into five ecological classes, based on their perceived grazing values, biomass production and palatability. The five ecological classes (and their constant multiplier in terms of ecological value as forage) were the following:

Class 1: Valuable and palatable tufted and stoloniferous grass species (creepers) with a high productivity and high grazing value (multiplier for veld condition: 10)

Class 2: Tufted grass species with an intermediate productivity and moderate grazing value (multiplier for veld condition: 7)

Class 3: Tufted grass species with a high productivity but a low grazing value (multiplier for veld condition: 5)

Class 4: Generally unpalatable and perennial tufted and stoloniferous grass species with an intermediate productivity and a low grazing value (multiplier for veld condition: 4)

Class 5: Unpalatable grass and forb species with a relatively low productivity and low grazing value (multiplier for veld condition: 1).

Bare soil: If no plant species was present within a 0.5 m radius of the step point it was recorded as bare soil (multiplier for veld condition: 0).

By using these classes, an ecological index was calculated to express veld condition. Theoretically, the maximum ecological index value that can be obtained is 100%, i.e. if all species present are classified as Class 1 species.

By using the ecological index, the mean grass canopy cover, mean annual rainfall, fire regime and accessibility of the area, an ecological and economic grazing capacity was calculated for each plant community. These values, weighted by the surface area covered by each community, were added to derive the ecological and economic stocking densities for the KDNR.

The grazing capacities of plant communities 1 – 12, were calculated for wildlife at a mean annual rainfall of 720 mm. The accessability of the different habitats and the influence of fire are included in the equation, while the availability of bush (for browsing), the selective grazing habits of wildlife species, behavioural requirements such as territoriality and home ranges and the restrictions of a one-camp system (lack of control over animal movements), were subjectively taken into consideration in the calculation of the capacity of the KDNR for wildlife.

The mean disc height per plant community (consisting of several sample plots), was used to determine the herbaceous biomass available. This information was used to determine the grazing capacity as well as for evaluating the available biomass (fuel load) for a fire management program.

Other methods to determine the ecological grazing capacity were also used for comparison such as the Veld Condition/Rainfall Method (Danckwerts 1989), the Herbaceous Phytomass Method (Moore & Odendaal 1987), and the Rainfall/Wildlife Biomass Method (Coe *et al.* 1976). The browsing capacity was estimated on the basis of the woody plant composition and structure, and published information, e.g. Snyman (1991), Dekker (1997), Tainton (1999), Bothma & Van Rooyen (2005) and Bothma (2010).

3.3.3 Stocking density

The grazing capacity, the recommended species suitable for the area, and the numbers of wildlife were calculated. The differences in diet (percentage grazing and percentage browsing) of each type of wildlife were used to determine the final recommended stocking density for the KDNR. Male: female ratios, natural population growth rates and number of offspring, have been provided as additional information.

CHAPTER 4

VEGETATION

4.1 Introduction

Phytogeographically, the KDNR is contained in the Highveld Grassland of the Kalahari-Highveld regional transition zone (White 1983). On the biome level, the KDNR falls in the Savanna Biome (Rutherford & Westfall 1986) and in particular in the Central Bushveld Bioregion (Mucina & Rutherford 2006). Acocks (1953, 1988) classified the area as Bankenveld whereas Low & Rebelo (1998) classified the area as Rocky Highveld Grassland. In the latest vegetation map of South Africa, Mucina & Rutherford (2006) mapped the KDNR as part of the Gold Reef Mountain Bushveld (SVcb9).

4.2 NEM:BA (2011) and Gauteng Conservation-plan, Version 3 (2011), Gauteng Department of Agriculture and Rural Development (GDARD)

According to the National list of threatened ecosystems in the National Environmental Management: Biodiversity Act (No. 10 of 2004) (NEM:BA 2011) and the GDARD Conservation plan (Version 3 of 2011), the KDNR is situated in the Roodepoort Reef Mountain Bushveld (GP 8), which includes the Roodepoort and Krugersdorp ridge systems and associated koppies (Figure 9). This ecosystem is considered as "critically endangered" with only about 12% of this vegetation type protected and approximately 29% of the system already transformed. Twenty threatened or endemic plant and animal species occur in this unit. General information on the Roodepoort Reef Mountain Bushveld is provided in BOX 2. The KDNR also falls in one of Gauteng's Core Biodiversity Areas (CBA).

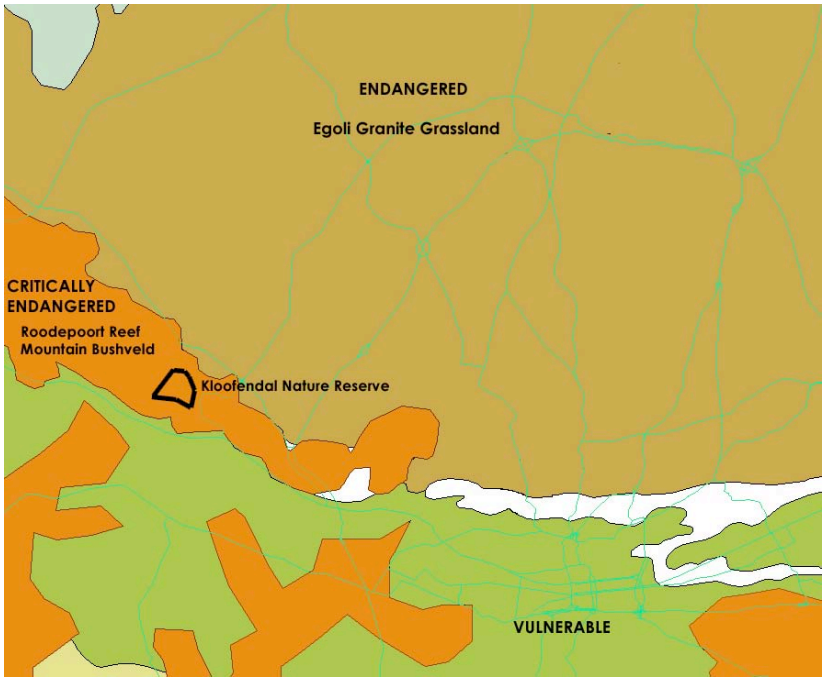

Figure 9. Location of Kloofendal Nature Reserve within the Roodepoort Reef Mountain Bushveld, which has a Critically Endangered status (indicated by orange).

BOX 2: The Roodepoort Reef Mountain Bushveld (GP 8)

Geographical location: West Rand of Gauteng including Roodepoort and Randfontein (2627BB and 2627BA respectively). Ecosystem delineated by the Roodepoort and Krugersdorp ridge system and associated koppies.

Ecosystem threat status: **Critically Endangered (CR)**

Listed under criterion F: Priority areas for meeting explicit biodiversity targets as defined in a systematic biodiversity plan - Very high irreplaceability and high threat.

Biome: Grassland & Savanna

Province: Gauteng

Municipalities: Mogale City (GT481) & City of Johannesburg (JHB)

Original area of ecosystem: 14000 ha

Remaining natural area of ecosystem (%): 71%

Proportion of ecosystem protected: Approximately 12% of the ecosystem is protected within the Krugersdorp Nature Reserve, Walter Sisulu Botanical Gardens, Ruimsig Entomological Reserve and Kloofendal Nature Reserve.

Known species of special concern: 20 threatened or endemic plants and animal species **e.g.** the following Red or Orange Listed taxa:

- Flora:
  Melolobium subspicatum, Aloe peglerae and *Delosperma leendertziae.*
- Mammals:
  Geoffry's Horseshoe Bat, Temminck's Hairy Bat and Schreiber's Long-fingered Bat
- Birds:
  Half-collared Kingfisher
- Invertebrates:
  Marsh Sylph, Roodepoort Copper Butterfly, Stobbia's Fruit Chafer, Gunning's Rock Scorpion and Golden Starburst Baboon Spider.
- Five vegetation types of Mucina & Rutherford (2006) occur within the Roodepoort Reef Mountain Bushveld ecosystem (NEM:BA 2011, GDARD C-plan 2011):
  Andesite Mountain Bushveld,
  Carletonville Dolomite Grassland,
  Egoli Granite Grassland,
  Gold Reef Mountain Bushveld, and
  Soweto Highveld Grassland

The Bloubankspruit, Klein Jukskei River, Muldersdrif se Loop, Wilgespruit and Rietspruit are key rivers in the ecosystem.

4.3 Vegetation types

The KDNR lies in the Gold Reef Mountain Bushveld vegetation type (SVcb9) (Mucina & Rutherford 2006 (Figure 10). This vegetation type occurs along rocky quartzite ridges of the Magaliesberg and other west-east trending ridges in the south of Gauteng. *Acacia caffra* is a dominant species in dense woody vegetation on south-facing slopes. The soils are shallow gravel lithosols.

The most prominant taxa include the trees *Acacia caffra, Protea caffra, Combretum molle, Celtis africana* and *Englerophytum magalismontanum*. The prominent shrubs include *Ehretia rigida, Gymnosporia buxifolia, Afrocanthium gilfillanii* and *Grewia occidentalis*. Low shrubs of note are *Athrixia elata, Searsia magalismontana, Searsia rigida* and *Xerophyta retinervis.* The grass layer is dominated by *Loudetia simplex, Schizachyrium sanguineum, Trachypogon spicatus* and *Alloteropsis semialata*. Prominent forbs include *Helichrysum nudifolium, Helichrysum rugulosum, Senecio venosus* and the fern *Pellaea calomelanos.* The alien *Melia azedarach* occurs locally in dense stands along drainage lines.

This vegetation type covers 2031 km^2 and is considered as "least threatened" with some 22% statutorily conserved (NEM:BA 2011, Mucina & Rutherford 2006). About 15% is transformed mainly by cultivation and urban and built-up areas.

The most prominant taxa include the trees *Acacia caffra, Protea caffra, Combretum molle, Celtis africana* and *Englerophytum magalismontanum*. The prominent shrubs include *Ehretia rigida, Gymnosporia buxifolia, Afrocanthium gilfillanii* and *Grewia occidentalis*. Low shrubs of note are *Athrixia elata, Searsia magalismontana, Searsia rigida* and *Xerophyta retinervis.* The grass layer is dominated by *Loudetia simplex, Schizachyrium sanguineum, Trachypogon spicatus* and *Alloteropsis semialata*. Prominent forbs include *Helichrysum nudifolium, Helichrysum rugulosum, Senecio venosus* and the fern *Pellaea calomelanos.* The alien *Melia azedarach* occurs locally in dense stands along drainage lines.

This vegetation type covers 2031 km^2 and is considered as "least threatened" with some 22% statutorily conserved (NEM:BA 2011, Mucina & Rutherford 2006). About 15% of the unit has been transformed, mainly by cultivation and urban and built-up areas.

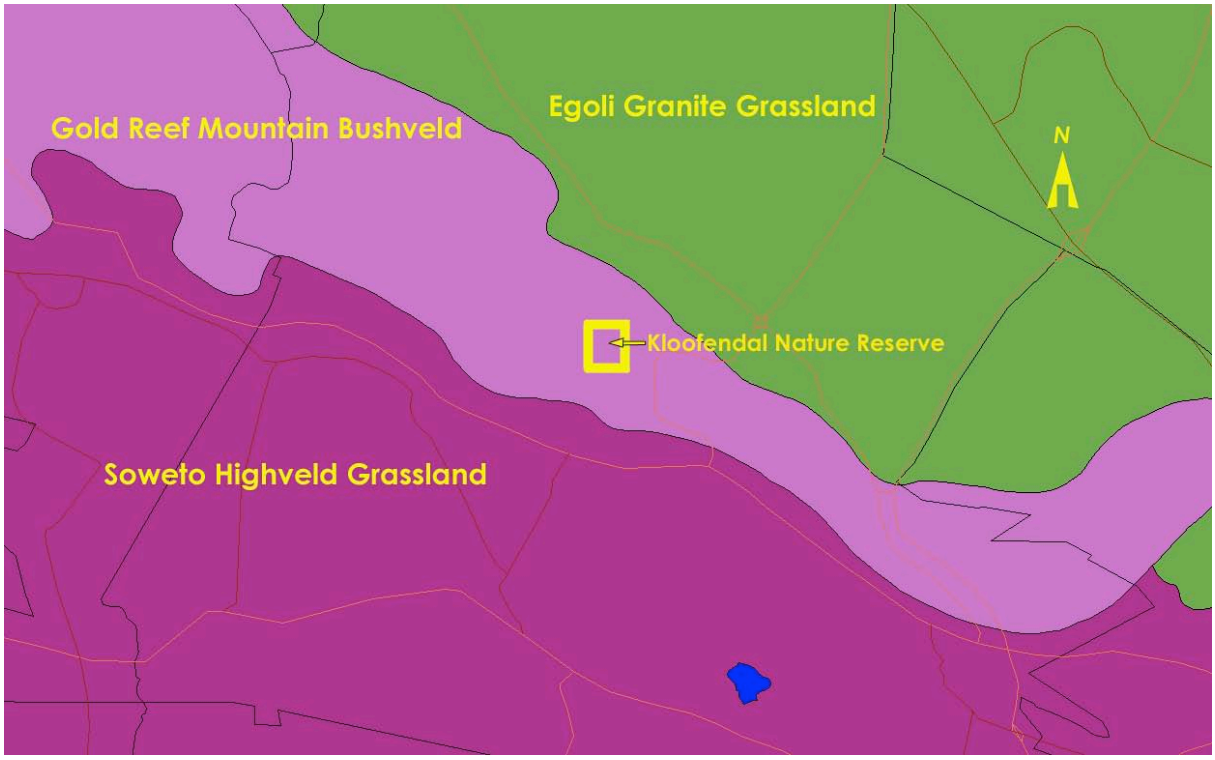

Figure 10. Vegetation types of the Kloofendal Nature Reserve region according to Mucina & Rutherford (2006).

4.4 Previous vegetation studies in the region

Several other vegetation studies have been conducted on the ridge systems in the Johannesburg area including Bredenkamp (1975), Bredenkamp & Bezuidenhout (1986), Behr & Bredenkamp (1988a, 1988b), Bredenkamp & Brown (1998), Brown & Bredenkamp (1998), Grobler (2000), Bredenkamp & Brown (2001), Brown & Bredenkamp (2001), Ellery *et al*. (2001), Grobler *et al.* (2002, 2006), Bredenkamp & Brown (2003) and Garratt (2006).

4.5 Classification and mapping of the vegetation of the Kloofendal Nature Reserve

Differences in geology, topography, rockiness, drainage, soil texture, soil depth, slope, and past management practices, result in different plant communities. Each plant community usually represents a specific habitat for certain types of animals and has its own inherent grazing and browsing capacity for herbivores.

The KDNR is characterised by grassland and rocky outcrops of the highveld, with open to dense patches of woody species on the rocky outcrops and against moderate to steep slopes. Frost during winter and grass fires play an important role in limiting the occurrence of trees and shrubs in the exposed grassland areas. The clay-loam soils in the bottomlands provide a suitable substrate for riparian forests to develop.

At a broad scale the vegetation can be subdivided into the following four habitat types (Figure 11):

- Shrubland of rocky outcrops (communities 1 & 2) covering 26 ha (20% of the reserve)
- Grasslands (communities 3, 4 & 5) covering 36 ha (28% of the reserve);
- Open bushveld (communities 6 & 7) covering 27 ha (16% of the total reserve);
- Dense bushveld and forests (communities 8, 9 & 10) covering 29 ha (28% of the reserve).

Infrastructure, the old mine, and communities 11 & 12 (gardens and alien vegetation patches) cover 10 ha (8% of the reserve). Although the entire old mine area has been mapped as community 12, only a small portion of the area of the fenced-off old mine area is severely disturbed and much of the vegetation in the enclosure is similar to the surrounding vegetation. No access was provided to the enclosure and surveys were not conducted in the area.

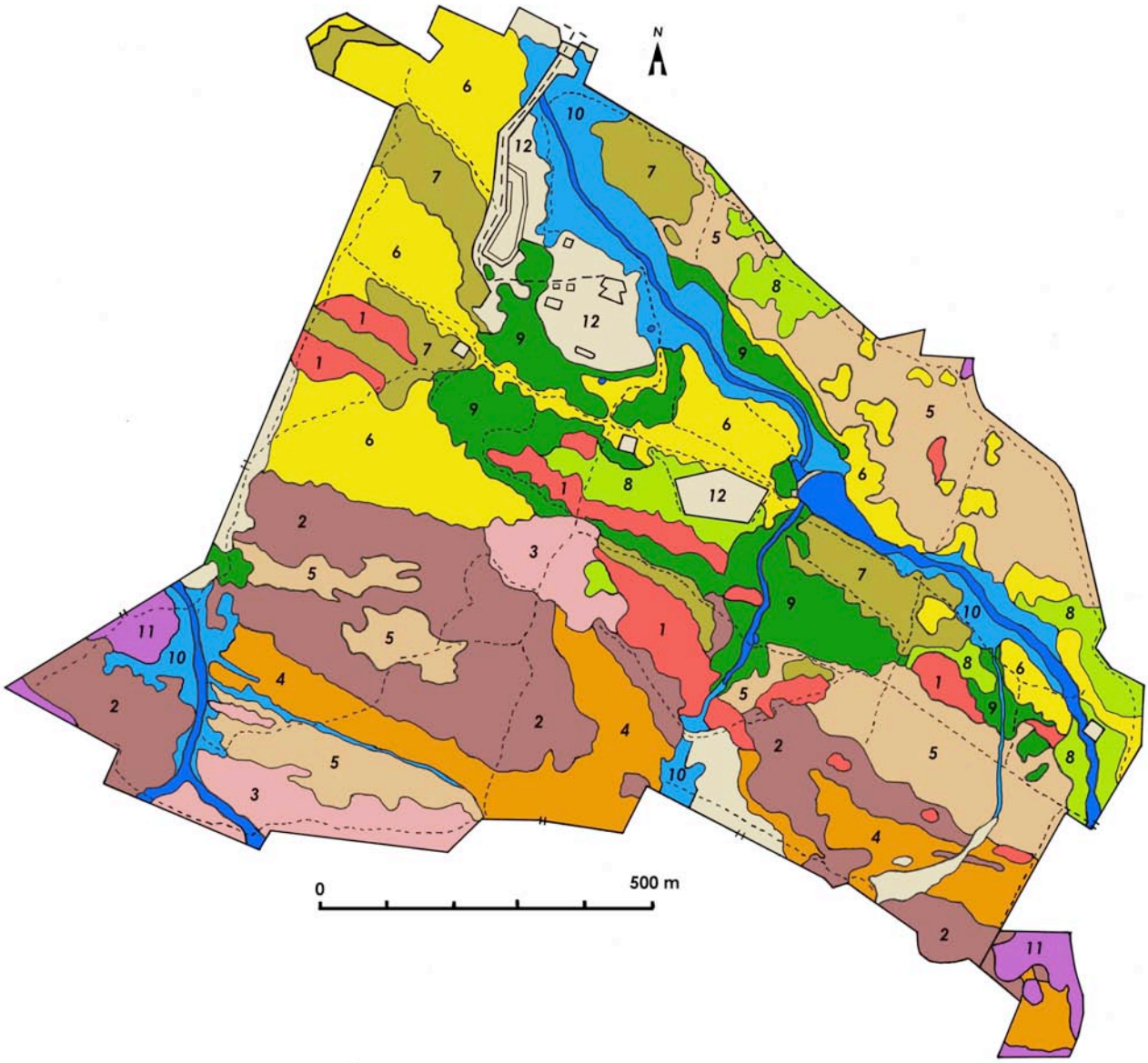

Figure 11. Vegetation map of the Kloofendal Nature Reserve. The numbers on the figure correspond to the numbers of the communities used in the text.

Legend for Figure 11.

4.6 Plant communities of the Kloofendal Nature Reserve

4.6.1 Ordination

The description of the individual plant communities is given below (Figures 11 – 30) (Table 6 - Appendix G). The percentage canopy cover and density (individuals/ha) for the communities are summarized in Tables 7 & 8 respectively.

Twelve plant communities were distinguished in the KDNR (Table 6; Figure 11). The recognition of the 12 communities was supported by the ordination of the data (Figure 12). The shrublands of the rocky outcrops, represented by communities 1 and 2, lie towards the top right of the ordination plane and the grasslands, represented by communities 3, 4 and 5, lie towards the lower right side of the ordination plane. The open bushveld communities, represented by communities 6 and 7, are transitional between the grassland and dense bushveld/forest communities and occupy the space in the centre of the ordination plan between these two groups. The dense bushveld/forests, represented by communities 8, 9 and 10, lie to the left of the ordination plane. Communities 11 and 12 represent the disturbed communities, which show most affinity to the dense bushveld/forest communities.

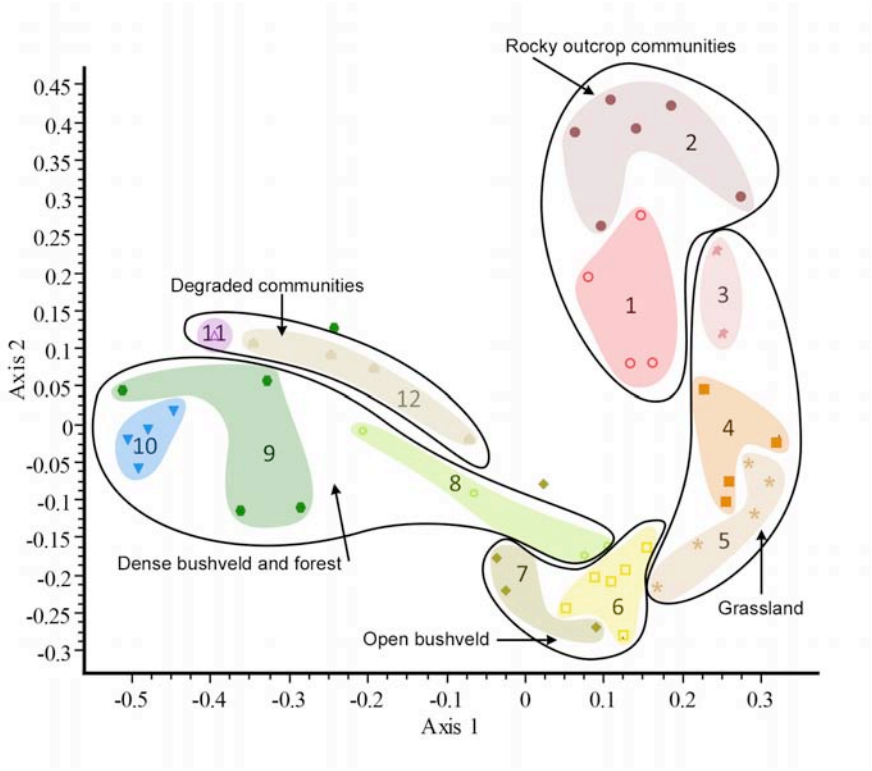

Figure 12. An ordination diagram (Principal Coordinates Analysis) of the 50 sample plots, based on the species composition, showing the 12 communities. Each symbol represents a plot and the closer two plots lie to one another in die diagram, the more related those plots are in terms of species composition.

The following plant communities were distinguished in Kloofendal Nature Reserve:

1. *Helichrysum lepidissimum – Vangueria parvifolia – Englerophytum magalismontanum* shrubland
2. *Adromischus umbraticola – Aristida transvaalensis – Englerophytum magalismontanum* wooded grassland
3. *Crassula sarcocaulis – Loudetia simplex* grassland
4. *Senecio coronatus – Panicum natalense – Loudetia simplex* wooded grassland
5. *Chascanum hederaceum – Tristachya rehmannii – Schizachyrium sanguineum* wooded grassland
6. *Protea roupelliae – Alloteropsis semialata open* bushveld
7. *Searsia discolor – Diheteropogon amplectens – Protea caffra* open bushveld
8. *Cotyledon orbiculata – Searsia pyroides – Protea caffra* bushveld
9. *Acacia caffra – Gymnosporia buxifolia – Zanthoxylum capense* dense bushveld
10. *Cliffortia linearifolia – Buddleja salviifolia – Leucosidea sericea* riparian bushveld and forest
11. *Eucalyptus camaldulensis – Solanum mauritianum* woodlot
12. *Cynodon dactylon – Eragrostis curvula* degraded or developed land

4.6.2 *Description of the plant communities (Table 6, Figure 11):*

1. *Helichrysum lepidissimum – Vangueria parvifolia – Englerophytum magalismontanum* shrubland

This shrubland was found in the central parts of KDNR (Figure 11) and covered approximately 6 ha (4.5% of the total KDNR). The community occurred on the crests of ridges, at a mean altitude of 1706 m (Figure 13). Surface rocks covered from 50 to 90% of the ground surface. The shallow, brown to redbrown, sandy loam soils were derived from quartzite.

The diagnostic species included *Helichrysum lepidissimum, Hypoxis galpinii and Kalanchoe thyrsiflora* (see species group 1, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 1% and were represented by *Searsia lancea* and the occasional *Prunus africana*.
- **Small trees** (>3–6 m) covered on average 4% of the area and the most prominent species were *Protea caffra, Searsia pyroides, Englerophytum magalismontanum, Cussonia paniculata* and *Searsia leptodictya*. The trees *Prunus africana, Kiggelaria africana, Pterocelastrus echinatus* and *Searsia lancea* were recorded locally. The small trees occurred at a mean density of 100 individuals/ha.
- **Shrubs** covered on average 10% of the area and included *Vangueria parvifolia, Vangueria infausta, Afrocanthium gilfillanii, Diospyros lycioides, Searsia dentata* and *Searsia rigida*. The shrubs occurred at a mean density of 600 individuals/ha.
- **Dwarf shrubs** had a mean canopy cover of 7% and included *Ancylobotrys capensis, Searsia magalismontana, Phymaspermum athanasioides, Indigofera comosa, Parinari capensis, Pygmaeothamnus zeyheri, Xerophyta retinervis* and *Elephantorrhiza elephantina.*
- The **grass layer** was poorly developed because of the high rock cover and had a mean canopy cover of 34%. The dominant grass species were *Loudetia simplex, Schizachyrium sanguineum, Aristida transvaalensis and Cymbopogon pospischilii.* Other less prominent grass species included *Panicum natalense, Alloteropsis semialata, Melinis nerviglumis, Andropogon schirensis, Diheteropogon amplectens* and *Themeda triandra.*
- **Herbaceous species** in this community covered up to 4% of the area. The most common species were *Berkheya seminivea, Sphenostylis angustifolium, Senecio venosus, Chaenostoma leve, Commelina africana, Cyanotis speciosa, Polydora poskeana* and *Gisekia africana.* The sedges included *Bulbostylis hispidula.*
- The **geophytes** were represented by *Haemanthus humilis, Hypoxis galpinii* and *Boophone disticha* while the **succulents** included *Kalanchoe thyrsiflora, Crassula swaziensis, Crassula setulosa* and *Aloe greatheadii* subsp. *davyana*.
- The ferns were represented by *Cheilanthes virides, Cheilanthes hirta* and *Pellaea calomelanos*.
- The following **alien species** were recorded in this community: *Acacia melanoxylon,*

Sonchus oleraceus, Tagetes minuta, Taraxacum officinale and *Withania somnifera.*

Figure 13. Community 1: *Helichrysum lepidissimum – Vangueria parvifolia – Englerophytum magalismontanum* shrubland on the rocky ridges in the KDNR.

2. *Adromischus umbraticola – Aristida transvaalensis – Englerophytum magalismontanum* wooded grassland

This community was found in the southern parts of KDNR (Figure 11) and covered approximately 20 ha (16% of the total KDNR). The community occurred on the steep slopes and plateaux of ridges, at a mean altitude of 1735 m (Figure 14). Surface rocks covered from 70 to 90% of the area. The shallow, greybrown to redbrown, sandy loam to sandy clayloam soils were derived from quartzite.

The diagnostic species included *Adromischus umbraticola, Coleochloa setifera, Aloe verecunda, Selaginella dregei, Microchloa caffra, Cineraria austrotransvaalensis* and *Kalanchoe paniculata* (see species group 2, Table 6).

- **No tall trees** (>6 m) were recorded in this community.
- **Small trees** (>3–6 m) covered a mere 1% of the area and the most prominent species were *Searsia lancea, Celtis africana, Englerophytum magalismontanum, Searsia pyroides* and *Kiggelaria africana*.
- **Shrubs** covered on average 8% of the area and included *Vangueria parvifolia, Diospyros lycioides, Vangueria infausta, Searsia dentata* and *Lopholaena coriifolia.* In some places *Lopholaena coriifolia* reached densities of up to 3300 individuals per ha.
- **Dwarf shrubs** had a mean canopy cover of 3% and included *Phymaspermum*

athanasioides, Cineraria austrotransvaalensis, Ancylobotrys capensis, Searsia magalismontana, Indigofera comosa, Elephantorrhiza elephantina, Parinari capensis, Cryptolepis oblongifolia and *Xerophyta retinervis.*

- The **grass layer** was poorly to moderately developed because of the high rock cover and had a mean canopy cover of 44%. The dominant grass species were *Aristida transvaalensis, Loudetia simplex, Schizachyrium sanguineum, Melinis nerviglumis* and *Cymbopogon pospischilii.* Other less prominent grass species included *Themeda triandra, Melinis repens, Hyparrhenia hirta, Andropogon schirensis, Diheteropogon amplectens* and *Urelytrum agropyroides.*

Figure 14. Community 2: *Adromischus umbraticola – Aristida transvaalensis – Englerophytum magalismontanum* wooded grassland in the southern parts of the Kloofendal Nature Reserve.

- **Herbaceous species** in this community covered up to 5% of the area. The most common species were *Senecio oxyriifolius, Wahlenbergia oxyphylla, Gerbera viridifolia, Cyanotis speciosa, Berkheya seminivea, Leonotis ocymifolia, Helichrysum cerastioides, Wahlenbergia undulata, Polydora poskeana, Oldenlandia herbacea, Cleome monophylla, Ursinia nana, Eriosema cordatum* and *Hypoestes forskaolii.* The **sedges** included *Coleochloa setifera, Bulbostylis hispidula* and *Abildgaardia ovata.*
- The **geophytes** were represented by *Haemanthus humilis, Boophone disticha, Chlorophytum fasciculatum, Ledebouria ovatifolia* and *Pelargonium luridum*, while the **succulents** included *Aloe greatheadii* subsp. *davyana, Aloe verecunda, Crassula setulosa, Crassula swaziensis* and *Kalanchoe paniculata*.
- The conspicuous **ferns** were *Selaginella dregei, Cheilanthes virides, Cheilanthes hirta* and *Pellaea calomelanos*.

- The following **alien species** were recorded in this community: *Acacia mearnsii, Bidens pilosa, Jacaranda mimosifolia, Opuntia ficus-indica, Pinus* sp. and *Tagetes minuta.*

3. *Crassula sarcocaulis – Loudetia simplex* grassland

This community was found in the southern and central parts of KDNR (Figure 11) and covered approximately 6 ha (4.3% of the total KDNR). The community occurred in the valleys and slight to moderately steep low ridges at a mean altitude of 1773 m (Figure 15). Surface rocks covered from 10 to 80% of the area. The shallow, brown, sandy loam soils were derived from quartzite.

The diagnostic species included *Aloe marlothii, Crassula sarcocaulis, Senecio oxyriifolius, Psammotropha myriantha, Leucas martinicensis, Cleome angustifolia* and *Ornithogalum saundersiae* (see species group 4, Table 6).

- **No tall trees** (>6 m) were recorded in this community.
- **Small trees** (>3–6 m) covered on average 1% of the area and the most prominent species were *Protea caffra* and *Celtis africana*.
- **Shrubs** had a mean canopy cover of 3% of the area and included *Lopholaena coriifolia, Mundulea sericea* and *Diospyros lycioides.*

Figure 15. Community 3: *Crassula sarcocaulis – Loudetia simplex* grassland.

- **Dwarf shrubs** in the community covered approximately 2% of the ground surface and the most conspicuous species were *Searsia magalismontana, Cryptolepis oblongifolia, Phymaspermum athanasioides, Indigofera comosa, Parinari capensis* and *Xerophyta retinervis.*

- The **grass layer** was moderately to well developed and had a mean canopy cover of 68%. The dominant grass species was *Loudetia simplex*. Other less prominent grass species included *Aristida transvaalensis, Diheteropogon amplectens, Trichoneura grandiglumis, Sporobolus pectinatus, Schizachyrium sanguineum, Brachiaria serrata, Themeda triandra, Bewsia biflora, Cymbopogon pospischilii* and *Melinis nerviglumis*.
- **Herbaceous species** in this community covered up to 4% of the area. The most common species were *Ursinia nana, Cyanotis speciosa, Anthospermum hispidulum, Leonotis ocymifolia, Polydora poskeana, Senecio oxyriifolius, Senecio venosus, Commelina africana* and *Commelina erecta*. The **sedges** included *Bulbostylis hispidula*.
- The **geophytes** were represented by *Bonatea antennifera* and *Boophone disticha*, while the **succulents** included *Aloe marlothii, Aloe greatheadii* subsp. *davyana, Crassula sarcocaulis, Crassula swaziensis* and *Crassula setulosa*.
- The **ferns** were represented by *Selaginella dregei, Cheilanthes virides, Cheilanthes hirta* and *Pellaea calomelanos*.
- The following **alien species** were recorded in this community: *Agave americana, Bidens pilosa, Campuloclinium macrocephalum, Cestrum laevigatum* and *Tagetes minuta*.

4. *Senecio coronatus – Panicum natalense – Loudetia simplex* wooded grassland

This grassland/wooded grassland was found in the southern parts of KDNR (Figure 11) and covered approximately 10 ha (7.8% of the total KDNR). The community occurred on the high plateaux and slight to steep midslopes of ridges, at a mean altitude of 1789 m (Figure 16). Surface rocks covered from 10 to 80% of the area. The shallow, brown to redbrown, sandy loam to sandy clayloam soils were derived from quartzite.

The diagnostic species included *Senecio coronatus, Panicum maximum, Syncolostemon pretoriae, Lantana rugosa* and *Tephrosia longipes* (see species group 7, Table 6).

- **No tall trees** (>6 m) were recorded in this community.
- **Small trees** (>3–6 m) covered on average 2% of the area and the most prominent species were *Protea caffra, Searsia leptodictya* and *Searsia lancea*.
- **Shrubs** covered on average 2% of the area with *Diospyros lycioides* and *Protea caffra* the only species present.
- **Dwarf shrubs** had a mean canopy cover of 3% and included *Indigofera comosa, Elephantorrhiza elephantina, Phymaspermum athanasioides, Seriphium plumosum, Pachystigma pygmaeum* and *Xerophyta retinervis*.
- The **grass layer** was well developed and had a mean canopy cover of 75%. The dominant grass species were *Loudetia simplex, Schizachyrium sanguineum* and *Panicum natalense*. Other less prominent grass species were *Aristida transvaalensis, Digitaria brazzae, Heteropogon contortus, Monocymbium ceresiiforme, Trachypogon spicatus, Aristida diffusa, Alloteropsis semialata, Urelytrum agropyroides, Themeda*

triandra, Melinis nerviglumis, Eragrostis curvula, Rendlia altera and *Diheteropogon amplectens*.

Figure 16. Community 4: *Senecio coronatus – Panicum natalense – Loudetia simplex* wooded grassland on midslopes in the southern part of the Kloofendal Nature Reserve.

- **Herbaceous species** in this community covered up to 3% of the area. The most conspicuous species were *Helichrysum cerastioides, Scabiosa columbaria, Dimorphotheca spectabilis, Senecio venosus, Chaenostoma leve, Ursinia nana, Helichrysum nudifolium, Chamaecrista comosa, Hypoestes forskaolii* and *Nidorella hottentotica*. The only **sedge species** was *Bulbostylis hispidula*.
- The **geophytes** were represented by *Ledebouria revoluta* and *Chlorophytum fasciculatum,* while the **succulents** included *Anacampseros subnuda, Khadia acutipetala, Aloe verecunda* and *Crassula setulosa*.
- The **ferns** were represented by *Cheilanthes hirta* and *Pellaea calomelanos.*
- The following **alien species** were recorded in this community: *Acacia melanoxylon* and *Tagetes minuta.*

5. *Chascanum hederaceum – Tristachya rehmannii – Schizachyrium sanguineum* wooded grassland

This large community was found predominantly in the south, east and northeastern parts of KDNR (Figure 11) and covered approximately 20 ha (16% of the total KDNR). The community occurred on the slight to moderate slopes and crest of low hills, at a mean altitude of 1722 m (Figure 17). Surface rocks covered from 5 to 30% of the area. The shallow to moderately deep, red to redbrown, sandy clayloam soils were derived from shale and quartzite.

The diagnostic species included *Chascanum hederaceum, Raphionacme galpinii, Polygala hottentotta* and *Dianthus mooiensis* (see species group 10, Table 6).

- **No tall trees** (>6 m) were recorded in this community.
- **Small trees** (>3–6 m) covered approximately 3% of the area and the most prominent species were *Protea roupelliae* and *Searsia pyroides*.
- **Shrubs** covered on average 2% of the area and included *Lopholaena coriifolia* and *Searsia rigida*.
- **Dwarf shrubs** had a mean canopy cover of 2% and the most prominent species were *Indigofera comosa, Phymaspermum athanasioides, Athrixia elata, Lippia javanica* and *Seriphium plumosum*.

Figure 17. Community 5: *Chascanum hederaceum – Tristachya rehmannii – Schizachyrium sanguineum* wooded grassland in the south, east and northeast of the Kloofendal Nature Reserve.

- The **grass layer** was well developed and had a mean canopy cover of 83%. The dominant grass species were *Loudetia simplex, Schizachyrium sanguineum, Panicum natalense, Alloteropsis semialata, Tristachya rehmannii* and *Monocymbium ceresiforme*. Other less prominent grass species were *Urelytrum agropyroides, Aristida transvaalensis, Digitaria brazzae, Trachypogon spicatus, Aristida diffusa, Brachiaria serrata, Themeda triandra, Andropogon schirensis* and *Diheteropogon amplectens*.
- **Herbaceous species** in this community covered up to 2% of the area. The most common species were *Acaclypha angustata, Hilliardiella aristata, Senecio venosus, Chaenostoma leve, Ursinia nana, Chamaecrista comosa, Helichrysum acutatum,*

Helichrysum coriaceum, Anthospermum rigidum, Pentanisia angustifolia and *Nidorella hottentotica*. **Sedges** included *Coleochloa setifera, Bulbostylis hispidula* and *Abildgaardia ovata*.

- The **geophytes** were represented by *Raphionacme galpinii, Boophone disticha* and *Ledebouria ovatifolia*, while the only **succulent** species recorded in this community was *Aloe greatheadii* subsp. *davyana.*
- The **ferns** were represented by *Selaginella dregei, Cheilanthes virides, Cheilanthes hirta* and *Pellaea calomelanos.*
- The following **alien species** were recorded in this community: *Acacia mearnsii, Campuloclinium macrocephalum, Conyza albida, Einadia nutans* and *Tagetes minuta.*

6. *Protea roupelliae – Alloteropsis semialata* open bushveld

This open bushveld was found in the western, central and northeastern parts of KDNR (Figure 11) and covered approximately 18 ha (14.4% of the total KDNR). The community occurred in the valleys, plains and on slight to moderate slopes of the hills, at a mean altitude of 1705 m (Figures 18 & 19). Surface rocks were often absent, but could cover up to 30% of the area. The shallow, orange, brown and redbrown, sandy loam soils were derived from shale and quartzite.

The diagnostic species included *Protea roupelliae, Helichrysum aureum, Crabbea angustifolia* and *Elionurus muticus* (see species group 12, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 1% and were represented mainly by *Protea roupelliae* and *Searsia leptodictya*.
- **Small trees** (>3–6 m) covered on average 8% of the area and the most prominent species were *Protea roupelliae, Protea caffra, Cussonia paniculata, Searsia pyroides, Searsia leptodictya, Searsia lancea* and *Afrocanthium gilfillanii.* The small trees occurred at a mean density of 167 individuals/ha.
- **Shrubs** had a mean canopy cover of 8% and included *Leucosidea sericea, Buddleja salviifolia, Searsia dentata* and *Diospyros lycioides.* The shrubs occurred at a mean density of 1367 individuals/ha.
- **Dwarf shrubs** had a mean canopy cover of 3% and the common species were *Seriphium plumosum, Elephantorrhiza elephantina, Athrixia elata* and *Phymaspermum athanasioides. Seriphium plumosum* occurred at densities of up to 2500 individuals per ha.
- The **grass layer** was well developed and had a mean canopy cover of 79%. The dominant grass species were *Alloteropsis semialata, Schizachyrium sanguineum, Loudetia simplex, Panicum natalense* and *Trachypogon spicatus.* Other less prominent grass species included *Tristachya rehmannii, Eragrostis chloromelas, Digitaria monodactyla, Cymbopogon caesius, Monocymbium ceresiiforme, Brachiaria serrata, Urelytrum agropyroides, Eragrostis racemosa, Themeda triandra,*

Melinis nerviglumis and *Hyparrhenia hirta*.

Figure 18. Community 6: *Protea roupelliae – Alloteropsis semialata* open bushveld covering the valley in the western section of the Kloofendal Nature Reserve.

Figure 19. Community 6: *Protea roupelliae – Alloteropsis semialata* open bushveld (with individuals of *Protea roupelliae* prominent) in the northeastern parts of the Kloofendal Nature Reserve.

- **Herbaceous species** in this community covered up to 5% of the area. The most conspicuous species were *Nidorella hottentotica, Sphenostylis angustifolia, Crabbea angustifolia, Senecio inornatus, Scabiosa columbaria, Acalypha angustata, Hilliardiella aristata, Commelina africana, Chamaecrista comosa, Hypoestes forskaolii* and *Helichrysum aureonitens.* The **sedges** included *Bulbostylis burchellii* and *Bulbostylis hispidula*.
- The **geophytes** were represented by *Hypoxis rigidula, Ledebouria ovatifolia* and *Ledebouria revoluta,* while the **succulents** included *Aloe greatheadii* subsp. *davyana* and *Crassula capitella.*
- The **ferns** were represented by *Cheilanthes virides* and *Pellaea calomelanos.*
- The following **alien species** were recorded in this community: *Acacia mearnsii, Acacia melanoxylon, Cotoneaster franchetii, Pyracantha angustifolia, Rumex saggitatus* and *Tagetes minuta.*

7. *Searsia discolor – Diheteropogon amplectens – Protea caffra* open bushveld

This open bushveld was found in the northern, northwestern and central parts of KDNR (Figure 11) and covered approximately 9 ha (6.7% of the total KDNR). The community occurred on the plains and gentle footslopes, at a mean altitude of 1677 m (Figure 20). Surface rocks covered from 10 to 30% of the area. The shallow to medium deep, red to redbrown, sandy clayloam soils were derived from shale, schist and quartzite.

The diagnostic species included *Searsia discolor, Nuxia congesta, Digitaria diagonalis* and *Ipomoea crassipes* (see species group 17, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 3% and were represented by *Acacia karroo* (new name *Vachellia karroo*). *Dombeya rotundifolia* and *Olea europaea*.
- **Small trees** (>3–6 m) covered on average 11% of the area and the most prominent species were *Protea caffra, Searsia pyroides, Nuxia congesta. Euclea crispa, Afrocanthium mundianum, Cussonia paniculata, Heteromorpha arborescens, Searsia lancea, Searsia leptodictya* and *Afrocanthium gilfillanii*. The small trees occurred at a mean density of 108 individuals/ha.
- **Shrubs** had a mean canopy cover of 14% and included *Ehretia rigida, Buddleja salviifolia, Leucosidea sericea, Searsia dentata* and *Diospyros lycioides.* The shrubs occurred at a mean density of 1117 individuals/ha.
- **Dwarf shrubs** covered approximately 4% of the area and the most conspicuous species were *Seriphium plumosum, Phymaspermum athanasioides, Clematis brachiata* and *Lippia javanica. Seriphium plumosum* occurred at densities of up to 2400 individuals per ha in this community.
- The **grass layer** was moderately to well developed and had a mean canopy cover of 70%. The dominant grass species were *Diheteropogon amplectens, Schizachyrium sanguineum, Loudetia simplex, Panicum natalense, Trachypogon spicatus, Cymbopogon pospischilii* and *Alloteropsis semialata.* Other less prominent grass

species included *Aristida transvaalensis, Digitaria brazzae, Monocymbium ceresiiforme, Brachiaria serrata, Eragrostis racemosa, Andropogon schirensis, Themeda triandra* and *Melinis repens*.

Figure 20. Community 7: *Searsia discolor – Diheteropogon amplectens – Protea caffra* open bushveld in the north of the Kloofendal Nature Reserve.

- **Herbaceous species** in this community covered up to 3% of the area. The most common species were *Sphenostylis angustifolia, Nidorella hottentotica* and *Pentarrhinum insipidum*.
- The **geophytes** were represented by *Gladiolis crassifolius*, while the **succulents** included *Aloe greatheadii* subsp. *davyana* and *Crassula capitella*.
- The **ferns** were represented by *Cheilanthes virides* and *Pellaea calomelanos*.
- The following **alien species** were recorded in this community: *Acacia melanoxylon, Bidens bipinnata, Cotoneaster franchetii, Physalis peruviana* and *Tagetes minuta*.

8. *Cotyledon orbiculata – Searsia pyroides – Protea caffra* bushveld

This community was found in the central, northern and eastern parts of KDNR (Figure 11) and covered approximately 5 ha (4.2% of the total KDNR). The community occurred on the slight to moderately steep slopes, at a mean altitude of 1707 m (Figures 21 & 22). Surface rocks covered from 5 to 30% of the area. The shallow, brown to redbrown, sandy loam soils were predominantly derived from shale.

The diagnostic species included *Tarchonanthus camphoratus, Ozoroa paniculosa, Cotyledon orbiculata, Macledium zeyheri* and *Crabbea acaulis* (see species group 21, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 4% and were represented by *Celtis africana* and *Searsia lancea*.
- **Small trees** (>3–6 m) covered on average 18% of the area and the most prominent species were *Protea caffra, Searsia pyroides, Cussonia paniculata, Maytenus undata, Euclea crispa, Ficus ingens, Afrocanthium mundianum* and *Afrocanthium gilfillanii.* A local patch of *Tarchonanthus camphoratus* was found in this community (Figure 21). The small trees occurred at a density of 400 individuals/ha.
- **Shrubs** covered approximately 20% of the area and included *Lopholaena coriifolia, Halleria lucida, Searsia dentata, Vangueria infausta* and *Diospyros lycioides.* The shrubs occurred at a density of up to 1900 individuals/ha.
- **Dwarf shrubs** had a mean canopy cover of 6% and included *Athrixia elata, Phymaspermum athanasioides, Lippia javanica, Parinari capensis* and *Seriphium plumosum.*
- The **grass layer** was poorly to moderately developed and had a mean canopy cover of 46%. The dominant grass species were *Loudetia simplex, Schizachyrium sanguineum, Trachypogon spicatus, Panicum natalense* and *Urelytrum agropyroides.* Other less prominent grass species included *Hyparrhenia hirta, Monocymbium ceresiiforme, Brachiaria serrata, Eragrostis racemosa, Diheteropogon amplectens, Themeda triandra, Andropogon schirensis, Cymbopogon pospischilii* and *Melinis repens.*
- **Herbaceous species** in this community covered up to 4% of the area. The most common species were *Plectranthus grallatus, Sphenostylis angustifolia, Nidorella hottentotica* and *Helichrysum coriaceum.*
- The **geophytes** were represented by *Hypoxis rigidula, Boophone disticha* and *Ledebouria revoluta* while the **succulents** included *Cotyledon orbiculata* and *Aloe greatheadii* subsp. *davyana.*
- The **ferns** are represented by *Ptisana fraxinea* and *Pellaea calomelanos*.
- Many **alien species** were recorded in this community: *Acacia mearnsii, Acacia melanoxylon, Achyranthes aspera, Conyza bonariensis, Lantana camara, Physalis peruviana, Schkuhria pinnata, Solanum mauritianum, Solanum rigescens* and *Zinnia peruviana.*

Figure 21. Community 8: *Cotyledon orbiculata – Searsia pyroides – Protea caffra* bushveld with *Tarchonanthus camphoratus* locally prominent.

Figure 22. Community 8: *Cotyledon orbiculata – Searsia pyroides – Protea caffra* bushveld.

9. *Acacia caffra – Gymnosporia buxifolia – Zanthoxylum capense* dense bushveld and bushclumps

This community was found in the central parts of KDNR (Figure 11) and covered approximately 12 ha (9% of the total KDNR). The community occurred in the valley and on slight to moderately steep, north-facing slopes, at a mean altitude of 1687 m (Figures 23 & 24). Surface rocks were absent in places, but could cover up to 50% of the area. The shallow to deep, red to dark brown, sandy loam to sandy clayloam soils were predominantly derived from shale.

The diagnostic species included *Acacia caffra, Gymnosporia buxifolia, Zanthoxylum capense, Grewia occidentalis, Pittosporum viridiflorum* and *Pterocelastrus echinatus* (see species group 27, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 16% and were represented by *Acacia caffra*, *Pittosporum viridiflorum*, *Dombeya rotundifolia, Celtis africana* and *Searsia lancea.*
- **Small trees** (>3–6 m) covered on average 34% of the area and the most prominent species were *Searsia pyroides, Heteromorpha arborescens, Cussonia paniculata, Pterocelastrus echinatus. Kiggelaria africana, Maytenus undata, Euclea crispa, Protea caffra, Ficus ingens, Dovyalis zeyheri, Afrocanthium mundianum* and *Afrocanthium gilfillanii.* The small trees occurred at a density of 400 individuals/ha.
- **Shrubs** covered on average 24% of the area and included *Buddleja salviifolia, Gymnosporia buxifolia, Zanthoxylum capense, Grewia occidentalis, Diospyros lycioides, Ehretia rigida, Halleria lucida, Searsia dentata, Vangueria infausta, Acocanthera oppositifolia, Pavetta gardeniifolia* and *Myrsine africana.* The shrubs occurred at a mean density of 1600 individuals/ha.
- **Dwarf shrubs** had a mean canopy cover of 2% and included *Phymaspermum athanasioides, Seriphium plumosum, Clematis brachiata, Lippia javanica* and *Lannea edulis.*
- The **grass layer** was poorly developed as a result of the high canopy cover of woody species and had a mean canopy cover of 23%. The most prominent grass species were *Hyparrhenia hirta* and *Melinis repens*. Other less conspicuous grass species were *Themeda triandra, Aristida congesta* subsp. *congesta, Bewsia biflora, Eragrostis curvula* and *Setaria sphacelata*.
- **Herbaceous species** in this community covered only approximately 2% of the area. The most common species were *Plectranthus hereroensis* and *Hermannia depressa*.
- The **geophytes** were represented by *Hypoxis rigidula, Bonatea antennifera* and *Ledebouria revoluta*, while the **succulents** included *Aloe greatheadii* subsp. *davyana*,
- The **ferns** were represented by *Pteridium aquilinum, Ptisana fraxinea, Cheilanthes viride*s and *Pellaea calomelanos.*
- The following **alien species** were recorded in this community: *Achyranthes aspera, Cotoneaster franchetii, Cyathula uncinulata, Eucalyptus camaldulensis, Lantana*

camara, Melia azedarach, Physalis peruviana, Phytolacca octandra, Solanum mauritianum, Solanum pseudocapsicum, Solanum rigescens and *Tagetes minuta*.

Figure 23. Community 9: *Acacia caffra – Gymnosporia buxifolia – Zanthoxylum capense* dense bushveld and bushclumps in the vicinity of the amphitheatre.

Figure 24. Community 9: *Acacia caffra – Gymnosporia buxifolia – Zanthoxylum capense* dense bushveld and bushclumps on the footslopes in the central parts of the Kloofendal Nature Reserve.

10. *Cliffortia linearifolia – Buddleja salviifolia – Leucosidea sericea* riparian bushveld and forest

This community was found in the valleys along the streams of KDNR (Figure 11) and covered approximately 12 ha (9.5% of the total KDNR). The community occurred at a mean altitude of 1693 m (Figures 25 & 26). Surface rocks may cover up to 30% of the area. The medium to deep, brown to dark brown, sandy clay to clayey soils were derived from quartzite and shale, with alluvial soils near the streams.

The diagnostic species included *Cliffortia linearifolia, Paspalum dilatatum, Setaria megaphylla, Dais cotinifolia* and *Ehrharta erecta* (see species group 32, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 25% and were represented by *Celtis africana, Searsia lancea, Buddleja saligna* and *Olea europaea*.
- **Small trees** (>3–6 m) covered on average 34% of the area and the most prominent species were *Searsia pyroides, Kiggelaria africana, Dais cotinifolia, Afrocanthium gilfillanii, Ficus ingens, Searsia leptodictya, Ziziphus mucronata, Rhamnus prinoides, Prunus africana* and *Heteromorpha arborescens*.
- **Shrubs** covered on average 32% of the area and included *Leucosidea sericea, Cliffortia linearifolia, Halleria lucida, Vangueria infausta* and *Searsia dentata*.
- **Dwarf shrubs** had a mean canopy cover of 1% and were represented by *Lippia javanica, Seriphium plumosum, Clematis brachiata* and *Ziziphus zeyheriana*.
- The **grass layer** was poorly developed because of the high canopy cover of woody species and had a mean canopy cover of 11%. The most prominent grass species were *Eragrostis curvula, Paspalum dilatatum, Setaria megaphylla, Urochloa mosambicensis* and *Ehrharta erecta*.
- **Herbaceous species** in this community covered up to 2% of the area. The most common species were *Plectranthus grallatus, Sida rhombifolia* and *Oxalis obliquifolia*.
- The **geophytes** were represented by *Ledebouria revoluta* and *Bonatea antennifera*, while the **succulents** included *Aloe greatheadii* subsp. *davyana*.
- The **ferns** were represented by *Ptisana fraxinea* and *Cheilanthus virides*.

Figure 25. Community 10: *Cliffortia linearifolia – Buddleja salviifolia – Leucosidea sericea* riparian bushveld and forest along the upper drainage lines in the Kloofendal Nature Reserve.

Figure 26. *Cliffortia linearifolia – Buddleja salviifolia – Leucosidea sericea* riparian bushveld and forest in the vicinity of the amphitheatre with *Celtis africana* and *Buddleja saligna* some of the prominent indigenous species.

- The following **alien species** were recorded in this community: *Acacia mearnsii, Acacia melanoxylon, Araujia sericifera, Bidens bipinnata, Bryophyllum delagoense, Cotoneaster franchetii, Crotalaria agatiflora, Euryops chrysanthemoides, Ipomoea purpurea, Pennisetum clandestinum, Persicaria capitata, Rhus succedanea, Richardea brasiliensis, Robinia pseudoacacia, Rumex saggitatus, Solanum pseudocapsicum, Tagetes erecta* and *Tagetes minuta.* The alien tree species such as *Acacia mearnsii* and *Acacia melanoxylon* were abundant in places.

11. Eucalyptus camaldulensis – Solanum mauritianum woodlots

These patches of predominantly alien trees were found in the west and southeast of KDNR (Figure 11) and covered approximately 2 ha (1.7% of the total KDNR). The community occurred at a mean altitude of 1672 m (Figure 27).

The diagnostic species included the aliens *Eucalyptus camaldulensis* and *Eucalyptus cinerea* (see species group 38, Table 6).

- **Tall trees** (>6 m) had a mean canopy cover of 70% and were represented by the aliens *Eucalyptus camaldulensis* and *Eucalyptus cinerea*.
- **Small trees** (>3–6 m) covered on average 20% of the area and the most prominent species were *Searsia pyroides, Kiggelaria africana* and *Afrocanthium gilfillanii.*
- **Shrubs** covered on average 10% of the area and included *Leucosidea sericea, Vangueria infausta* and *Zanthoxylum capense.*
- **Dwarf shrubs** had a mean canopy cover of 1% with *Lippia javanica* the only dwarf shrub recorded.
- The **grass layer** was poorly developed and had a mean canopy cover of 5%. The grass species included *Ehrharta erecta, Sporobolus africanus, Cynodon dactylon, Melinis repens* and *Pennisetum clandestinum.*
- **Herbaceous species** in this community covered up to 2% of the area. The most common species were *Plectranthus grallatus, Pentarrhinum insipidum* and *Cucumis zeyheri.*
- No **geophytes, sedges** or **succulents** were recorded in this degraded community.
- The **ferns** were represented by *Ptisana fraxinea.*
- The following **alien species** were recorded in this community: *Acacia mearnsii, Achyranthes aspera, Amaranthus hybridis, Bidens pilosa, Celtis australis, Cestrum laevigata, Cyathula uncinulata, Eucalyptus camaldulensis, Eucalyptus cinerea, Euryops chrysanthemoides, Ipomoea purpurea, Lantana camara, Mirabilis jalapa, Pennisetum clandestinum, Phytolacca octandra* and *Solanum mauritianum.*

Figure 27. Community 11: *Eucalyptus camaldulensis – Solanum mauritianum* woodlots on the western boundary of the Kloofendal Nature Reserve.

12. *Cynodon dactylon – Eragrostis curvula* degraded or developed land

This unit consists of degraded land and the areas of the old mine, as well as the terrain around the offices and main entrance road of KDNR (Figure 11) and covered approximately 8 ha (6.5% of the total KDNR) (Figures 28, 29 & 30). Surface rocks were mostly absent.

This was a diverse community and the diagnostic species included *Cynodon dactylon, Hyparrhenia tamba, Hyparrhenia dregeana* and *Conyza podocephala* (see species group 42, Table 6).

- **Tall trees** (>6 m) were represented by *Combretum erythrophyllum, Acacia caffra, Celtis africana, Celtis australis, Kiggelaria africana* and *Olea europaea*.
- **Small trees** (>3–6 m) included *Searsia lancea*, *Searsia pyroides* and *Rhamnus prinoides*. The tree *Buddleja saligna* was locally abundant.
- **Shrubs** were represented by *Searsia rigida, Diospyros lycioides* and *Tecoma capensis.*
- **Dwarf shrubs** had a mean canopy cover of 2% and included *Lippia javanica* and *Plumbago zeylanica.*

Figure 28. Community 12: *Cynodon dactylon – Eragrostis curvula* degraded or developed land in the uplands in the south of the Kloofendal Nature Reserve.

Figure 29. *Community 12: Cynodon dactylon – Eragrostis curvula* degraded or developed land. with *Acacia mearnsii* encroachment along the drainage line in the southeast of the Kloofendal Nature Reserve.

Figure 30. *Community 12: Cynodon dactylon – Eragrostis curvula* degraded or developed land along the western boundary of the Kloofendal Nature Reserve with *Cosmos bipinnatus* prominent.

- The dominant **grass species** were *Eragrostis curvula, Eragrostis chloromelas, Cynodon dactylon* and *Hyparrhenia hirta*, while *Hyparrhenia tamba* and *Hyparrhenia dregeana* were locally abundant. Other less prominent grass species included *Melinis repens, Eragrostis gummiflua, Melinis nerviglumis, Pennisetum clandestinum, Paspalum notatum* and *Urochloa panicoides.*
- **Herbaceous species** were represented by *Conyza podocephala, Selago densiflora, Pentarrhinum insipidum, Senecio inornatus, Polydora poskeana, Leonotis ocymifolia* and *Plantago lanceolata.*
- No **geophytes** and **sedges** were recorded. The succulents are represented by *Aloe arborescens* that occurred in the gardens at the offices.
- The following **alien species** were recorded in this community: *Acacia mearnsii, Acacia melanoxylon, Celtis australis, Chenopodium album, Cosmos bipinnatus, Gomphrena celosioides, Ipomoea purpurea, Pennisetum clandestinum, Richardia brasiliensis, Tagetes minuta, Trifolium repens* and *Verbena bonariensis.*

4.7 Woody vegetation structure

The primary elements of vegetation structure are growth form (trees and shrubs), stratification (layers), cover and density. Vegetation structure can relate to the feeding pattern of wildlife as well as the suitability of a habitat for different types of browsers. The available leaf mass and volume at different height levels are valuable in determining the suitability of a habitat for browsers. The density of the woody species can also affect the condition of the

herbaceous layer.

The locally dominant or most widespread woody species in the KDNR in terms of cover, density and distribution were:

Acacia caffra
Buddleja salviifolia
Celtis africana
Diospyros lycioides
Englerophytum magalismontanum
Heteromorpha arborescens
Leucosidea sericea
Protea caffra
Protea roupelliae
Searsia lancea
Searsia leptodictya
Searsia pyroides

4.7.1 Cover

The mean percentage canopy cover of the different strata in communities 1 – 11 are summarised in Table 7. There was a marked division between the cover of woody species in the grassland communities (communities 3 – 5), the open bushveld communities (communities 6 & 7) and the dense bushveld and forest communities (communities 8 – 10). Communities 6 & 7 are typical bushveld and are transitional between the grassland and dense bushveld and forest/woodlot communities (communities 8 – 11). High canopy cover of woody species, especially where closed canopies occur, usually have a marked impact on the grass cover due to competition for soil moisture and through shading, e.g. communities 9 – 11 (Figure 11).

Table 7. Mean canopy cover (%) of communities 1 to 11 on Kloofendal Nature Reserve

	Rocky outcrops		Grassland			Open bushveld		Dense bushveld & forest			Wood-lot
	1	2	3	4	5	6	7	8	9	10	11
Tall trees (>6 m)	1	0	0	0	0	1	3	4	16	25	70
Small trees (3 – 6 m)	4	1	1	2	3	8	11	18	34	34	20
Shrubs (<3 m)	10	8	3	2	2	8	14	20	24	32	10
Total woody	15	9	4	4	5	17	28	42	74	91	90
Dwarf shrubs	7	3	2	3	2	3	4	6	2	1	1
Grasses	34	44	68	75	83	79	70	46	23	11	5
Forbs	4	5	4	3	2	5	3	4	2	2	2

The relationship between the total woody cover (tall tree, small tree plus shrub layer) and grass cover is illustrated in Figure 31 (rocky outcrops omitted from graph). It is evident that the

higher the woody cover the lower the grass cover (see communities 8, 9, 10 & 11, Table 7). The grass cover is particular low when the total woody cover exceeds 50% and the mean percentage grass cover in these communitiues can be as low as 5%.

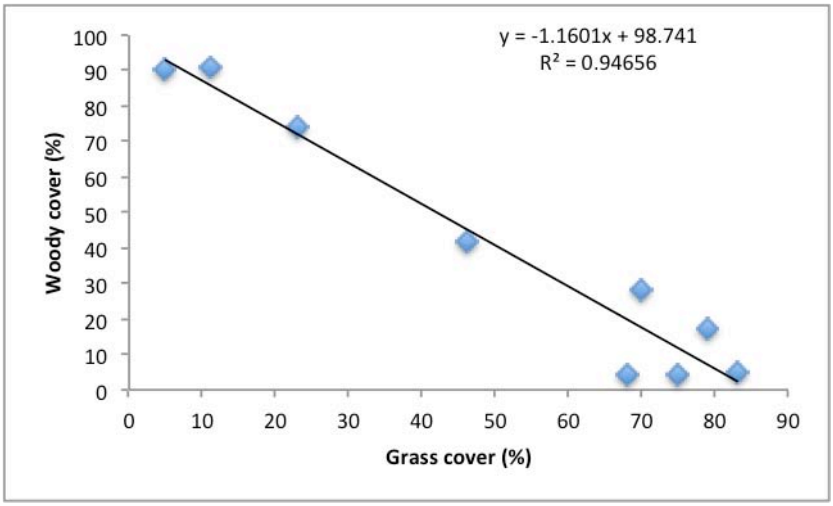

Figure 31. Relationship between total woody and grass cover using data of communities 3 - 11.

4.7.2 Density

The mean density of the tall tree, small tree and shrub layers for communities 1, 6, 7, 8 & 9 is summarised in Table 8.

The density of *Lopholaena coriifolia* (fluff bush) was determined in community 2 where up to 3300 individuals per ha were recorded. The density of *Seriphium plumosum* (bankrupt bush) in communities 6 & 7 was 2350 and 2400 individuals per ha respectively. The highest tree and shrub densities occurred in communities 8 & 9. The high woody density in communities 8 and 9 could be mainly attributed to *Searsia pyroides*, *Acacia caffra, Protea caffra, Celtis africana, Buddleja salviifolia* and *Diospyros lycioides*.

Table 8. Approximate density of woody species (ind./ha) in some communities on the Kloofendal Nature Reserve

Community	1	2	6	7	8	9
Tall trees (>6 m)	0	-	0	0	-	-
Small trees (3 - 6m)	100	-	167	108	400	400
Shrubs (<3 m)	600	-	1367	1117	1900	1600
Dwarf shrubs (<1 m)	-	3300	2350	2400	-	-

CHAPTER 5

VELD CONDITION, GRAZING CAPACITY AND BROWSING CAPACITY

5.1 Introduction

Veld condition, and consequently the grazing capacity of any area, will generally vary from season to season, depending mainly on the rainfall, and also to a certain extent on past and present grazing pressure. Each plant communities in a particular area is associated with a specific habitat, has its own diagnostic species composition, and therefore also has its own specific grazing and browsing capacity.

5.2 Veld condition and grazing capacity assessment (March 2014)

5.2.1 Definitions

The following basic definitions and principles have been applied in the determination of the grazing capacity of the KDNR:

Stocking density:
The stocking density is the number of large herbivores that are kept on a given unit of land surface (e.g. a hectare). The stocking density depends on a management decision that is based on the objectives for the KDNR, but it must be within the ecological capacity of the habitat to support grazing and browsing herbivores. Low stocking densities relative to the ecological capacity of the habitat are aimed at the maximum meat production per animal unit (kg per animal), whereas high stocking densities are aimed at the maximum meat production per unit area (kg per ha).

Grazing capacity:
In the current agricultural usage in South Africa, grazing capacity is the area of land that is required to maintain a Large Animal Unit (LAU) in order to achieve maximum profit in the short term, while maintaining the condition of the vegetation and soil in such a way as to be able to fulfil the needs and aspirations of future land users. Defined in this way, grazing capacity is either expressed as ha per Large Animal Unit, or as Large Animal Units per ha. For wildlife, grazers and browsers are separated and the grazing and browsing capacity are expressed in terms of Grazer Units (GU) per 100 ha and Browser Units (BU) per 100 ha.

Economic and ecological capacity:
When wildlife is introduced to an area, their numbers will increase from an initial low to a level where resources such as available food, water and shelter become limiting. Numbers increase slowly at first and once a critical stage is reached, the growth rate at first becomes exponential and the population size increases rapidly. At a certain upper level, density-

dependent factors such as competition for resources sets in and lower fecundity and increased mortality result in a leveling-off of population growth to a point where births equal deaths, and net growth (or yield) is zero (S-curve). In practice, the ultimate population density fluctuates around an upper level, which arises from, for example, variations in rainfall, interspecific competition, predator-prey relations or accidental fires. The level around which the population oscillates is known as the **ecological capacity.** It is the population level that is likely to exist in unmanaged large natural areas. Fluctuations in numbers can be quite dramatic, with severe crashes occurring during catastrophes such as periods of prolonged drought or disease epidemics.

If a population is being maintained below the ecological capacity by cropping or capture, the net growth of the population is positive, as there is room for expansion in the form of resource abundance. The population is then held at an **economic capacity**, implying that this capacity is efficient in ensuring a positive growth rate. There is no one single economic capacity but it is usually set at 70 of the ecological capacity. There is also a point at which maximum sustained yield (MSY) is obtained, which is usually around 50% of the ecological capacity (or more or less in the middle of the exponential phase).

Allowing certain wildlife to attain high densities may impact negatively on other more sensitive ones. Therefore, should the management objective be to increase wildlife diversity, the numbers of aggressively competitive wildlife have to be controlled.

Grazing capacity for wildlife:
This concept reflects the ecological production potential of the grazeable portion of a homogeneous unit of vegetation, and represents the area of land (ha) that is required to maintain a single Grazer Unit (GU) over an extended number of years without deterioration of the vegetation or the soil. A blue wildebeest *Connochaetes taurinus taurinus* with a mass of 180 kg is taken as being equivalent to a Grazer Unit. The grazing capacity for wildlife is expressed as the number of Grazer Units per 100 ha.

Browsing capacity for wildlife:
This concept reflects the ecological production potential of the browseable portion of a homogeneous unit of vegetation and is expressed as the area of land (ha) that is required to maintain a single Browser Unit (BU) over an extended number of years without deterioration of the vegetation or the soil. A Greater kudu *Tragelaphus strepsiceros* of 180 kg is taken as being equivalent to a Browser Unit. The browsing capacity for wildlife is expressed as the number of Browser Units per 100 ha.

In combination, the ecological grazing and browsing capacity form the ecological capacity of the vegetation (habitat) to support large herbivores. In essence the ecological capacity for herbivores of a habitat is the maximum number of grazers and browsers that a given area of land can sustain based on the biophysical resources of the area at a given time. Depending on the management objectives, the ***economic*** grazing and browsing capacities

can be adjusted, provided that it remains within the limits set by the ***ecological*** capacity of the area for herbivores. For optimum wildlife production on a reserve, the ***economic*** grazing capacity is usually set at 70 of the ***ecological*** grazing capacity.

Different equations have been proposed to calculate the grazing/browsing capacity of an area. In general, by combining an ecological or veld condition index; the grass production and/or canopy cover; rainfall; the incidence of fire; the accessibility of the terrain; the grazing habits and social behaviour of the wildlife, it is possible to estimate an ecological capacity for a particular plant community based on the quantity and quality of the plant resources that are available.

At a broad scale the following four habitat types were distinguished on the KDNR:

- Shrubland of rocky outcrops (communities 1 & 2) covering 26 ha;
- Grasslands (communities 3, 4 & 5) covering 36 ha;
- Open bushveld (communities 6 & 7) covering 27 ha;
- Dense bushveld and forests (communities 8, 9 & 10) covering 29 ha; and
- Infrastructure, old mine, gardens and alien vegetation (communities 11 & 12) covering 10 ha.

About 30% of the KDNR is not suitable and/or accessible for grazing by wildlife. This includes the dense woody vegetation of the valley and north-facing slopes, bush clumps and rocky ridges as well as the areas covered by the infrastructure, old mine, gardens and alien vegetation. These areas were excluded from the calculations to avoid overestimating the grazing capacity of the reserve. The area that was used to calculate the grazer stocking density was 90 ha (70% of the KDNR) and about 56 ha was considered suitable for browser types of wildlife. The fenced section in the southeastern part of the reserve was excluded.

5.2.2 Veld condition

A veld condition index of <40% usually reflects dominance by many unpalatable 'sour' grasses and forbs (Class 3, 4 & 5), some with low cover and low biomass production and bare soil, and consequently indicates veld that is in poor condition for grazers. Veld that is in a moderate condition has a veld condition index of 40% to 55%, and veld in good condition has a veld condition index of >55% to 70%, with a high grass cover (usually >70%) and a high presence of perennial Class 1, Class 2, and some Class 3 species. Excellent veld has a veld condition index higher than 70%, and is dominated by Class 1 grass species. Apart from the different classes of the herbaceous species (grasses and forbs), the impact of dense woody layers, steep and rocky slopes, accessibility and the temporary negative impact of fire on biomass production, has an influence on the grazing capacity of each community.

The veld condition index of the different plant communities in the KDNR ranged from 24% (very poor) to 48% (moderate) with a mean of 36% (poor)(Table 9). About 55% of the KDNR

was in moderate condition with veld condition indices from 40% to 48%, while 45% of the reserve was in poor condition. From a grazing point of view the veld in the reserve was therefore not in a good condition. However, the poor to moderate veld condition does not necessarily reflect poor veld management on the reserve, but is the consequence of the sour, unpalatable grass species composition that is typical of the Highveld grasslands. These grass species thrive under high rainfall conditions and leached sandy soils, usually derived from quartzite or sandstone.

It is recommended that the veld condition of the different communities be monitored regularly. Initially, monitoring should be done annually to build up a database and to establish whether the veld is improving with new management initiatives.

Table 9. Veld condition and grazing capacity of the KDNR at mean annual rainfall (720 mm)

Plant community	1	2	3	4	5	6	7	8	9	Total
Area (ha)	6	20	6	10	20	18	9	5	12	106
Percentage tree cover	5	1	1	2	3	9	14	22	50	
Percentage shrub cover	10	8	3	2	3	2	3	4	6	
Bush factor	0.93	0.97	0.98	0.98	0.97	0.93	0.90	0.84	0.65	
Ecological classes (%)										
Class 1	4	7	4	15	12	4	5	6	5	
Class 2	9	3	3	11	6	11	21	6	8	
Class 3	19	22	9	12	25	27	40	24	14	
Class 4	17	10	49	17	21	33	15	23	9	
Class 5	38	51	35	45	36	25	19	26	29	
Bare area	13	7	0	0	0	0	0	15	35	
Total	100	100	100	100	100	100	100	100	100	
Veld condition index (%)	30	29	34	40	41	41	48	34	24	36
Percentage grass cover	34	44	68	75	83	79	70	46	23	
Mean annual rainfall	720	720	720	720	720	720	720	720	720	
Accessibility	0.8	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.9	
Fire	0.9	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0	
Ecological grazing capacity at mean annual rainfall										
Number GU per 100 ha	26	30	45	49	49	45	44	34	25	
Number GU (game)	2	6	3	5	10	8	4	2	3	42
Mean grazing capacity (GU per 100 ha) =										39
Economical grazing capacity at mean annual rainfall										
Number GU per 100 ha	18	21	32	34	34	31	31	24	18	
Number GU (game)	1	4	2	3	7	6	3	1	2	29
Mean grazing capacity (GU per 100 ha) =										27

5.3 Veld condition and grazing capacity per community in 2014 (Table 9)

1. *Helichrysum lepidissimum – Vangueria parvifolia – Englerophytum magalismontanum* shrubland

Community 1 is in poor condition with a veld condition index of 30% (Table 9). The mean grass cover on these rocky outcrops was only 34% and bare surface had a frequency of 13%. Class 5 species (unpalatable grass and forb species) were dominant, although Class 3 species (tufted grass species, with a high productivity but a low grazing value) and Class 4 species (unpalatable and perennial grass species with an intermediate productivity and a low grazing value) were also abundant. Overall the grass layer was thus dominated by unpalatable species with a low grazing value. The economic grazing capacity for community 1 was 18 Grazer Units per 100 ha (11.1 ha/LAU) and on the 6 ha, one GU can be sustained.

2. *Adromischus umbraticola – Aristida transvaalensis – Englerophytum magalismontanum* wooded grassland

Community 2 was also in a poor veld condition with a veld condition index of 29% (Table 9). The mean grass cover in this rocky community was 44%. Class 5 species had a frequency of >50% and Class 3 species were also abundant. The economic grazing capacity for community 2 was 21 Grazer Units per 100 ha (9.5 ha/LAU) and on the 20 ha, 4 GUs can be sustained.

3. *Crassula sarcocaulis – Loudetia simplex* grassland

This grassland was also in a poor veld condition with a veld condition index of 34% (Table 9) although the mean grass cover in community 3 was as high as 68%. Class 4 species dominated with Class 5 species showing the second highest frequency. The economic grazing capacity for this grassland was 32 Grazer Units per 100 ha (6.3 ha/LAU) and on the 6 ha, 2 GUs can be sustained.

4. *Senecio coronatus – Panicum natalensis – Loudetia simplex* wooded grassland

Community 4 was in a moderate veld condition with a veld condition index of 40% (Table 9). The mean grass cover in this rocky community was 70%. Class 5 species dominated, with Classes 1 – 4 grass species making more or less equal contributions. Class 1 species, being valuable and palatable grass species with a high productivity and high grazing value, had the highest frequency (15%) in this community. The economic grazing capacity for community 4 was 34 Grazer Units per 100 ha (5.9 ha/LAU), together with community 5 the highest value for the reserve. The 10 ha of this grassland will be able to sustain 3 GUs.

5. *Chascanum hederaceum – Tristachya rehmannii – Schizachyrium sanguineum* wooded grassland

This grassland was also in a moderate veld condition with a veld condition index of 41% (Table 9). The mean grass cover in community 5 was 83%, the highest grass cover of all communities. However, Class 5 species were dominant and Classes 3 & 4 species were also abundant. Class 1 species were also fairly well represented. The economic grazing capacity for this grassland was 34 Grazer Units per 100 ha (5.9 ha/LAU), and together with community 4 the highest value for the reserve. The 20 ha of this grassland will be able to sustain 7 GUs.

6. *Protea roupelliae – Alloteropsis semialata* open bushveld

Community 6 was in a moderate veld condition with a veld condition index of 41% (Table 9). The mean grass cover in this open bushveld was 79%. Classes 3, 4 & 5 species were almost equally represented and Classes 1 and 2 species (tufted grass species with an intermediate productivity and moderate grazing value) were not abundant. The economic grazing capacity for community 6 was 31 Grazer Units per 100 ha (6.5 ha/LAU) and on the 18 ha, 6 GUs can be sustained.

7. *Searsia discolor – Diheteropogon amplectens – Protea caffra* open bushveld

This open bushveld was in a moderate veld condition with a veld condition index of 48% (Table 9), the highest veld condition index on the reserve. The mean grass cover in community 7 was 70%. Class 3 species dominated with Class 2, 4 and 5 species also well represented. The economic grazing capacity for this open bushveld was 31 Grazer Units per 100 ha (6.5 ha/LAU) and on the 9 ha, 3 GUs can be sustained.

8. *Cotyledon orbiculata – Searsia pyroides – Protea caffra* bushveld

Community 8 was in a poor veld condition with a veld condition index of 34% (Table 9). There were many bare areas and the mean grass cover in this dense bushveld was only 46%, mainly as a result of the high cover of woody species. Classes 3, 4 & 5 species were almost equally represented and Classes 1 and 2 species were scarse. The economic grazing capacity for community 8 was 24 Grazer Units per 100 ha (8.3 ha/LAU) and 1 GU can be sustained on the 5 ha covered by this community.

9. *Acacia caffra – Gymnosporia buxifolia – Zanthoxylum capense* dense bushveld

This dense bushveld was in a poor veld condition with a veld condition index of only 24% (Table 9), the lowest veld condition on the reserve. The mean grass cover in this dense bushveld was only 23%, mainly because of the shading effect of the dense tree layer. Bare areas with no herbaceous species within a 50 cm radius of the step point had the highest frequency. Classes 3 and 5 species were best represented. The economic grazing capacity

for community 9 was 18 Grazer Units per 100 ha (11.1 ha/LAU) and on the 12 ha, 2 GUs can be sustained.

10. *Cliffortia linearifolia – Budleja salviifolia – Leucosidea sericea* riparian bushveld and forest

No veld condition assessment was conducted since this habitat is not suitable for grazers.

11. *Eucalyptus camaldulensis – Solanum mauritianum* woodlot

No veld condition assessment was conducted since this habitat is not suitable for grazers.

12. *Cynodon dactylon – Eragrostis curvula* degraded or developed land

No veld condition assessment was conducted since this habitat is not suitable for grazers.

5.4 Variation in grazing capacity

Rainfall is the main determinant of forage production in the savanna environment. Since rainfall varies widely from year to year, often with an alternating series of wet and dry years, forage production varies widely over time. Consequently, regular field surveys have to be done to advise on adjusting the stocking densities to the quantity and quality of the forage at a specific point in time.

The mean ecological and economic grazing capacity for the KDNR was calculated for the individual plant communities at mean annual rainfall (720 mm per annum), as well as the expected economic grazing capacity at above-mean (800 mm per annum) and below-mean annual rainfall (600 mm per annum). These mean values for KDNR are provided in Table 10 and represent the expected variation in the vegetation quality and quantity in KDNR as a result of possible rainfall fluctuation and grass biomass production. The economic grazing capacity can consequently range from a low of 20 GU/100 ha (10.0 ha/LAU) at below mean rainfall conditions (600 mm), to a high of 33 GU/100 ha (6.1 ha/LAU) at above mean rainfall conditions (800 mm). It should be noted that according to the rainfall statistics provided in Table 3 in two out of every 10 years the rainfall is expected to be below 600 mm per annum. Furthermore, it is important to realize that this variation was calculated on the current (2014) veld condition. Should the veld condition improve or deteriorate these threshold values will change accordingly.

It should be noted that Kuschke & Malherbe (2014) found that dry and wet seasons tend to cluster together and according to their predictions extended droughts may come into effect from 2018 onwards.

Table 10. Ecological and economic grazing capacity uoder mean annual rainfall conditions (720 mm p.a), above-normal (800 p.a.) and below-mean (600 mm p.a.) rainfall conditions (GU/BU method) for the Kloffendal Nature Reserve

	Ecological capacity		Economic capacity	
	GU per 100 ha	ha/LAU	GU per 100 ha	ha/LAU
Mean rainfall (720 mm p. a.)	39	5.1	27	7.4
Above-mean rainfall (800 mm p. a.)	46	4.3	32	6.2
Below-mean rainfall (600 mm p. a.)	29	6.9	20	10.0

5.5 Browsing capacity

The application of only the agricultural Large Animal Unit (LAU) concept does not allow for the ecological separation of herbivorous ungulates into feeding classes such as grazers, mixed feeders and browsers, and thus overlooks the potential for using the specialized and complementary resource use habits of wild ungulates to maximize veld utilization (Snyman 1991; Peel *et al.* 1994; Dekker 1996, 1997; Bothma 2010). The combined Grazer Unit/Browser Unit (GU/BU) method was specifically developed to incorporate complementary resource use by ungulates to maximize veld utilisation. The Grazer Unit/Browser Unit method of Bothma *et al.* (2004) was used to determine the approximate grazing capacity of KDNR (Table 9). The browsing capacity must be assessed separately and together with the grazing capacity this represents the full capacity of the reserve to carry wildlife. The recommended stocking densities for the KDNR are discussed in Chapter 6.

Browse is the sum total of woody plant material that is potentially edible for a specific set of herbivores in a specific area. The term *available browse* indicates a more restricted quantity and includes all the leaves, twigs, bark, flowers and pods that are within reachable height of a given type of browser. The browsable volume is usually limited to the foliage up to 2 m for most browsers, and up to 5.5 m for wildlife such as the giraffe and elephant.

The available browse is influenced by the following factors:

- the density of woody plants;
- the amount of leaf material within reach of an animal;
- the species composition of the woody vegetation;
- the growth potential of woody species;
- phenology of woody species (time when in leaf, flower and fruit);
- chemical defences of woody plants e.g. condensed tannins that affect the palatability and digestibility of the leaves of the woody vegetation; and
- structural defences e.g. spines and thorns.

Browsers are limited by their food supply rather than other factors such as water and territoriality. The browse supply in the late dry season imposes a limit on the stocking density for browsers. Greater kudu mortalities in the bushveld region of South Africa have been attributed to sudden cold spells (pneumonia), disease (anthrax) and, most importantly, the lack of **evergreen** palatable plant species for the kudus to survive the late dry season (low resource availability). These conditions are often responsible for mortalities when wildlife (e.g. nyala and gemsbok) are introduced into areas with unsuitable habitat and climate (Bothma & Van Rooyen 2004; Bothma 2010).

The browsing capacity on a reserve is difficult to assess, especially when mixed feeders, that can switch seasonally and even daily between grazing and browsing are present. The economic browsing capacity for the KDNR was estimated at approximately 8 Browser Units per 100 ha for those communities that contain suitable browse (communities 6 – 10). This value does not refer to the number of animals, but includes the contribution of grazers and mixed feeders to the browsing in their diet (see tables in Chapter 6). This estimate is based on accessibility of the terrain, the woody plant species composition and density and the known browsing capacity values for different savanna areas. A detailed quantitative survey of the woody layer is needed where tree/shrub leaf volumes are determined to calculate the browsing capacity more accurately.

5.6 Alternative approaches to determine the grazing capacity of the KDNR (Schmidt *et al.* 1995, Bothma 2010)

Other methods are available to estimate short and long-term grazing and browsing capacities. These methods were developed in savanna regions of southern Africa. In most of these methods, the ecological capacity is expressed in terms of a Large Animal Unit (LAU), which is the equivalent of a steer of 450 kg and a dry matter intake of 10 kg/day.

- **Agricultural recommendation**

The estimated **agricultural grazing capacity** for the region, according to the 2007 carrying capacity map of South Africa, ranges from 7 - 9 ha/LAU, depending on the vegetation condition and topography (Agricultural Research Council 2007).

- **Combined veld condition and rainfall method (Danckwerts 1989)**

This model involves the following:

GC = {-0.03 +0.00289 x (X1) + [(X2 - 419.7) x 0.000633]}

where: GC = grazing capacity in large stock units per hectare (LAU/ha)
X1 = veld condition index (%)
X2 = mean annual rainfall (here 550 mm)

Using the veld condition indices that were calculated in Table 9, and using a mean annual rainfall of 720 mm, the ecological grazing capacity for the KDNR was calculated as 3.8 ha/LAU (= 53 Grazer Units per 100 ha). If the economic grazing capacity is taken as 70% of the ecological grazing capacity, an economic capacity of approximately **5.4 ha/LAU** (= 37 Grazer Units per 100 ha) for the KDNR was obtained.

- **Herbaceous phytomass method (Moore & Odendaal 1987)**

In this method, the stocking density for grazer species is calculated from the herbaceous phytomass data (see Table 11) by using the following equation:

$$SR = \text{phytomass (kg/ha)} \times 0.35^{b} / (10^{bb} \times 365^{bbb})$$

where:

SR = stocking density in large animal units per hectare per year
B = a utilisation factor: only 35% of the herbaceous material is grazed while 30% remains as tufts and stubbles and 35% is lost to other environmental factors
bb = 10 kg feed per day is required per large stock unit
bbb = number of days in a year

Table 11. Grass biomass of the different plant communities of KDNR and ecological grazing capacity according to the equation of Moore & Odendaal (1987)

Plant community number	Area (ha)	Biomass (kg/ha)	ha/LAU	LAU/ community	GU/100 ha	GU/ community
2	20	2642	3.9	5.1	51	10.1
3	6	3878	2.7	2.2	74	4.5
4	10	3319	3.1	3.2	64	6.4
5	20	3119	3.3	6.0	60	12.0
6	18	3004	3.5	5.2	58	10.4
7	9	2887	3.6	2.5	55	5.0
8	5	3341	3.1	1.6	64	3.2
12	2	5681	1.8	1.1	109	2.2
Total	90			26.8		53.7
			Mean	3.4		59.6

The phytomass of the herbaceous layer was determined with the Disc Pasture Meter (Trollope & Potgieter 1986; Dörgeloh 2002; Zambatis *et al*. 2006; Table 11), which provides a measure of the dry mass of the available grass in a given area. The grazing capacity of the KDNR according to this method is approximately 3.4 ha/LAU (= 59 Grazer Units per 100 ha). If the economic grazing capacity is taken as 70% of the ecological grazing capacity, an economic capacity of approximately **4.8 ha/LAU** (= 41.5 Grazer Units per 100 ha) was obtained.

- **Rainfall method (Coe, Cumming & Phillipson 1976)**

In African savannas a significant relationship was found ($r^2 = 0.94$, $P < 0.001$) between rainfall (range: 165 to 650 mm) and large herbivore biomass (range: 405 to 4 848 kg/km²). The equation derived was:

Large Herbivore Biomass (kg/km²) = 8.684 x (mean annual rainfall in mm) - 1205.9

The herbivore biomass data included wildlife counts from east and southern Africa and a wide range of the most common large African grazers and browsers. Herbivore biomass estimates that were obtained from the above equation would therefore represent first approximations of the combined grazing and browsing capacity of an area. Shortcomings of this approach are that the broad relationship between biomass and rainfall does not take into account local temporal and spatial variations in the habitats. Furthermore, the model was based on animal numbers that were obtained from a wide variety of counting methods.

Although a rainfall of 720 mm p.a. is slightly beyond the range of the equation, the Large Herbivore Biomass for the KDNR calculates to 5047 kg/km² or 6309 kg for the 128 ha of the property. In terms of LAU this converts to about 14 LAU. As a result, an ecological and economic stocking density of 8.9 ha/LAU and 12.7 ha/LAU respectively were obtained. At 12.7 ha/LAU, about 10 LAUs can be accommodated on the KDNR.

By comparison, the approximate **economic grazing capacities** (ha/LAU) determined by the different methods are:

Agricultural Research Council estimates (2007):	**7 - 9 ha/LAU (22 - 29 GU/100 ha)**
GU/BU method (Bothma *et al*. 2004)(only grazing component)	**7.4 ha/LAU (27 GU/100 ha)**
Veld condition/rainfall method (Danckwerts 1989)	**5.4 ha/LAU (37 GU/100 ha)**
Herbaceous phytomass method (Moore & Odendaal 1987)	**4.8 ha/LAU (41.5 GU/100 ha)**
Rainfall/wildlife biomass method (Coe *et al*. 1976)	**12.7 ha/LAU (16 GU/100 ha)**

Conclusion: The Grazer Unit/Browser Unit method resulted in a mean ecological and economic grazing capacity of 5.1 ha/LAU and 7.1 ha/LAU respectively. The GU/BU Unit method value was therefore within the range of the ARC but more conservative than the methods of Danckwertz (1989) and Moore & Odendaal (1987), but not as conservative as the value derived by the Rainfall/Wildlife biomass equation of Coe *et al.* (1976).

CHAPTER 6

WILDLIFE ASSESSMENT

6.1 Introduction

Distribution maps indicating the perceived natural range of wildlife in southern Africa were drawn by Du Plessis (1969); Mills & Hes (1997); Friedmann & Daly (2004); and Skinner & Chimimba (2005). The Department of Environmental Affairs (DEA) compiled the most recent preliminary draft distribution maps in 2012 (CVDB2@environment.gov.za). Wildlife that historically occurred in the Gauteng region and those that did not occur in the area in the past, are listed below.

6.2 Wildlife historically present and absent in the region

- Wildlife that historically occurred in the area are the black wildebeest, blesbok, blue wildebeest, plains zebra, grey duiker, eland, klipspringer, mountain reedbuck, ostrich, red hartebeest, springbok and steenbok. However, the distribution maps of DEA (2012) indicate that the natural range of blue wildebeest and plains zebra did not cover the southern parts of Gauteng.

- The KDNR is on the boundary of the natural distribution range for herbivores such as grey rhebok, hippopotamus, impala, kudu, oribi, sable antelope, southern reedbuck, tsessebe, white rhinoceros and warthog. These species, e.g. grey rhebok and oribi could be introduced in the KDNR depending on the presence of suitable habitat. However, the distribution maps of DEA (2012) indicate that the natural range of the impala, kudu, sable antelope, tsessebe and white rhinoceros did not cover the southern parts of Gauteng.

- Wildlife that did not occur in the area historically are the black rhinoceros, blue duiker, bontebok, buffalo, bushbuck, bushpig, Cape grysbok, Cape mountain zebra, gemsbok, giraffe, Hartmann's zebra, Lichtenstein hartebeest, Livingstone eland, nyala, red duiker, roan antelope, Sharpe's grysbok, suni and waterbuck. The species that were historically absent from the area are not recommended for the KDNR.

6.3 Additional considerations when selecting suitable species

- Only one of the two wildebeest species, e.g. black wildebeest, can be accommodated because of the possibility that they may interbreed with fertile offspring. However, black wildebeest bulls may show aggressive behaviour and should be monitored for such behaviour if introduced.

- Ostriches are not recommended because of the danger that the males may pose to hikers.

- The grasslands on the plateaux and mixed bushveld and shrubland and ridges may provide suitable habitat for oribi and klipspringer respectively. However, klipspringer and oribi usually do not thrive where high levels of human activity are present.

- The vegetation on the KDNR is only marginally suitable for browser species. This is due to the difficult terrain and the lack of palatable semi-evergreen and evergreen plant species to survive the late winter and early spring period. Open bushveld, dense bush and forested kloofs may accommodate giraffe, kudu, nyala and bushbuck, and mixed feeders such as impala and eland. However, many of these species did not historically occur in the region. Furthermore, for eland and kudu the fence around the reserve must meet the specifications of GDARD before these species can be introduced.

- Nyala and bushbuck did not historically occur in the region and are therefore not recommended for the KDNR.

- The sour veld and dense bush in KDNR are generally not suitable for sable antelope, except for the open bushveld of communities 6 & 7 (covering 33 ha). Sable antelope are sensitive to competition from other animals, especially competition from large herds of short grass grazers such as plains zebra, black wildebeest and blesbok. The numbers of these species should be controlled if the introduction of sable antelope in the KDNR is considered. The sable antelope is not recommended for introduction to the KDNR.

- During droughts or in the late winter and spring when deciduous plants lose their leaves, browsers have to feed on less palatable evergreen plants that they normally avoid for most of the year. Tannins in the leaves of plants, especially evergreen plant species, play a role in the defence of plants against utilisation by herbivores (Van Hoven 1991). The presence of high concentrations of tannin in plant parts is associated with indigestibility and unpalatability. Tannins inhibit the digestive process (rumen fermentation) because it binds with the enzymes in the stomach of an animal and consequently, animals may die with a stomach full of undigested food. The kudu is especially sensitive to the presence of tannins in its food and their introduction in not recommended.

- Supplementary feeding of wildlife is not recommended because this promotes exceeding the stocking density of the reserve and the grazing/browsing pressure on the vegetation is not reduced. However, if necessary some supplements may temporarily be provided in the dry period, especially if rare species are introduced.

- When introducing new wildlife to the area it is recommended that wildlife from the surrounding region and from similar habitats be purchased, to minimize the adaptation of the animals to the habitat and to minimize the risk of animals consuming poisonous plants.

6.4 Stocking densities

In all the following calculations the total area available and accessible for wildlife was taken as 90 ha for grazers and 56 ha for browsers (Tables 12 – 15). The suitable area for grazers included all the areas covered by the grasslands as well as some 50% of the bushveld vegetation. The suitable area for browsers included all the bushveld communities.

The diet of the wildlife has been incorporated into the calculations. Conversion factors were used to express the grazing component of a herbivore in terms of Grazer Units, and the browsing component in terms of Browser Units. For example:

> If 8 plains zebras are recommended for the KDNR, and grazing forms 95% of their diet, then multiplying 8 with 0.95, converts to the equivalent of 7.6 animals. This number of animals is multiplied with the conversion value for plains zebra of 1.32 Grazer Units per animal, to obtain a total of 10 Grazer Units. The same is done with the percentage browse (5%) in the diet of a plains zebra to obtain a total of 0.5 Browser Units (i.e. 8 x 0.05 x 1.32).

The selection of which wildlife species are to be introduced to KDNR will depend on the requirements and objectives of JCPZ for the KDNR and should be discussed with the Friends of Kloofendal. Two examples are provided in this report: (a) using the full capacity of the reserve and a diversity of wildlife (Table 12); and (b) understocking with a limited number of species (Table 13). The latter option is similar to the *status quo*, but red hartebeest and springbok have been added. Because this option is well below economic capacity, animal numbers at above and below mean rainfall conditions are not relevant.

In Table 12 the stocking density, at economic capacity, of a variety of grazers and browsers at mean annual rainfall (720 mm) and under the current veld condition is provided. Stocking densities at above- and below-average rainfall conditions for the same complement of wildlife are given in Tables 14 &15 respectively.

Table 12. Recommended stocking densities of a variety of grazers and browsers **at economic capacity** and mean annual rainfall of 720 mm

Species	Total number of animals	Percentage grass in diet	Number of grazers	Grazer units (GU per) animal)	Number of GU	Percentage browse in diet	Number of browsers	Browser units (BU per animal)	Number of BU
Low-selective feeders									
Plains zebra	6	95	6	1.32	8	5	0	1.32	0
High selective feeders									
Blesbok	12	85	10	0.50	5	15	2	0.50	1
Black wildebeest	0	81	0	0.90	0	19	0	0.90	0
Mountain reedbuck	22	95	19	0.20	4	5	1	0.20	0
Oribi	0	90	0	0.15	0	10	0	0.15	0
Red hartebeest	8	75	6	0.70	4	25	2	0.70	1
Reedbuck	0	95	0	0.40	0	5	0	0.40	0
Mixed feeders									
Cape eland	0	50	0	2.00	0	50	0	2.00	0
Ostrich	0	80	0	0.50	0	20	0	0.50	0
Springbok	18	50	9	0.30	3	50	9	0.30	3
Browsers									
Grey duiker	10	20	2	0.20	0	80	8	0.20	2
Grey rhebok	0	7	0	0.20	0	93	0	0.20	0
Klipspringer	0	20	0	0.10	0	80	0	0.10	0
Steenbok	5	34	2	0.20	0	66	3	0.20	1
Total	81				24				8

Total area available for grazers (ha)	90
GU/100 ha	27.2
Total area available for browsers (ha)	56
BU/100 ha	14.1

Table 13. Recommended stocking densities with limited diversity of grazers and browsers **below economic capacity** and mean annual rainfall of 720 mm (similar to *status quo*)

Species	Total number of animals	Percentage grass in diet	Number of grazers	Grazer units (GU per) animal)	Number of GU	Percentage browse in diet	Number of browsers	Browser units (BU per animal)	Number of BU
Low-selective feeders									
Plains zebra	0	95	0	1.32	0	5	0	1.32	0
High selective feeders									
Blesbok	12	85	10	0.50	5	15	2	0.50	1
Black wildebeest	0	81	0	0.90	0	19	0	0.90	0
Mountain reedbuck	22	95	21	0.20	4	5	1	0.20	0
Oribi	0	90	0	0.15	0	10	0	0.15	0
Red hartebeest	0	75	0	0.70	0	25	0	0.70	0
Reedbuck	0	95	0	0.40	0	5	0	0.40	0
Mixed feeders									
Cape eland	0	50	0	2.00	0	50	0	2.00	0
Ostrich	0	80	0	0.50	0	20	0	0.50	0
Springbok	15	50	8	0.30	2	50	8	0.30	2
Browsers									
Grey duiker	10	20	2	0.20	0	80	8	0.20	2
Grey rhebok	0	7	0	0.20	0	93	0	0.20	0
Klipspringer	0	20	0	0.10	0	80	0	0.10	0
Steenbok	5	34	2	0.20	0	66	3	0.20	1
Total	64				12				6

Total area available for grazers (ha)	90
GU/100 ha	13.6
Total area available for browsers (ha)	56
BU/100 ha	10.1

Table 14. Recommended stocking densities of variety of grazers and browsers **at economic capacity** and below mean annual rainfall (600 mm)

Species	Total number of animals	Percentage grass in diet	Number of grazers	Grazer units (GU per) animal)	Number of GU	Percentage browse in diet	Number of browsers	Browser units (BU per animal)	Number of BU
Low-selective feeders									
Plains zebra	5	95	5	1.32	6	5	0	1.32	0
High selective feeders									
Blesbok	12	85	10	0.50	5	15	2	0.50	1
Black wildebeest	0	81	0	0.90	0	19	0	0.90	0
Mountain reedbuck	15	95	14	0.20	3	5	1	0.20	0
Oribi	0	90	0	0.15	0	10	0	0.15	0
Red hartebeest	6	75	5	0.70	3	25	2	0.70	1
Reedbuck	0	95	0	0.40	0	5	0	0.40	0
Mixed feeders									
Cape eland	0	50	0	2.00	0	50	0	2.00	0
Ostrich	0	80	0	0.50	0	20	0	0.50	0
Springbok	0	50	0	0.30	0	50	0	0.30	0
Browsers									
Grey duiker	10	20	2	0.20	0	80	8	0.20	2
Grey rhebok	0	7	0	0.20	0	93	0	0.20	0
Klipspringer	0	20	0	0.10	0	80	0	0.10	0
Steenbok	5	34	2	0.20	0	66	3	0.20	1
Total	53				18				5

Total area available for grazers (ha)	90
GU/100 ha	20.1
Total area available for browsers (ha)	56
BU/100 ha	8.4

Table 15. Recommended stocking densities of variety of grazers and browsers **at economic capacity** and above mean annual rainfall (800 mm)

Species	Total number of animals	Percentage grass in diet	Number of grazers	Grazer units (GU per) animal)	Number of GU	Percentage browse in diet	Number of browsers	Browser units (BU per animal)	Number of BU
Low-selective feeders									
Plains zebra	6	95	6	1.32	8	5	0	1.32	0
High selective feeders									
Blesbok	20	85	17	0.50	9	15	3	0.50	2
Black wildebeest	0	81	0	0.90	0	19	0	0.90	0
Mountain reedbuck	22	95	21	0.20	4	5	1	0.20	0
Oribi	0	90	0	0.15	0	10	0	0.15	0
Red hartebeest	9	75	7	0.70	5	25	2	0.70	2
Reedbuck	0	95	0	0.40	0	5	0	0.40	0
Mixed feeders									
Cape eland	0	50	0	2.00	0	50	0	2.00	0
Ostrich	0	80	0	0.50	0	20	0	0.50	0
Springbok	18	50	9	0.30	3	50	9	0.30	3
Browsers									
Grey duiker	10	20	2	0.20	0	80	8	0.20	2
Grey rhebok	0	7	0	0.20	0	93	0	0.20	0
Klipspringer	0	20	0	0.10	0	80	0	0.10	0
Steenbok	5	34	2	0.20	0	66	3	0.20	1
Total	90				28				9
Total area available for grazers (ha)		90							
GU/100 ha		31.5							
Total area available for browsers (ha)		56							
BU/100 ha		15.4							

It should be stressed that the stocking density at economic capacity recommended in Table 12 exceeds the capacity of KDNR for years below mean annual rainfall and it is therefore imperative that wildlife numbers should be reduced in dry years to avoid range degradation and/or losses of animals. **The current economic capacity of the KDNR was based on the veld condition assessment which was determined in the summer after rains and may therefore decrease during the dry season. The recommended numbers of wildlife may be changed depending on the requirements and objectives of the reserve.**

The relationship (%) of low-selective feeders, high selective feeders, mixed feeders and browsers for grassland is generally taken as 20:50:28:2. For savanna it depends on the particular region, but as general guideline 20:30:25:20 can be used. The ratios for the different scenarios on KDNR are as follows:

Table 12 (variety of species, full economic capacity, normal rainfall)	25:49:17:9
Table 13 (small variety of species, below economic capacity)	0:60:27:13
Table 14 (variety of species, full economic capacity, low rainfall)	29:58:0:13
Table 15 (variety of species, full economic capacity, high rainfall)	21:56:15:8

The ratios with a variety of species are close to that recommended for grassland.

The number of animals on KDNR at different scenarios is summarized in Table 16. It should be noted that the total stocking density in Table 16 (indicated by the ha/LAU) represents the combined grazing and browsing components and is therefore higher than if only the grazing component is taken into consideration (Chapter 5).

Table 16. Numbers of wildlife at different scenarios

	Option			
	Full capacity, normal rainfall	Below grazing capacity	Full capacity, low rainfall	Full capacity, high rainfall
Blesbok	12	12	12	20
Grey duiker	10	10	10	10
Mountain reedbuck	20	22	15	22
Plains zebra	6	0	5	6
Red hartebeest	8	0	6	9
Springbok	18	15	0	18
Steenbok	5	5	5	5
ha/LAU (on 90 ha)	**5.6**	**10.1**	**7.9**	**4.9**
ha/LAU (on entire reserve area)	**7.9**	**14.0**	**11.0**	**6.8**

It is important that animal stocking densities should be revised if the veld condition improves or deteriorates.

The sex ratio and long-term population growth rate of the recommended herbivores (Table 12) are summarised in Table 17. It is important that the sex ratio of the populations of wildlife be determined to prevent the development of skewed population structures, especially where selective harvesting takes place. As a result of the small size of the reserve, some of the species might be reduced to below minimum herd size during dry years. In the above example springbok were totally removed in dry years to allow some of the other species to be maintained close to minimum herd size. These decisions will depend on the specific numbers of the different species at that particular point in time.

The population growth of all species should be monitored. Live sales, harvesting and/or culling should be implemented to keep the stocking density at or below economic grazing and browsing capacity. At ecological capacity, productivity will be low and overgrazing and overbrowsing will be to the detriment of the veld and animals. Social behaviour, territoriality and home range constraints also play a role in the saturation point of an animal population. Because of the small size of the reserve the numbers recommended for some species, e.g. plains zebra and springbok, are below the minimum herd size generally recommended for wildlife enterprises. These low numbers should slow the rate of increase in these populations. At the same time management should be cautioned against inbreeding in such small populations and male animals should be removed and new males introduced at most every

three years.

The auction prices of some wildlife in South Africa up to 2013 are summarized in Table 18.

Table 17. Number of animals for Kloofendal Nature Reserve, minimum herd size and other population characteristics (at economic capacity and mean annual rainfall of 720 mm) (see Table 12)

Wildlife	Number of animals	Sex ratio (M:F)	Number of males	Number of females	Minimum herd size (number)	Natural population growth (%)	Expected annual production
Low selective feeders							
Burchell's zebra	6	1:6	1	5	10	25	2
High selective feeders							
Blesbok	12	1:8	1	11	12	32	4
Mountain reedbuck	22	1:6	3	19	8	20	4
Red hartebeest	8	3:5	3	5	8	20	2
Mixed feeders							
Springbok	18	1:4	4	14	25	40	7
Browsers							
Grey duiker	10	1:1	5	5	6	20	2
Steenbok	5	1:1	3	3	5	20	1
Total							22

Table 18. Mean auction prices per animal in breeding groups from 2002 to 2013 (Game/Hunt 2002 - 2014)

Widlife	Mean 2007	Mean 2008	Mean 2009	Mean 2010	Mean 2011	Mean 2012	Mean 2013
Blesbok	1161	1156	1328	1262	1122	1226	1482
Black wildebeest	3019	2825	2435		1000	1756	1000
Plains zebra	4894	5265	5248	4550	4826	4262	4975
Cape eland	5633	6605	6879	7153	6711	5473	7097
Giraffe	13673	16118	13647	18264	14187	15678	14846
Grey duiker	1459	1387	1183	811	2790	1941	3831
Grey rhebok							7000
Impala	982	1153	1099	1122	1160	1122	1283
Greater kudu	4009	4991	4894	5417	5089	4124	6646
Klipspringer					10000	10000	19797
Mountain reedbuck	1949	2159	1910	3097	2857	3110	4556
Oribi*							
Ostrich	1262	1491	1285	1297	2619	1735	2031
Red hartebeest	3861	4138	4409	3971	4314	3828	4663
Southern reedbuck	4694	5515	4218	4650	5000	7299	7000
Sable antelope	63607	71462	121827	117731	152122	178121	206509
Springbok	616	1108	866	1900	1392	1451	1683
Steenbok	1450	2100	1761	5012	4438	4355	6565

*No oribi sold on auction since 2004

6.5 Alien species

Although the viewpoint may be puristic of nature, there is ample evidence that the introduction of alien (exotic) plant species and/or wildlife can have profound impacts on the environment, biological diversity, the economy and ecosystems and their services. No 'alien' species have been recommended for KDNR.

Some examples of negative impacts are:

- New diseases and parasites could be introduced to the area.
- Displacement of the indigenous wildlife by the alien (exotic) types could occur. Because only highly adaptable alien (exotic) wildlife will survive in foreign areas, they occupy habitats where indigenous animals already occur. The availability of suitable habitat is therefore not a valid argument to introduce alien animals.
- Selective and destructive impact on the vegetation could result.
- There is also a legal and economic impact. The NEM: BA (No. 10 of 2004) of South Africa regulates the distribution of indigenous animals to areas where they are considered to be alien (exotic). Economically it entails the possibility of compensation for financial losses because of the introduction or transfer of pathogens to other animal production systems in the region.

CHAPTER 7

BUSH ENCROACHMENT

7.1 Introduction

There is a delicate balance between the woody component and the grass component in savannas. Livestock grazing and the absence of browsers also favour the establishment of woody plant species. In years with a high rainfall the scale is tipped in favour of the grass layer, while the woody species are advantaged during droughts. Woody plant species also benefit when the grass layer is being overgrazed, because competition with woody species by established grasses is reduced.

The general increase in bush density over large parts of southern Africa in recent years has been attributed, amongst others, to the overstocking with grazers, changes in fire regime and climate change. Factors such as low frequencies of hot fires, the replacement of indigenous wildlife with domestic grazers at high stocking densities in the past, the fencing of wildlife ranches that limits animal movement, and the provision of abundant artificial watering points, all contribute to the trend of bush densification. Even the higher carbon-dioxide levels that are associated with climate change have been linked to bush densification by some researchers.

It is important to note that once an area has reached a stable bush encroached state, the removal of herbivores from such an encroached area, even under high rainfall regimes, will not reverse the process, even after decades. The only way to intervene is through mechanical, chemical or biological control measures. The best way of preventing bush encroachment is to maintain a high basal cover of grasses through sound veld management. In the early stages of bush encroachment, when the recovery potential of the veld is still high, selective bush control delivers good results in terms of increased grass production.

Some common density threshold values are often applied to establish whether an area has reached levels of severe bush encroachment. Some researchers regard a density of >400 large shrubs or 500 to 700 medium-sized shrub to represent thresholds of encroachment, whereas others would only consider the area encroached when a density of >1000 shrubs per ha is exceeded. The size of shrubs (and by implication the canopy cover) influences their density, i.e. tall shrubs occur at lower densities per hectare than small shrubs (at the same total canopy cover). For dwarf shrubs a density of 1500 dwarfs shrubs per ha is generally regarded as the threshold above which encroachment occurs.

7.2 Woody density on KDNR

Overall, it appeared that woody **cover** had a more pronounced effect on grass cover than

woody **density** (see Figure 31). The cover of the woody layer at which the grass canopy cover decreases to lower than 40% gives a good indication of threshold canopy cover values that can be applied for bush encroachment. In those communities where closed canopies occur, the grass cover and grass biomass are negatively impacted by the tree canopy layer (e.g. communities 9 & 10). However, dense bushveld and forest communities do not necessarily represent an encroached state. Many areas of dense bush in the KDNR contain a mixture of various woody plant species. These are regarded as natural bush as opposed to an encroached state. Generally, encroached areas are recognised by the dominance of one or two species. Relatively dense plant communities in the KDNR have the advantage that they may afford protection for animals against cold, wet and windy conditions.

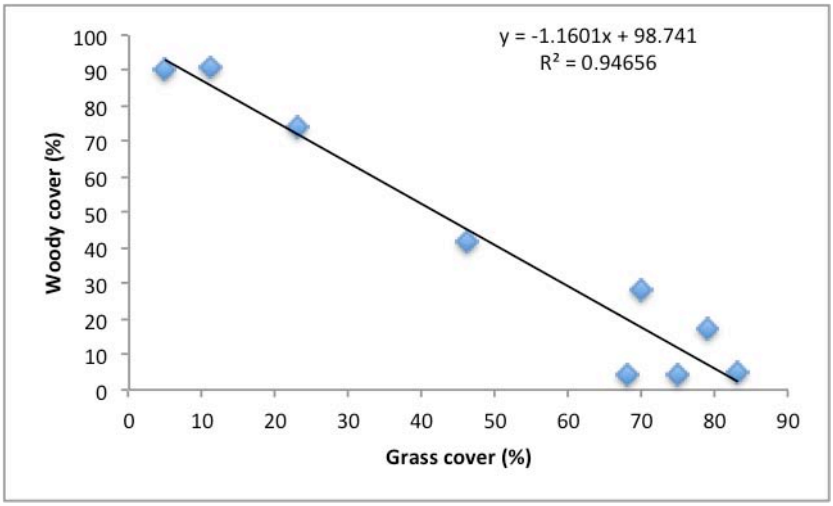

Figure 31. Relationship between total woody and grass cover using data of communities 3 – 11. (Figure 31 is a duplicate from Chapter 4).

Mean densities for the different woody layers in several communities are provided in Table 19. The main problem **dwarf shrub species** on KDNR were *Seriphium plumosum* and *Lopholaena coriifolia.* The highest dwarf shrub densities occur in community 2 (*Lopholaena coriifolia* – mean of 3300 individuals per ha), community 6 *(Seriphium plumosum* – mean of 2350 individuals per ha) and community 7 *(Seriphium plumosum* – mean of 2400 individuals per ha). Where these high densities occur, measures to control the encroachment should be implemented (see Part 2).

Shrub densities were high in communities 6, 7, 8 and 9. The dominant **shrub species** appeared to be *Searsia pyroides*, *Diospyros lycioides, Acacia caffra, Leucosidea sericea, Searsia lancea* and *Afrocanthium* spp. A comparison of the historical aerial photograph of 1941 (Figure 32, FroK website) with a recent satellite image clearly indicates the areas where extensive densification has occurred and could indicate areas where control measures could be implemented. Although intense encroachment in the open bushveld communities 6 and 7 was not yet apparent on the recent satellite image, dwarf shrub and shrub densities in these communities were particularly high and will have to be controlled. Communities 8, 9 and 10

showed the largest differences in woody cover between the two images.

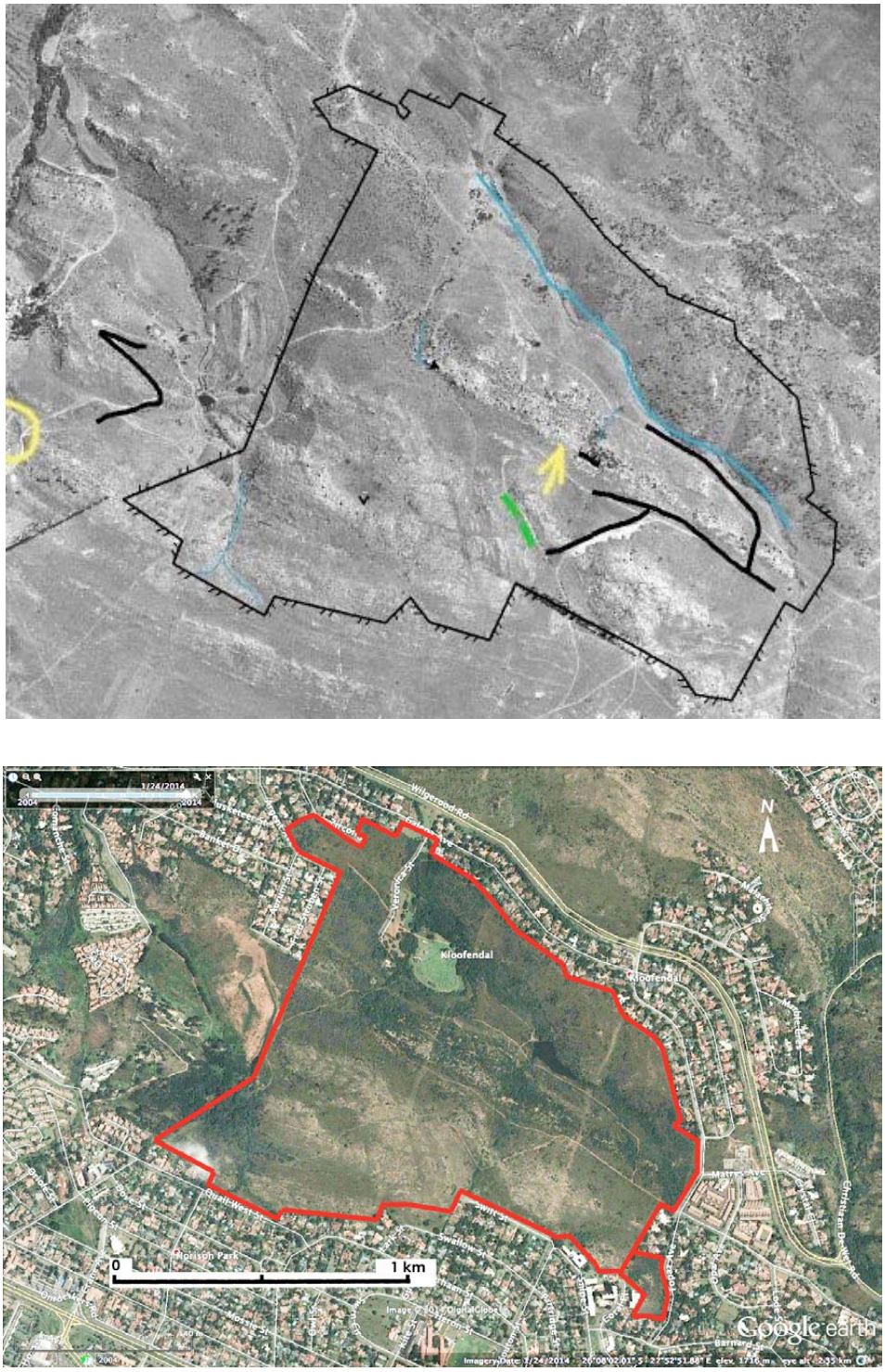

Figure 32. Comparison of a historical aerial photograph (1941, FroK website) with a recent satellite image of the Kloofendal Nature Reserve indicating areas where bush densification has occurred.

Table 19. Mean density of woody species (ind./ha) in different communities on Kloofendal Nature Reserve

Community	1	2	6	7	8	9
Tall trees (>6 m)	0	0	-	-	-	-
Small trees (3 - 6m)	100	-	167	108	400	400
Shrubs (<3 m)	600	-	1367	1117	1900	1600
Dwarf shrubs (<1 m)	-	3300	2350	2400	-	-

It is recommended that regular monitoring of shrub densities is conducted to detect increases in density or increases in shrub and tree cover which can negatively affect grass production. Wherever bush control measures have been applied, it is also imperative to monitor the reaction of the vegetation to these interventions.

It is contended that veld burning contributes to the partial control of woody encroachers and where a bush control programme is implemented, the treated areas should be followed up by prescribed burning depending on the grass biomass (fuel load) available (see Chapter 9 on fire).

Some generic background information is given below to assist in understanding the problem of bush densification on the basis of causal factors, effects and control mechanisms.

7.3 Objectives of bush control

The reasons for controlling bush may be ecological, economic or aesthetic.

Ecological: The aim of bush control is firstly to prevent further encroachment, secondly to re-instate natural ecological functioning and thirdly to create habitats for specific wildlife. Bush encroachment is a **symptom** of an underlying problem and the causes of this problem should be addressed rather than the symptoms.

Economic: Bush control is expensive in terms of labour, vehicles, tools, fuel and chemicals. Selective removal of bush leads to an increase in grass production and the benefits are an increase in grazing capacity and animal production. When applied timeously it has been shown that these benefits outweigh the costs of the control measures in the bushveld environment.

Aesthetic: Selective bush control produces an attractive open landscape, facilitates increases in grazing wildlife, and improves the visibility of wildlife to tourists. It also creates habitat for gamebirds. Although bush control need not necessarily be done across the entire bushveld areas on the KDNR from the start, it can be done successfully in localised patches to increase habitat and

animal diversity.

7.4 Factors causing bush encroachment

The causes of bush encroachment are still debated by plant ecologists and no consensus has yet been reached on the true causes. Nevertheless, one or a combination of the following factors plays a role in promoting bush encroachment (Table 20):

Table 20. Factors playing an important role in bush encroachment and their relevance to KDNR

Factor	Relevance in the Kloofendal Nature Reserve
Injudicious grazing practices such as continuous heavy grazing and a lack of resting, which decrease the vigour of grasses. Excessive removal of the leaf material of grasses reduces the photosynthetic rate; suppresses root development and decreases the uptake of soil water by grasses in the upper soil layers.	Grazing pressure on the reserve is currently very low. Bush encroachment is however, not necessarily the result of current grazing practices, but could be the outcome of past overgrazing or habitat degradation e.g. before 1970s.
Absence of fires together with underutilization can reduce the vigour of grass plants and cause them to become moribund.	Fires occur regularly on KDNR. Future management of the KDNR should include a fire programme which depends on veld condition, fuel load and rainfall.
Misuse of fire, e.g. too frequent fires retard grass development and provide woody species with a competitive advantage.	Management of the KDNR should include a fire programme where fires are only implemented under specified conditions.
The absence of browsers. However, only large herbivores such as elephant and giraffe normally have a significant impact on the woody communities.	Few browsers are currently present and introduction of browsers should be considered to utilise woody species.
Closely spaced and incorrect positioning of watering points and artificial lick sites, for example when water and licks are placed in small sweetveld areas on fertile soils or on steep slopes. This leads to degradation, which is often followed by bush encroachment.	Grazing pressure on the reserve is currently low and due to the presence of water in the Wilgespruit and some artificial watering points, most of the reserve is accessible to water-dependent grazers without any additional watering points.
Human disturbance of vegetation	Small areas appear to have been previously degraded and currently present a problem in terms of dense thatch grasses (*Hyparrhenia* spp.) or encroachment by *Seriphium plumosum*.

7.5 Consequences of bush encroachment

Bush encroached areas have the following characteristics:

- An increase in the cover and density of woody species.

- A dense woody cover lowers the effective rainfall for grazers, e.g. the woody cover generally intercepts the first 5 mm of rain.
- A decrease in the grass cover, grass production and the grazing capacity of the veld.
- Changes in plant species composition, especially where perennial and palatable tufted grasses are replaced by inferior annual grass species.
- Lowered vitality and high mortality of grasses during droughts;
- An increase in surface water run-off and soil erosion due to soil capping.
- An increase in water loss due to evapotranspiration from the woody plants.
- Effective rainfall for grass growth decreases when droughts occur and this impact extends over longer time-scales.
- Although the leaves, shoot tips and fruits of many shrubs and trees are palatable and nutritious, and should therefore theoretically increase the browsing capacity of woody areas, heavily encroached areas do not compensate in ecological capacity for the loss in grass cover, grass production and the exposure of the soil.
- Bush encroachment can also be detrimental to browsers. Encroached areas are more drought-sensitive, because of a lack of soil water, and the woody plants tend to lose their leaves earlier in the winter than in less encroached areas. Furthermore, new growth appears later in spring compared with unencroached areas and therefore, the leafless period lasts longer.

The shallow roots of encroacher woody plant species can extend up to 10 times the canopy diameter of the plant away from the stem or six times the height of the plant. These plants are therefore able to utilise soil water efficiently over a large area, to the detriment of the grasses.

7.6 Methods of controlling bush encroachment (also applicable to alien invasive woody species)

An on-site evaluation is advisable to determine the level of thinning required. Depending on the level of encroachment, a thinning of 60 to 80% of heavily encroached vegetation can be required. A combination of mechanical and chemical control is generally recommended. Follow-up treatments of coppice growth after two to three years are extremely important. There are four basic methods to control encroachment:

7.6.1 Physical (mechanical) control mechanisms

Chopping, slashing and felling: An axe, hand or tractor-driven chain or circular saw or brush cutter can be used. Stumps should be **treated immediately** with a chemical weed-killer to prevent coppicing. Check that a dye has been added to the herbicide to indicate which plants have been treated.

Ring-barking (girdling): The bark of trees is removed around the trunk with an axe or power-driven saw. The exposed bark area should preferably also be treated with a herbicide. Trees that have been ring-barked in such a way, usually die within one to three years.

7.6.2 Chemical control mechanisms

A wide range of chemical herbicides is available under a range of trade names (see Grobler *et al.* 2000, Henderson 2001, Xact 2005, Bromilow 2010, Van Zyl 2012). It is important to follow the instructions on the label of the product regarding application, safe and proper use and storage (Jordaan 2014).

Before using herbicides the following important aspects should be considered:

- the toxicity for man and animals, e.g. birds, fish and insects;
- the volatility of the herbicide;
- the length of the active period of the chemical;
- precautions for proper and safe use;
- economic justification; and
- staff training.

Chemical treatment is usually recommended in situations where:

- the chemicals have enough selectivity towards the target plant species and is thus regarded as environmentally friendly;
- the bush is impenetrable for browsers;
- the kind of bush is unacceptable (unpalatable) for browsers;
- absence of suitable browsers; and
- exceptional dense bush encroachment inhibits grass growth and the accumulation of herbaceous biomass to sustain a fire.

Herbicides can be classified as selective versus non-selective and as contact versus systemic herbicides:

- Non-selective herbicides affect any plant with which they come into contact.
- Selective herbicides affect only the target plant species or growth forms (grasses, broad-leaved weeds, woody plant species).
- Contact herbicides affect only those plant parts with which they come into direct contact.
- Systemic herbicides translocate the chemical substance throughout the plant. Systemic herbicides are often preferred and can be applied as solutions (liquids) or granules (pellets). This group can be subdivided into those with:
    - a long residual action (months to years - usually granules);
    - a short residual action (days - water-based chemicals).

Herbicides come in various forms such as granules, water-based solutions and chemicals that can be mixed with oil or wetting powders. Wetting agents are usually added to spray mixtures to enhance the contact with the plant. A dye is also usually mixed with the chemicals to indicate already treated plants. Soil treatments will vary depending on the clay content of the soil (the higher the clay content the higher the dose needed), organic matter

content, pH of the soil and the type and size of plant. Applications can be made by hand, brush, hand sprayer or aerial applications.

Solutions have the advantages that:

- the application can be selective if done by hand; and
- plants that are cut and treated can be considered to be dead.

The disadvantages of systemic solutions are:

- some chemicals must be applied over a large leaf area of an actively growing plant (i.e. in summer);
- the application is time-consuming and labour intensive;
- the chemical cannot be applied during rainy weather;
- wetting agents have to be added to improve the retention of the spray droplets on the plant; and
- strong wind affects the effectiveness of the application and is unsafe for the operator.

Systemic granules (pellets) that are applied to the soil have the following advantages:

- the granules can be applied at any time of the year in any kind of weather conditions;
- the application is quick;
- the granules can be applied selectively by hand;
- the granules are safer to work with than solutions;
- the granules have a low toxicity to animals once they are in the soil because granules must be buried;
- depending on the soil type and rainfall, these granules remain active for up to four years and thus prevent regrowth or the establishment of seedlings of the woody plants; and
- the granules are effective and allow little coppice formation or regrowth from the roots, which limits follow-up treatment to a minimum.

The disadvantages of systemic granules are:

- their effectiveness decreases as the clay and organic content of the soil increases. On soils with more than 20% clay the required application levels can become uneconomical;
- the effectiveness also decreases as the soil acidity decreases (higher pH values).
- dosages may differ between plant species;
- chemicals in the granules may remain active for long periods;
- some chemicals in the granules are not target-specific and might kill non-target species;
- the chemicals become active only after rainfall and trees may take up to two years to die;
- large numbers of dead standing trees are not aesthetically pleasing; and
- toxic granules on the soil surface may be eaten by animals and cause mortalities.

Foliar application: The chemicals are applied with a hand spray or a power-driven spray mounted on a trailer, tractor, truck or aircraft. The best time to spray is in summer when the leaves of the plants are growing actively.

Stem-notching and application: This method is the most effective for trees with a trunk diameter of less than 150 mm. Downward notches are made around the lower 300 mm of the trunk and the chemical is either sprayed or applied with a brush.

Stump treatment: Trees and shrubs are cut off at approximately 200 mm or less above ground level. The stumps should be cut horizontally and not at an angle because the resultant sharp spikes may harm animals or damage equipment. The cut stumps are treated immediately with a herbicide within three hours of cutting. The advantages are that the extent of the thinning process can be seen immediately, and that the cut branches can be used as firewood or to cover bare areas. The method has a low chemical consumption, the application is selective, and the result is aesthetically acceptable. Mechanical implements are available to deal with dense and thorny bushes such as chain saws, brush cutters and motorized machines e.g. BOSCUT and BARKO machines.

Soil treatment: The chemical is applied in the form of a water-soluble liquid or powder on the soil at the base of the trunk or is buried in the case of granules. The chemical is then dispersed during the rainy season and taken up by the roots of the target plant. These chemicals are most effective in sandy soils. The chemicals remain active in the soil for up to four years and, depending on the rainfall, it may take up to three years for the plants to die.

7.6.3 Biological control mechanisms

Browsers: This approach was shown to succeed only in relatively small fenced areas where high browsing pressure was applied by goats after the application of fire. In natural areas elephants and giraffe can have a significant impact on woody cover.

Insects: Suitable host-specific insects that only target the problem plant, are sometimes released on invader **exotic plant species** but this method cannot be applied to indigenous species causing bush encroachment.

Pathogens: In some instances pathogenic fungi cause increased mortality, e.g. when *Acacia mellifera* plants grow at high densities.

7.7 Examples of results achieved by bush clearing

In Namibia a density of 4000 shrubs per ha of *Acacia mellifera* was decreased to 400 shrubs/ha by chemical control, resulting in an increase in grass production of up to 1500

kg/ha. In another case where an area with 3000 shrubs/ha was chemically treated from the air, the grazing capacity increased just more than two-fold from 15 ha/LAU to 7 ha/LAU.

Sickle bush (*Dichrostachys cinerea*), blue thorn (*Acacia erubescens*) and black thorn *(Acacia mellifera*) have been shown to decrease the annual production of grass in natural arid and semi-arid savannas. Decreases of 40% to 92% of grass production have been reported as a result of bush encroachment by these species. A density of more than 2000 shrubs/ha almost completely suppresses grass production.

In the eastern Kalahri and sweet bushveld of the Limpopo province, less than 400 shrubs/ha are considered ideal and in an area receiving 461 mm rain per annum, bush control led to an increase in grass production of 1000 kg/ha and an increase in grazing capacity from 28 ha/LAU to 10 ha/LAU. Where bush had been removed mechanically 1800 kg of grass was produced per ha after thinning of bush (389 mm annual rainfall), as opposed to 383 kg grass per ha where bush had not been removed. In the mopaneveld of Limpopo province in South Africa, not more than 500 shrubs/ha are recommended and these should have a canopy cover of less than 30%.

Although the short-term response to **total** bush clearing is increased grass growth, the long-term results may be detrimental. With time the grass species composition changes and total grass production generally decreases because of the lack of input of slowly decomposing tree litter. The soil organic matter content declines and the mosaic of nutrient-enriched sites below tree canopies disappear. In the long-term the quality and quantity of grass production in areas totally cleared of trees is likely to decline as a result of nutrient loss. It is therefore recommended that selective bush clearing be done, for example by removing shrubs selectively to obtain a balanced tree, shrub and grass ratio.

7.8 Post-control treatment

Treated veld should be rested for at least one season to increase grass seed and forage production, whereafter prescribed fire and herbivores may be introduced. These areas should preferably be temporarily fenced off to exclude herbivores. After bush control has been implemented, renewed bush encroachment must be prevented by maintaining a productive grass layer through sound veld management and/or the treatment of coppice growth with herbicides. It is essential that the stocking density should initially be conservative, bare areas should be reclaimed and grass growth promoted.

7.9 Control of problem plant species on KDNR

Guidelines on how to control the main problem plant species are provided in the management plan (see Part 2; the Ecological Management Plan).

CHAPTER 8

ALIEN INVASIVE PLANT SPECIES

8.1 Introduction

An "invasive species" is any species whose establishment and spread outside of its natural distribution range (i) threatens ecosystems, habitats or other species or has a demonstrable potential to threaten ecosystems, habitats or other species; and (ii) may result in economic or environmental harm or harm to human health. Invasive alien plant species are globally considered as one of the greatest threats to the environment, biodiversity, ecosystem integrity and the economy.

The worst invaders in South Africa are the bramble (*Rubus* species), triffid weed (*Chromolaena odorata),* black wattle (*Acacia mearnsii),* silver wattle *(Acacia dealbata),* lantana (*Lantana camara)*, as well as invasive aquatic plant species such as *Eichhornia crassipes* and *Myriophyllum aquaticum*. The syringa (*Melia azedarach)* is considered the second most extensive alien species in streamline habitats in South Africa after *Ricinus communis*. More recent prominent alien invasive species include *Campuloclinium macrocephalum, Parthenium hysterophorous* and *Prosopis* spp. (Moran *et al.* 2013).

According to the Conservation of Agricultural Resources Act (No. 43 of 1983 - Regulation 15, 30 March 2001), and the National Environmental Management: Biodiversity Act (No. 10 of 2004)(NEM:BA 2014), invasive alien plant species should be controlled and eradicated with an emphasis on urgent action in biodiversity priority areas.

The purpose of the new draft legislation on alien species (NEM:BA 2014) is to prevent the illegal introduction of alien and potentially invasive species into the country, and to regulate listed invasive species and potentially invasive species within the country.

8.2 The Categories of Listed Invasive Species:

Category 1a plant species: landowners are obliged to take immediate steps to control Category 1a species.

None recorded.

Category 1b plant species: The requirement for Category 1b species is to "contain" the invasive species. However, where an Invasive Species Management Programme has been developed for a Category 1b species, then landowners are obliged to "control" the species in accordance with the requirements of that programme. Therefore, Category 1a triggers an

immediate obligation to control, whereas that obligation only comes into effect for Category 1b species when an Invasive Species Management Programme is implemented for that species in the specific area. The Category 1b species recorded in the KDNR were:

*Acacia elata
Agave americana
*Ageratina adenophora
Araujia sericifera
*Argemone ochroleuca
Bryophyllum delagoense
Campuloclinium macrocephalum
Cereus jamacaru
Cestrum laevigatum
*Cirsium vulgare
Cortaderia selloana
Cotoneaster franchetii
Crotalaria agatiflora
Cuscuta campestris
*Datura stramonium
Eucalyptus camaldulensis
*Ipomoea indica
Ipomoea purpurea
Jacaranda mimosifolia
Lantana camara
*Malva verticillata
Melia azedarach
Mirabilis jalapa
*Opuntia aurantiaca
Opuntia ficus-indica
Opuntia spinulifera
Pennisetum clandestinum
Persicaria capitata
Phytolacca icosandra
Pinus sp.
Pyracantha angustifolia
Robinia pseudoacacia
*Solanum elaeagnifolium
Solanum mauritianum
Solanum pseudocapsicum
*Solanum sisymbrifolium
*Tecoma stans
*Tradescantia fluminensis
Verbena bonariensis
*Verbena brasiliensis

*species recorded by FroK and not by NvR

Category 2 plant species: They are species requiring a **permit** for their cultivation and are species that have economic, recreational, aesthetic or other valued properties, notwithstanding their invasiveness. These species will be allowed in areas and under conditions specified in the permit. It is important to note that a Category 2 species that falls outside the demarcated area specified in the permit, becomes a Category 1b invasive species. Permit-holders must take all the necessary steps to prevent the escape and spread of the species, including the growth or spread of seeds or any other specimens of the species, outside the area for which the permit is issued, and must take all necessary steps to control any specimen that escapes or spreads. The following Category 2 species have been recorded in KDNR:

Acacia dealbata
Acacia mearnsii
Acacia melanoxylon

However, because these species are not cultivated for economic purposes and no permit has been issued for KDNR, they must be regarded as Category 1b species.

Category 3 plant species**:** Category 3 species are less-transforming invasive species which are regulated by activity. The principal focus with these species is to ensure that they are not introduced, sold or transported. However, Category 3 plant species are automatically Category 1b species within riparian and wetland areas. The following Category 3 species have been recorded in KDNR:

Celtis australis
Ligustrum japonicum
**Ligustrum ovalifolium*
Morus alba
*species recorded by FroK and not by NvR

In those instances where *Celtis australis, Ligustrum* spp. and *Morus alba* occurred within the riparian zone on KDNR, they must be regarded as Category 1b species.

Other non-declared alien species recorded in KDNR include (see Appendix A):

Achyranthes aspera
Amaranthus hybridus
**Amaranthus spinosus*
Bidens bipinnata
Bidens pilosa
Chenopodium album
Chenopodium sp.
Conyza alba
Conyza bonariensis
Cosmos bipinnatus
Cyathula cylindrica
Cyathula uncinulata
Dichondria micrantha
Dietes cf. iridioides
Einadia nutans
Eucalyptus cinerea
Gomprena celosioides
Lactuca inermis
**Lavateria orbea*
**Myosotis amplexicaulis*
**Oenothera tetraptera*
Oxalis corniculata
**Persicaria lapathifolia*
Physalis peruviana
Plumbago aurantiaca
Rhus succedanea
Richardia brasiliensis
Rumex sagittatus
Schkuhria pinnata
Sonchus oleraceus
Sonchus wilmsii
Tagetes erecta
Tagetes minuta
Taraxacum officinale
Trifolium repens
Withania somnifera
Zea mays
Zinnia peruviana
*species recorded by FroK and not by NvR

8.3 Control of alien invasive plant species

8.3.1 Strategies to prevent invasion

There are a number of strategies that can be employed to prevent the introduction of new invasive plant species:

- Maintaining a healthy grass cover by sound veld management and judicious burning of the grass sward.
- Integrated catchment management with the surrounding neighbours because areas around and upstream of protected areas provide an unlimited source of seed which invade downstream areas.
- Creating a buffer zone of alien-free vegetation around protected areas.
- Limiting their introductions by humans, such as into gardens (e.g. amphitheatrea area), with animal fodder and with thatch grass.

Some generic background information on the control of serious infestations of alien plant species (Van Rooyen 2005) is provided below:

8.3.2 Principles

Regardless of the method or combination of methods chosen to eradicate alien invasive plant species, there are three general principles that apply:

- Light infestations are easier to deal with than heavy infestations.
- Infestation generally proceeds downhill and downstream, particularly when considering riverine vegetation. Clearing operations should start at the highest point and work downwards since it is ineffective to clear an area when an infestation source exists uphill or upstream.
- No control operation succeeds the first time. One or more follow-ups are essential. Cleared areas should be inspected at regular intervals to ensure that elimination is complete. If initial control has not been successful then follow-up control has to be applied.

8.3.3 Control (see also Chapter 7)

Controlling alien invasive plants is a costly exercise. It is important to evaluate the expenditure of the control operation in terms of the benefits that are gained from improved ecosystem goods and services. Versfeld *et al.* (1998) suggest that before embarking on any alien plant control operation an assessment of the problem should be made to answer the following questions:

- What is the extent of the problem?
- What species are implicated?

- What impacts do the invasive alien plant species currently have on the environment?
- What will it cost to deal with the problem?
- Who will benefit from clearing?
- Can the invaded areas be prioritized?

Overall, the alien plant infestation in the KDNR is currently light, except for the lower riparian areas in the northwest and some isolated patches with *Acacia* spp. and *Eucalyptus* spp. It would therefore be prudent to remove these alien plants before they become a serious problem.

When controlling weeds and invaders, damage to the environment has to be limited to the minimum. Environmental damage that might be caused by control actions, are:

- the removal of non-target plants;
- herbicidal damage to non-target plants;
- the chemical pollution of soil and/or water;
- the irresponsible use of fire;
- creation of a fire hazard by allowing flammable material to accumulate in fire-sensitive areas;
- unnecessary or irresponsible soil disturbance, especially on riverbanks or slopes; and
- failure to rehabilitate denuded areas to prevent soil erosion and invasion by other undesirable species.

If done responsibly, removal of alien invasive plants currently present in KDNR can be achieved without causing any of these forms of damage.

Mechanical and/or chemical control: Alien invaders can be controlled by mechanical and/or chemical means. Mechanical means include ringbarking (girdling), uprooting, chopping, slashing and felling. An axe or chain saw or brush cutter can be used. Stumps or ringbarked stems should be treated immediately with a chemical weedkiller (see references below). Follow-up treatment is mostly needed (see also Chapter 7). According to Moran *et al.* (2013), the Working for Water Programme of the Department of Environmental Affairs has managed to retard, rather than reverse, the invasions by alien plant species and more needs to be invested in research and implementation of Weed Biological Control agents if the situation is to be at least stabilised or improved.

Weed Biological Control agents: Biological control is the most cost-effective and sustainable control method against invasive alien plant species (Moran *et al*. 2013). Of the weed species in South Africa on which Weed Biological Control agents have become successfully established, 23% have been completely controlled and 38% are under substantial biological control.

Biological control involves the use of host-specific natural enemies of weeds or invaders from

the plant's country of origin, to either kill or remove the invasive potential of these plants. It may only be initiated by and carried out under the supervision of an organisation established by legislation (i.e ARC, Agricultural Research Council), which practises and researches biological control of weeds and invader plants. Effective bio-control agents cause gradual thinning of dense stands of invading alien plants, thus allowing the natural vegetation to return as part of the natural process. Insect control of especially exotic plant invaders is a promising approach to plant control. Insects have been successfully used against exotic plants such as *Opuntia* species, *Cereus jamacaru*, *Sesbania punicea* and *Hypericum perforatum (Moran et al.* 2013).

Currently, South Africa is one of the leading nations in the exploration and release of agents for the biological control of three weeds of major international significance, namely lantana (*Lantana camara*), water hyacinth (*Eichhornia crassipes)*, and triffid weed *(Chromolaena odorata)* (Moran *et al*. 2013).

Integrated control strategies (ICS): The satisfactory control of weeds and other invasive species is usually only achieved when several complementary methods, including biological control, improved land management practices, herbicides and mechanical methods, are carefully integrated (Richardson 1997). Such a strategy is termed an integrated control strategy (ICS). An integrated approach to control relies on a number of important principles (see also 8.3.2):

- It must be recognised that in most cases control is achievable, although eradication might not be, and that the problem requires a long-term approach and a long-term commitment.
- Clearing of lightly infested areas, where invaders are spreading most rapidly, is usually far more effective than the clearing of areas that are already fully invaded.
- It is best to begin control at the source area, e.g. headwaters of rivers.
- Follow-up operations always have higher priority than new clearing operations.
- Training of staff in integrated control must be provided.

8.4 Control of alien invasive plant species in KDNR

Thirty-four Category 1b alien invasive species were recorded in the KDNR during the current survey and an additional 13 species were recorded by other collectors (Table 21). These numbers include the three Category 2 species because they are not cultivated for economic purposes and no permit has been issued for them; and four Category 3 species in riparian areas. In total the Category 1b species contribute approximately 10% of the total number of species on the reserve. The legal requirement for Category 1b species is to "contain" the invasive species. However, where an Invasive Species Management Programme has been developed for a Category 1b species, then landowners are obliged to "control" the species in accordance with the requirements of that programme.

Most of the Category 1b species were not common in the KDNR, except for *Cotoneaster franchetii, Acacia mearnsii, Acacia melanoxylon, Solanum mauritianum* and *Eucalyptus camaldulensis*. The severity of infestation of the species recorded during other surveys is not known and may be low.

In Figure 33 the communities have been ranked into three classes on the basis of the number of Category 1b alien invasive species encountered in them. Class 1 represented all those communities in which less than 5 Category 1b species were recorded in the 2014 surveys. Class 2 contained from 5 to 10 Category 1b alien invasive species, whereas Class 3 contained more than 10 Category 1b alien invasive species.

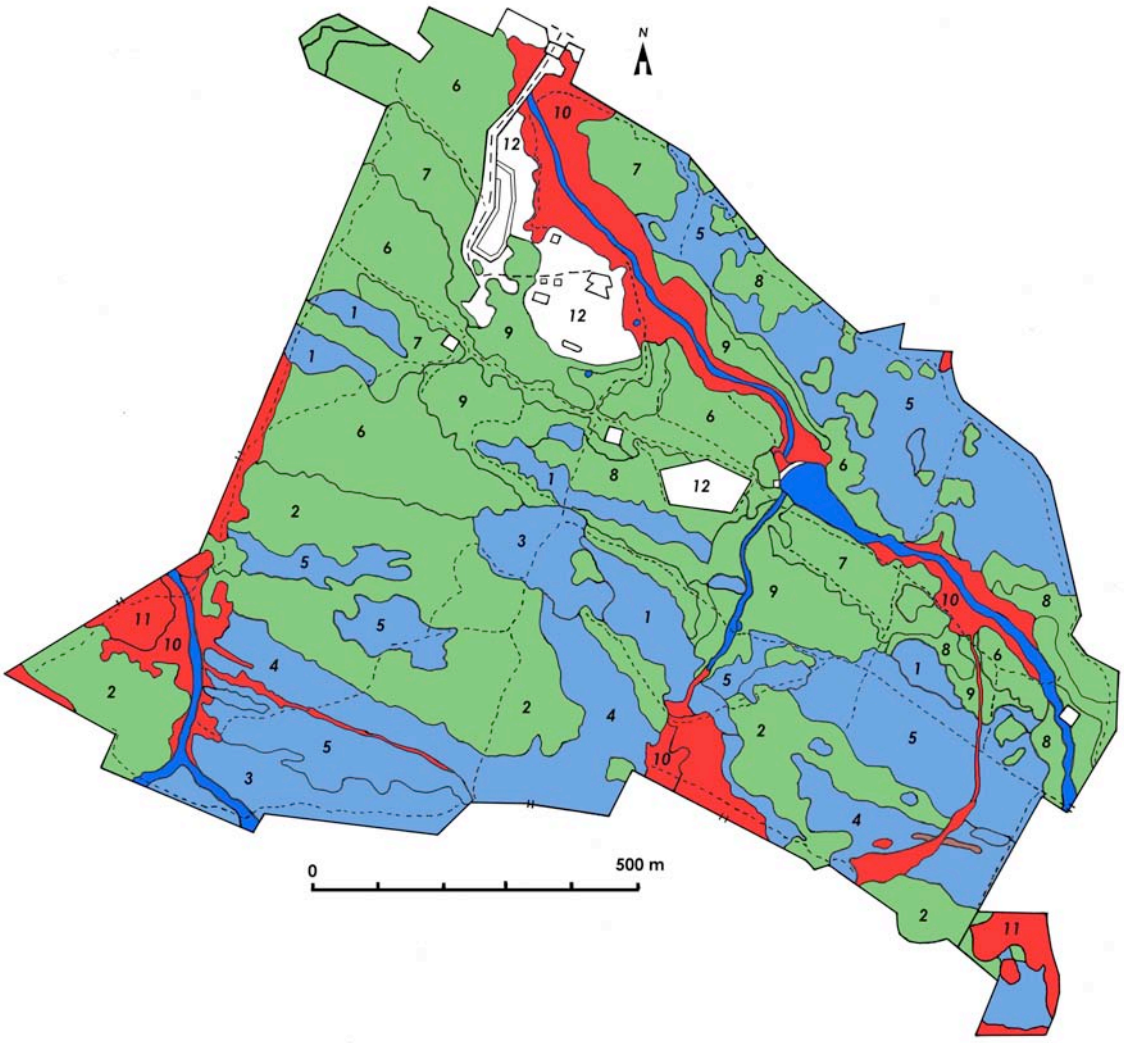

Figure 33. Ranking of communities on the basis of the number of Category 1b alien invasive species recorded in the 2014 surveys. Class 1 (blue) contained <5 Category 1b species; Class 2 (green) contained 5 – 10 Category 1b species and Class 3 (red) contained >10 Category 1b species. White areas include the garden and other infrastructure and the historical Confidence Mine area.

Communities 1, 3, 4 and 5 had low numbers of alien invasive species, whereas communities 2, 6, 7, 8 and 9 had intermediate number of alien invasive species. The highest number of Category 1b species were encountered in communities 10, 11 and 12. Because the riparian community (community 10) is also regarded as ecologically sensitive, this community should be targeted for control operations.

Table 21. Category 1b declared alien invasive species in KDNR and their level of infestation

Species	Severity of infestation	Community
Acacia dealbata	Not recorded in current study	
Acacia elata	Not recorded in current study	
Acacia mearnsii	Widespread, problem only in community 12	5, 6, 8, 9, 10, 11, 12
Acacia melanoxylon	Widespread, low	1, 4, 6, 7, 8, 10, 12
Agave americana	Local, low	3
Ageratina adenophora	Not recorded in current study	
Araujia sericifera	Local, low	9, 10
Argemone ochroleuca	Not recorded in current study	
Bryophyllum delagoense	Local, low	10
Campuloclinium macrocephalum	Widespread, low	3, 5, 6, 9, 12
Celtis australis	Local, moderate	11, 12
Cereus jamacaru	Noted in current study, low	
Cestrum laevigatum	Local, low	3, 11
Cirsium vulgare	Not recorded in current study	
Cortaderia selloana	Noted in current study, low	
Cotoneaster franchetii	Widespread, moderate	6, 7, 8, 9, 10
Crotalaria agatiflora	Local, low	10, 12
Cuscuta campestris	Local, low	2, 12
Datura stramonium	Not recorded in current study	
Eucalyptus camaldulensis	Problem in community 11	9, 11, 12
Ipomoea indica	Not recorded in current study	
Ipomoea purpurea	Local, low	2, 10, 11, 12
Jacaranda mimosifolia	Local, low	2, 3
Lantana camara	Problem in communities 2, 11	2, 6, 8, 9, 11
Ligustrum japonicum	Local, low	7, 10
Ligustrum ovalifolium	Not recorded in current study	
Malva verticillata	Not recorded in current study	
Melia azedarach	Local, low	9, 10, 12
Mirabilis jalapa	Local, low	11
Morus alba	Only noted in current study	
Opuntia aurantiaca	Not recorded in current study	
Opuntia ficus-indica	Local, low	2
Opuntia spinulifera	Only noted in current study	

Pennisetum clandestinum	Local, low	10, 11, 12
Persicaria capitata	Local, low	10
Phytolacca icosandra	Local, low	7, 10, 11
Pinus sp.	Local, low	2
Pyracantha angustifolia	Local, low	6, 7, 10
Robinia pseudoacacia	Local, low	10
Solanum elaeagnifolium	Not recorded in current study	
Solanum mauritianum	Widespread, problem in community 11	2, 4, 6, 7, 8, 9, 10, 11
Solanum pseudocapsicum	Local, moderate	8, 9, 10
Solanum sisymbrifolium	Not recorded in current study	
Tecoma stans	Not recorded in current study	
Tradescantia fluminensis	Not recorded in current study	
Verbena bonariensis	Local, low	10, 11, 12
Verbena brasiliensis	Not recorded in current study	

A large number of herbicides are registered for the control of alien invasive species (see books by XACT 2005; Bromilow 2010; Van Zyl 2012) and more detail on the control of alien invasive plant species is provided in the management plan. Practical guidelines on how to control the main alien invasive plant species are provided in the management plan (see Part 2; the Ecological Management Plan).

CHAPTER 9

FIRE

9.1 Introduction

Fire is considered an essential component of many ecosystem types including grasslands and savannas (Bond & Keeley 2005). It has the potential to act as a landscape level disturbance agent to create spatial and temporal diversity in rainfall-driven systems. Fire is used as a tool by management for influencing the quality and quantity of grazing for large herbivores in both livestock and conservation areas (Tainton & Mentis 1984). A cornerstone of a fire management policy should be to accept naturally caused fires that are controlled and, where necessary, supplemented and complemented by prescribed burning. Whenever possible, the local natural fire regime should be imitated, and coupled with the regulation of herbivore populations, adjusted with the grazing/browsing capacity of the area. In order to maintain spatial heterogeneity it is important to vary fire parameters (type of fire, fire size, frequency, intensity and seasonality) spatially and temporally across the landscape.

Where fire is applied correctly it can have many positive outcomes: it increases forage production; contributes to nutrient cycling; partly controls woody species; can be used as an after-care method following other methods of bush control; changes the structure of woody vegetation for easier access by browsers; increases forage flow; is used for protection of property; improves palatability of grasses (regrowth) and removes moribund material (especially in moist sourveld areas). In conservation areas it maintains spatial and temporal diversity; improves habitat diversity; creates openness that increases visibility; and contributes to some rotational grazing of wildlife.

The negative effects of wild fires in South Africa have prompted the legal requirement of the annual burning of fire-breaks. According to the National Veld and Forest Fire Act (No. 101 of 1998), a duty is placed on owners of natural veld to prepare and maintain firebreaks on their side of the boundary. Owners of adjoining land and the Fire Protection Association for the area should be informed when burning is planned. Detailed requirements on fire protection associations, firebreaks and fire fighting equipment are described in the Act.

9.2 Fire parameters and types of fires

The impact of fire varies depending on different factors, such as the type of fire, fire intensity, season of burn and the frequency of burning.

Type of fire: Three types of fire are distinguished: those that burn fuels at ground level are called surface fires or grass fires; those that burn in tree canopies are known as crown fires and those that burn in organic layers of the soil are called ground fires.

Surface fires are generally the most common type of fire in grassland and savanna ecosystems. The term fire type can also distinguish between back fires and head fires. Back fires are those that burn against the wind and head fires, are those that burn with the wind (Trollope 1999). More heat is released during back fires at ground level when compared to head fires. Woody vegetation is more susceptible to crown and surface head fires that burn with the wind as these types of fires cause more topkill of branches and stems (Trollope & Trollope 2002).

Fire intensity: Fire intensity refers to the heat energy released during a fire and provides a measure of how fiercely a fire burns. This fire parameter depends on the fuel load, and the season in which a fire occurs, as the moisture content of the grass sward varies due to seasonal curing.

Season of fire: The timing of the fire season affects the fire intensity, which is higher in winter and spring and lower in summer. The natural fire season, caused by lightning, is in late spring and early summer. Often the fire season is determined by low fuel moisture which tends to be the driest time of the year. In this way, humans have largely altered the fire season in most ecosystems throughout the world by causing ignitions outside the natural fire periods (Bond & Keeley 2005).

Frequency of fire: Fire frequency refers to the time between consecutive fires and influences the production of fuel since the last fire.

The importance of variability and flexibility in burning is increasingly being promoted, and increased patchiness and heterogeneity is widely held to be the most appropriate way to burn in fire-prone areas. A key assumption (although still contested) is that fire patterns act as surrogates for biodiversity so that fire patchiness in space and time results in a high level of biodiversity. It is argued that patch-burning will provide a range of habitats through space and time that will enable the persistence of biota in the regional landscape. The presence of a variety of herbivores, and the need for their conservation in the same area, is one of the prime arguments for developing the patch mosaic burning system.

9.3 Fire management approaches in grassland and savanna – background information

Africa has the capacity to support fires because it is highly prone to lightning storms and has an ideal fire climate comprising dry and wet periods (Trollope & Trollope 1996). It is believed that lightning-ignited fires played a significant role in the evolution, maintenance and distribution of plant communities in southern Africa long before man began to use fire in the region.

Lightning is the main source of ignition in many areas in southern Africa. For example in the Etosha National Park up to 73% of veld fires between 1970 and 1979 were caused by lightning and occurred chiefly (78%) from October to December, the commencement of the seasonal

summer rainfall (Siegfried 1981). Presently, man-made fires in certain areas are far more frequent than lightning fires. In the Kruger National Park, anthropogenic and lightning fires contributed to 90% and 10% respectively of all burning from 1985 to 1992 (Trollope & Trollope 1996). Studies in the Kruger National Park showed that lightning fires occurred most frequently during late spring and summer (October to January) when thunderstorms are most frequent.

If burns are implemented in winter or spring before the rains, there is always the risk of a long period without rain after the burn, and therefore loss of grazing. When fire is used in management it is therefore recommended that the natural fire regime be simulated as far as season is concerned, i.e. late spring and early summer. The season of the fire is critical to the survival of grass seeds. The practice to prescribe burning in winter and early spring is thus questionable if the natural fire season is from October to January, and even later in the arid western areas.

Season of burn is critical for soil seed banks (Harrington & Driver 1995). Burning in autumn and early winter will greatly reduce seed rain if undertaken before seed fall, whereas burning once the seed is in the ground (late spring or early summer) may enhance germination and seedling establishment in that summer (Ernst 1991). Species with selfburying seeds (e.g. *Aristida* spp. and *Stipagrostis* spp.) are at an advantage over other species by being able to avoid surface fires, which destroy litter and surface lying seeds. In general seeds buried in the soil and dormant in the dry season are not harmed much by fire (Trollope 1982, Sweet 1983). The effect of a fire with a fuel load of 3 000 kg/ha was investigated on grass seeds. Grass seeds on or above the soil surface, were destroyed due to the high inflammability of the glumes and appendages (Ernst 1991). These reactions of grasses to frequent hot fires and dry heat may help to explain the decrease of many grass species in encroached savannas and may lead to local extinction of certain grass species.

The phenological and physiological state of the plant, are the most important factor determining damage to the plant (West 1965; Kennan 1971), however, these are often related to a particular season. Actively growing plants are more susceptible to damage by fire than dormant plants. Savanna trees are most sensitive to fires when sprouting in spring, when grasses are still dormant and are not harmed (Rose-Innes 1971). However, bush in the Kruger National Park was apparently not sensitive to season of burn and low mortality was shown even when actively growing (Trollope 1993).

9.3.1 Kruger National Park (Van Wilgen et al. 1990, 1998, 2004, 2007)

Active fire management has been implemented in African savanna ecosystems for many years now (Van Wilgen *et al.* 1990). The various fire practices and policies have changed through the years as new facts on the role of fire have become apparent (Bond & Archibald 2003). Approaches to fire management in the Kruger National Park have changed several times over the past six decades. These approaches have included regular and flexible prescribed burning on fixed area, so-called burn blocks, and a policy that sought to establish

a natural lightning-driven fire regime. The achievement of a high degree of spatial heterogeneity, by point-ignition and patch-mosaic burning, has recently been included as an important goal of conservation management in African savannas.

Currently, the Kruger National Park has adopted a hybrid system of Patch Mosaic Burning (PMB) and lightning fires, with tolerance of wildfires under certain conditions. Fire patterns are monitored and tested against "thresholds of potential concern' (TPC) (Van Wilgen *et al.* 1998), within a framework of adaptive management. The framework included thresholds relating to fire-return periods, the seasonal distribution of fires, the range of desired fire intensities, the extent of fires and the cause of fires, e.g natural or human-initiated fires. Point ignitions are used to start fires in areas where fire is deemed necessary. Surveys of grass-sward composition and grass fuel-loads are used to identify areas to be burned.

The essence of the findings that has emanated from the KNP fire experiments over >50 years, the ecological understanding gained and its relevance to management are summarized by Van Wilgen *et al*. (2007).

- Woody plant composition, species richness and density were little affected, although tree size depended on different fire treatments and fire exclusion, for example, large trees were promoted by fire exclusion. Lethal scorching of aerial parts of woody plants ("topkill") increased with increasing fire intensity, forcing them to resprout from the base. Fire was therefore not critical for the maintenance of woody plant diversity, but did affect structure, phenology and seed production. Managers can therefore retard or increase the rate at which trees are recruited into the larger, fire-resistant classes by selecting fire intensity levels, e.g. early wet season burns.
- Herbaceous species composition changed little with fires in the dormant season, but more so with fire in the wet growing season, and with fire exclusion. The manipulation of fire regimes in terms of season was therefore not critical for the maintenance of herbaceous plant species diversity.
- There were noticeable effects of fire on small mammal communities, with unburnt sites supporting the most species and the highest densities. Protection from fire seemed to be the best option for small mammal diversity, but it was believed not to be practically achievable, except for creating fire refugia.
- Species richness and composition of birds did not vary in response to a wide range of fire regimes.
- There was no significant effect of burning on ant species richness and abundance between fire treatments, but significant differences in ant assemblage composition between burnt and unburnt plots. Conservation of ant species associated with unburnt areas should be achieved in fire refugia.
- Nitrogen losses during fires were replenished regardless of the fire treatment. Annual burning increased soil crusting. Therefore infrequent burning will not lead to severe nutrient losses and soil crusting.

- Carbon and nitrogen emissions increased with increased biomass and post-fire age and contribute to an increase in atmospheric carbon dioxide concentration.

The picture that emerges from the above is that fire has less effect on the ecosystem than may have been expected. The most notable effects were from treatments that deviate most from the natural fire regime. These included extremes of fire frequency (either annual burning, or total exclusion of fire) or burning in mid-summer/wet season. According to Van Wilgen *et al.* (2007), none of these two options are practical or desirable for fire management.

Despite different fire policies in the KNP over the years, the area that burnt in any given year was independent of the management approach and was strongly related to rainfall (and therefore grass fuel loads) in the preceding two years (Van Wilgen *et al*. 2004), and this relationship is used to determine the percentage area to be burned. These findings were surprising as they indicated that management had less influence on fire occurrence than expected. On the other hand, management did affect the spatial heterogeneity of fires, their seasonal distribution, and the intensity of fires (Van Wilgen *et al*. 2007). Grass fuel loads were therefore a critical driver of the fire potential of an area (Brockett *et al.* 2001). Managers can probably influence fire intensity by choosing the weather for burning and by selecting the ignition pattern, such as initiating fires from point ignitions rather than perimeter ignitions (Van Wilgen *et al.* 2004).

In terms of fire-return intervals, the sequencing of annual rainfall had an overriding influence on fire-return intervals, regardless of the management approach adopted at the time. Therefore, although the policy was supposed to apply a regular fire regime, the result was a random fire regime dominated by the overriding influence of amount of rainfall and grass production.

9.3.2 *Patch mosaic burning (PMB) (Parr & Anderson 2006)*

Fire management is increasingly focusing on introducing heterogeneity in burning patterns under the assumption that "pyrodiversity-begets-biodiversity". This concept has been formalized as patch mosaic burning (PMB) in which increased fire variability is introduced into the landscape to create a mosaic of patches representative of a range of fire histories to generate heterogeneity across space and time. Patch mosaic burning is supposed to produce patches with different characteristics in the landscape. This diversity is achieved by applying numerous different burns from April[1] to November (late autumn and early summer), in the form of point ignitions. The end result of a patch mosaic burning system is a variation in the number, size, seasonality, intensity, location of fires and the total area burnt for that particular year. All ignitions are point ignitions and, once a fire has established, no further ignition is applied to assist the spread of a fire.

[1] See previous comment on burning in winter is a questionable practice except for establishing fire-breaks.

According to Brocket *et al.* (2001), PMB may not be a suitable system for landscapes with diverse mixtures of forest, grassland and riparian valleys. With PMB in Pilanesberg National Park, a "natural" fire regime is not imposed on the ecosystem, but rather an attempt to simulate a situation which may have existed when early humans ignited the vegetation in the past. The presence of a variety of herbivores, and the need for their conservation in the same area, was one of the prime arguments for developing the patch mosaic burning system (Brockett et al. 2001). PMB has also been linked to traditional burning by indigenous peoples in a range of ecosystems globally (Parr & Anderson 2006).

According to Brockett *et al*. (2001), fine-scale mosaics enhance the abundance and diversity of terrestrial vertebrate fauna, for example small mammals and ground-nesting birds such as francolins. However, many biota in savannas are resistant or resilient to burning across a wide range of fire regimes (Parr & Anderson 2006). The richness and composition of woody plants appear to be extremely resistant to variation in fire regimes, although structure and biomass does change markedly.

There are often species with special fire-management requirements. In many cases fire-sensitive species simply require relatively infrequently burned habitat, and consequently a combination of frequently and less frequently burned habitat may provide a refuge for most species in the landscape.

When an area burns, the entire landscape is seldom burnt and the intensity will vary across the landscape. Fire is therefore inherently heterogeneous and the impact of fire varies markedly within burned areas. Thus there will always be some level of pyrodiversity regardless of management intervention. **In western Australia, the need to increase the area of relatively long unburned habitat has been identified as a management priority.**

A sound understanding of the extent of pyrodiversity required for biodiversity, the interventions required to achieve them, and methods of evaluation can only be translated into effective management through the provision of clear targets and operational guidelines. Targets should include total percentage of area burned, desired patch-size frequency distribution, and seasonal distribution of fires. Operational guidelines should cover the number and timing of fires and ignition locations (which may be random).

9.3.3 *Ithala Game Reserve (Gordijn et al*. 2012, Gordijn & Ward 2013)

According to Gordijn *et al.* (2012) the mean annual rainfall in Ithala Game Reserve increased from about 720 mm to some 850 mm since the 1930s. As a consequence the tree cover and density increased significantly over 64 years. Herbivore population numbers have also increased since 1972 and contributed to reduced fuel loads. Fire was consequently suppressed leading to an accellerated rate of woody plant invasion. For effective control of woody plant ebcroachment, it appears that fire frequency and the appropriate numbers

and ratios of grazing and browsing herbivores have to be achieved.

In a study of old field grasslands in Ithala Game Reserve, the density of woody plants was greater in areas burnt annually as well as in areas burnt once every 10 years, compared to areas burnt once every 2 – 4 years (Gordijn & Ward 2013). In these grasslands, areas burnt annually were dominated by woody plants <2 m in height. The reduction in fire frequencies in a *Combretum*-dominated woodland led to an increase in broad-leaved evergreen and unpalatable woody vegetation. In addition, this vegetation suppressed the herbaceous layer and resulted in decreased fire intensities and frequencies. In areas burnt annually, encroaching microphyllous woody species, e.g. *Acacia* spp., were promoted by fire. It was suggested that for effective control of encroaching woody plants in Ithala Game Reserve, an intermediate fire frequency (one burn every 2-4 years) is required. Furthermore, the intensity of the fires must be sufficient to increase topkill, e.g. more than 4000 kg/ha of fuel. Therefore, management should aim to foster the development of grassy biomass for fuel for fires.

9.4 Practical aspects of fire

In practise the implementation of a fire programme is easier said than done, even when an agreement has been attained on its nature (e.g. lightning-ignited burning, patch mosaic burning or prescribed regular fire). Unplanned fires often burn large areas, which disrupts the fire targets that have been agreed upon by management.

The application of fire as a management option should be carefully considered in the KDNR. Patch mosaic burning is currently proposed for savannas where fire is introduced to create a mosaic of patches representative of a range of fire histories to generate heterogeneity across space and time (Parr & Anderson 2006). A veld condition and fuel load assessment should be done before the decision is made to burn an area. However, burning in winter and early spring before rains is not recommended.

The risk of fires spreading out of control and causing damage is high in areas on KDNR with high fuel loads, e.g. Communities 3 - 8 and patches of tall grass in unit 12 (Table 22). Therefore, it is compulsary to create firebreaks around the boundary of the reserve and the same could be done around other infrastructure bordering on natural veld. Especially buildings with thatch roofs should be protected against fire by using for example water sprinklers on the roofs and around buildings. Annual firebreaks are generally burnt in autumn and winter. Once effective firebreaks have been established it is possible to use fire for ecological reasons, but this should only be undertaken by experienced teams.

Based on the biomass data obtained during the 2014 surveys (Table 22), some projections can be made as to how the vegetation in the various communities will respond to fire. Community 12 currently has a mean fuel load in excess of 5000 kg/ha, mainly because of the stands of *Hyparrhenia tamba*. Such a high fuel load will support a hot fire. Communities 2 to 8 have mean biomass values of between 2000 kg/ha and 4000 kg/ha. These communities

therefore have fuel loads that can sustain fires. Under hot and dry conditions community 2 will probably sustain a hot fire. The herbaceous biomass in communities 6 and 7 is not sufficient for controlling bush encroachment since values in excess of 4000 kg/ha are recommended for bush control.

Table 22. Grass biomass of the different plant communities of Kloofendal Nature Reserve

Plant community number	Area (ha)	Biomass (kg/ha)
2	25	2642
3	7	3878
4	12	3319
5	25	3119
6	23	3004
7	10	2887
8	6	3341
12	2	5681
Total	110	3484

Some general guidelines for KDNR:

- As a long-term aim, lightning fires should be allowed to burn undisturbed in a particular burning block, but prevented from spreading to other areas in the KDNR.
- Type of fire depends on environmental conditions. The type of fire e.g. cool or hot, surface fire or crown fire could be controlled by choosing the conditions suitable for the kind of fire. For example a cool grass fire could be achieved by burning late in the season after the spring or early summer rains, when the grasses are green, and on relatively cool, cloudy days (or at night). Hot fires will ensue if conditions are hot and dry and with a high fuel load.
- The fire frequency may vary from 3 to 4 years depending on rainfall, veld condition and fuel load.
- The time (season) of the fire treatment of a specific designated section may vary from October to January.
- The fire intensity may be varied. However, the fire intensity is related to fire frequency because the longer the interval between fires, the greater the chance that the fuel load will be higher. For example, an early summer burn (November) after 4 years of no burn, may result in a hot burn if the rains are late.
- Human-ignited fires of areas not prescribed for a specific year should be actively prevented, suppressed or contained to the smallest possible area, especially if that section was burnt the previous year.

Practical guidelines on the application of fire on KDNR are provided in Part 2 (Ecological Management Plan).

CHAPTER 10

CONSERVATION: VEGETATION & FLORA

10.1 Introduction

The conservation status of plant species (the term species is here used in a general sense to denote species, subspecies and varieties) serves as a guideline to determine which species need to be conserved to prevent the possibility of extinction. Conservation priorities and monitoring strategies can be implemented to ensure that those taxa with a threatened status are protected in their natural habitat. Besides rarity, aspects such as economic value, medicinal value, genetic distinction and endemism are added criteria to determine the status of species.

In a similar way, ecosystems also have a conservation status with the level of transformation being one of the criteria of assessment. Ecosystem status is based on how much of an ecosystem's original area remains intact, relative to certain thresholds (Driver *et al*. 2004).

10.2 Conservation status of vegetation types

The KDNR falls in the Gold Reef Mountain Bushveld vegetation type (SVcb9, Mucina & Rutherford 2006) (Figure 6). This vegetation type covers 2031 km^2 and is considered as "least threatened" with some 22% statutorily conserved (NEM:BA 2011, Mucina & Rutherford 2006). About 15% is transformed, mainly by cultivation and urban and built-up areas.

However, according to more recent evaluations (NEM:BA 2011; Gauteng GDARD C-plan Version 3.3 2011), the KDNR falls in *the Roodepoort Reef Mountain Bushveld* type (GP 8). This vegetation type is classified as "Critically Endangered" and according to the systematic biodiversity plan, it is listed as a type with a high irreplaceability and high threat. Only 71% of the area is regarded as natural and approximately 12% is protected, e.g. in the KDNR.

10.3 Threats to the indigenous flora

The main threats to the survival of rare plant species include mining related activities, agriculture, illegal collecting, especially of succulent plants, habitat fragmentation and habitat destruction. The most apparent threats to plant diversity include land transformation, alien weed infestation, over-exploitation of the natural resources, bush encroachment and unmanaged and regular out-of-season fire.

10.4 Species richness and other diversity parameters

In total 312 indigenous and 68 alien species were recorded in the 2014 survey on KDNR

Appendix A). This list does not represent a full check-list of species occurring on the reserve, because the approach followed in the current survey was to identify communities and not to compile a complete check-list of the flora. In Appendix A a list the collections/reports by the Friends of Kloofendal Nature Reserve (lists provided by K Spottiswoode) and the study by IMR Garratt were also incorporated. According to Appendix A, 457 species have been recorded (identifications not necessarily confirmed) on the reserve to date, with 86 of these species being alien (19% of all species). In total 47 of the 457 species were Category 1b declared invasive species according to the 2014 list of NEM:BA. Appendix B lists all the species in die SIBIS database of the South African National Biodiversity Institute for the 2627BB ROODEPOORT quarter degree grid in which KDNR falls.

In the nearby Walter Sisulu Botanical Garden Behr & Bredenkamp (1988a) recorded a total of 556 species of which approximately 9% were alien.

Several biodiversity parameters were calculated for each of the communities: species richness (i.e. the mean number of species per sample plot), species evenness (i.e. how well abundance is distributed among the species), Shannon-Wiener index of diversity and Simpson's index of diversity (both these indices take richness and evenness into account) (Table 23).

Table 23. Summary of the diversity parameters for the 12 plant communities distinguished on the Kloofendal Nature Reserve

Community	Total number of species	Mean values per sample plot			
		Species richness	Evenness	Shannon-Wiener index	Simpson index
1	102	48	0.84	3.21	0.93
2	129	53	0.80	3.16	0.91
3	92	60	0.66	2.71	0.77
4	102	52	0.71	2.80	0.86
5	108	42	0.62	2.33	0.75
6	132	51	0.71	2.78	0.86
7	105	50	0.75	2.93	0.90
8	111	51	0.77	3.02	0.90
9	119	42	0.73	2.70	0.88
10	94	40	0.67	2.45	0.83
11	34	34	0.57	2.01	0.73
12	87	30	0.72	2.76	0.85

The two rocky outcrop communities had the highest species evenness, Shannon-Wiener and Simpson index of diversity. Community 3 (grassland) had the highest mean number of species per sample plot, although it had a relatively low evenness and a low total number of species per community. The open bushveld community 6 had the highest number of species per community, whereas community 11 (*Eucalyptus* woodlot) had the lowest total number of species per community, as well as the lowest evenness, Shannon-Wiener and Simpson index

of diversity, but was represented by a single sample plot. Community 12, was a disturbed community, and had the lowest mean species richness per plot with a large number of alien species recorded.

10.5 Protected, threatened, Red Data and endemic species

The National Environmental Management, Biodiversity Act (No. 10 of 2004) (NEM:BA) requires authorities to publish lists of threatened species and species in need of protection from certain restricted activities (see draft Gauteng Nature Conservation Bill 2013). Red Data Lists provide assessments of a species' conservation status and are a source of information for decision-makers to monitor the rate of loss of biodiversity.

Rare plant species for Gauteng province are listed in the draft Gauteng Nature Conservation Bill 2013. The Red list of South Africa (Raimondo *et al*. 2009) was also consulted to determine whether any Red Data species occurred in the KDNR. The protected trees according to the National Forests Act (No. 84 of 1998)(NFA 2013), the National Environmental Management: Biodiversity Act, (No. 10 of 2004) (NEM:BA 2013), and CITES appendices (2014) were also consulted to establish whether any species were listed.

10.5.1 Red Data list

The following species on KDNR have a Red Data List status higher than 'least concern' (Raimondo *et al*. 2009):

Boophone disticha	declining
Hypoxis hemerocallidea	declining

A taxon is declining when it does not meet any of the five IUCN criteria and does not qualify for the categories CE, EN, VU or NT, but there are threatening processes causing a decline in the population.

10.5.2 Draft Gauteng Nature Conservation Bill (2014)

The Gauteng Nature Conservation Ordinance (Ordinance 12 of 1983) will be repealed when the Gauteng Nature Conservation Bill is introduced (see Appendix C for a full list of the rare plant species of Gauteng province). The rare plant species of Gauteng are categorised under **Schedule 5** as "Protected Plants" (see Appendix C). The following species listed in the bill were recorded on Kloofendal Nature Reserve during the current survey:

Adromischus umbraticola
Cineraria austrotransvaalensis
Prunus africana

Additionally, the following protected species occur in the 2627BB quarter degree grid and could possibly occur in KDNR (GDARD databank):

Bowiea volubilis subsp. *volubilis*
Brachycorythis conica subsp. *transvaalensis*
Cheilanthes deltoidea subsp. nov.
Delosperma leendertziae
Habenaria barbertoni
Melolobium subspicatum

The following Red/Orange List plant species has been recorded from the farm on which KDNR is situated / within 5 km of the reserve (GDARD databank).

Delosperma leendertziae (1 km NW)

According to the databank of GDARD concerning rare plant species of Gauteng, the following Red/Orange listed plant species are of importance in the region and have been recorded from the quarter degree grid 2627BB in which KDNR is situated:

Alepidea attenuata
Aloe peglerae
**Boophone disticha*
Bowiea volubilis subsp. *volubilis*
Brachycorythis conica subsp. *transvaalensis*
**Callilepis leptophylla*
**Cineraria austrotransvaalensis*
Delosperma leendertziae
Eucomis autumnalis
Habenaria barbertoni
Holothrix randii
**Hypoxis hemerocallidea*
Ilex mitis var. *mitis*
Melolobium subspicatum
Pearsonia bracteata

*species recorded in KDNR

10.5.3 Protected trees

The following protected tree species listed under Notice No. 877 of 22 November 2013 (National Forests Act (No. 84 of 1998)), were recorded on KDNR:

Pittosporum viridiflorum
Prunus africana

10.5.4 CITES

Appendix I lists species that are threatened with extinction and the CITES listing prohibits international trade in specimens of these species, except when the purpose of the import is not commercial, for instance for scientific research. Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled. Appendix III is a list of species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation. Families and genera applicable to KDNR are all in the Appendix II category. The following species were recorded in KDNR during the current field survey:

**Aloe arborescens* (introduced)
**Aloe greatheadii* subsp. *davyana*
**Aloe marlothii*
Aloe peglerae (GDARD list)
**Aloe verecunda*
**Anacampseros subnuda*
**Prunus africana*
*species recorded in KDNR

10.5.5 Threatened and protected species (draft TOPS list of March 2013) of the National Environmental Management: Biodiversity Act (No. 10 of 2004) which could possibly occur in KDNR are the following:

Aloe peglerae	Endangered (GDARD list)
Bowiea volubilis subsp. *volubilis*	Vulnerable medinical plant
**Prunus africana*	Vulnerable medinical plant

*species recorded in KDNR

10.5.6 Endemic species

The KDNR does not fall within any Centre of Endemism (Van Wyk & Smith 1998).

Aloe peglerae and *Frithia pulchra* are listed as endemic plant species for the Gold Reef Mountain Bushveld (Mucina & Rutherford (2006). These two species were not recorded on KDNR during the current survey.

10.6 Conservation of rare plant species

- In situ conservation of rare plant species is preferable to ex situ conservation.

- Rare and endemic species/populations must be afforded the maximum protection, as they occur nowhere else in the world.
- It is imperative that ecological processes maintaining Red Data plant populations are maintained.
- It is vital that pollinators active within Red Data plant populations are conserved by managing the habitat to provide nest sites and suitable host and forage plants; protect pollinators from herbicides and pesticides; prevent soil disturbance; and prevent habitat fragmentation.

In situ conservation would involve the following:

- Ensure the persistence of the rare plant populations.
- A suitable buffer zone around the populations needs to be applied.
- Ensure connectivity with adjacent natural vegetation.
- Faciitate/augment natural ecological processes such as fire and herbivory.
- It is usually recommended that access to rare populations be prohibited.
- Monitor and eradicate alien plant invasions that may threaten the rare plant populations.
- It is important that a management plan for the species includes a monitoring plan, particularly to determine whether operational activities are negatively impacting the populations. Such a monitoring program should be structured to collect the following data:
    - Size of population;
    - Age structure and vigour of the population
    - Number of plants;
    - Number of seedlings; and
    - Evidence of plant mortality.

10.7 Medicinal plant species

The following plant species with medicinal properties or value were recorded in KDNR (Van Wyk *et al.* 1997; Van Wyk & Gericke 2000; Van der Walt 2010; Van Wyk & Van Wyk 2013); * = alien species):

Acacia caffra
Acacia karroo
Acalypha angustata
**Achyranthes aspera*
Acocanthera oppositifolia
Aloe marlothii
Aloe greatheadii subsp. *davyana*
**Araujia sericifera*
Boophone disticha
Centella asiatica
Clematis brachiata
Commelina africana
**Commelina benghalensis*
Cotyledon orbiculata
Cucumis zeyheri
**Datura stramonium*

Dicoma anomala
Dombeya rotundifolia
Ehretia rigida
Elephantorrhiza elephantina
Euclea crispa
Felicia muricata
Gnidia kraussiana
Gomphocarpus fruticosus
Gymnosporia buxifolia
Helichrysum aureonitens
Helichrysum coriaceum
Helichrysum kraussii
Heteromorpha arborescens
Hilliardiella aristata
Hillardiella oligocephala
Hypoxis hemerocallidea
Ipomoea crassipes
**Ipomoea purpurea*
Lannea edulis
**Lantana camara*
Lantana rugosa
Leonotis ocymiifolia
Lippia javanica
**Melia azedarach*
Olea europaea subsp. *africana*
**Opuntia ficus-indica*
Pachycarpus schinzianus
Pelargonium luridum
Pellaea calomelanos
Pittosporum viridiflorum
Plumbago aurantiaca
Plumbago zeylanica
Polygala hottentotta
Protea caffra
Prunus africana
Rhoicissus tridentata
Scabiosa columbaria
Scadoxus puniceus
Searsia pyroides
**Solanum mauritianum*
Tarchonanthus camphoratus
Tephrosia longipes
Typha capensis
**Withania somnifera*
Xerophyta retinervis
Zanthoxylum capense
Ziziphus mucronata
Ziziphus zeyheriana

10.8 Poisonous plant species

A veterinarian must be consulted in cases of suspected plant poisoning. The plant species that are known to be toxic to livestock are listed below (see Vahrmeijer 1981; Kellerman *et al.* 1988; Van Wyk *et al.* 2002). Wildlife can also be poisoned when consuming toxic plant species, but wildlife that are adapted to a specific region usually tend to avoid these plant species naturally. It is safe practice not to relocate animals to a new area during late winter and early spring when many of these poisonous plants have sprouted and are green and highly visible in the dry grass layer.

The following plant species, many of them alien, with poisonous properties were recorded in the KDNR (*alien species):

Acacia caffra
Acacia karroo
Acocanthera oppositifolia
Amaranthus hybridus
**Araujia sericifera*
Boophone disticha
Cestrum laevigatum
**Chenopodium album*

Cotyledon orbiculata
Crotalaria spp.
Cucumis spp.
**Datura stramonium*
Elephantorrhiza elephantina
Ficus ingens
Gnidia kraussiana
Gomphocarpus fruticosus
**Ipomoea purpurea*
Kalanchoe paniculata
Kalanchoe thyrsiflora
Lantana camara
Ledebouria ovatifolia
Lippa javanica
**Melia azedarach*
Mundulea sericea
**Opuntia ficus-indica*
Ornithogalum saundersonii
Pachystigma pygmaeum
Pteridium acquilinum
Pygmaeothamnus zeyheri
**Robinia pseudoacacia*
Scadoxus puniceus
Senecio venosus
**Solanum mauritianum*
**Solanum pseudocapsicum*
**Solanum sisymbrifolium*
Strychnos pungens
Tephrosia longipes

10.9 Sensitive and/or problem areas

Sensitive areas on KDNR include the entire Wilgespruit and the associated riparian vegetation (Figure 34) as well as the rocky ridge (community 1). These areas should receive attention in terms of alien plant invasive species and soil erosion (donga formation). The clusters of *Protea roupelliae* and the central rocky ridge have been indicated in Figure 34 as sentitive.

The main problem areas in terms of indigenous enchroachment species are those areas encroached by *Seriphium plumosum* and *Lopholaena coriifolia*.

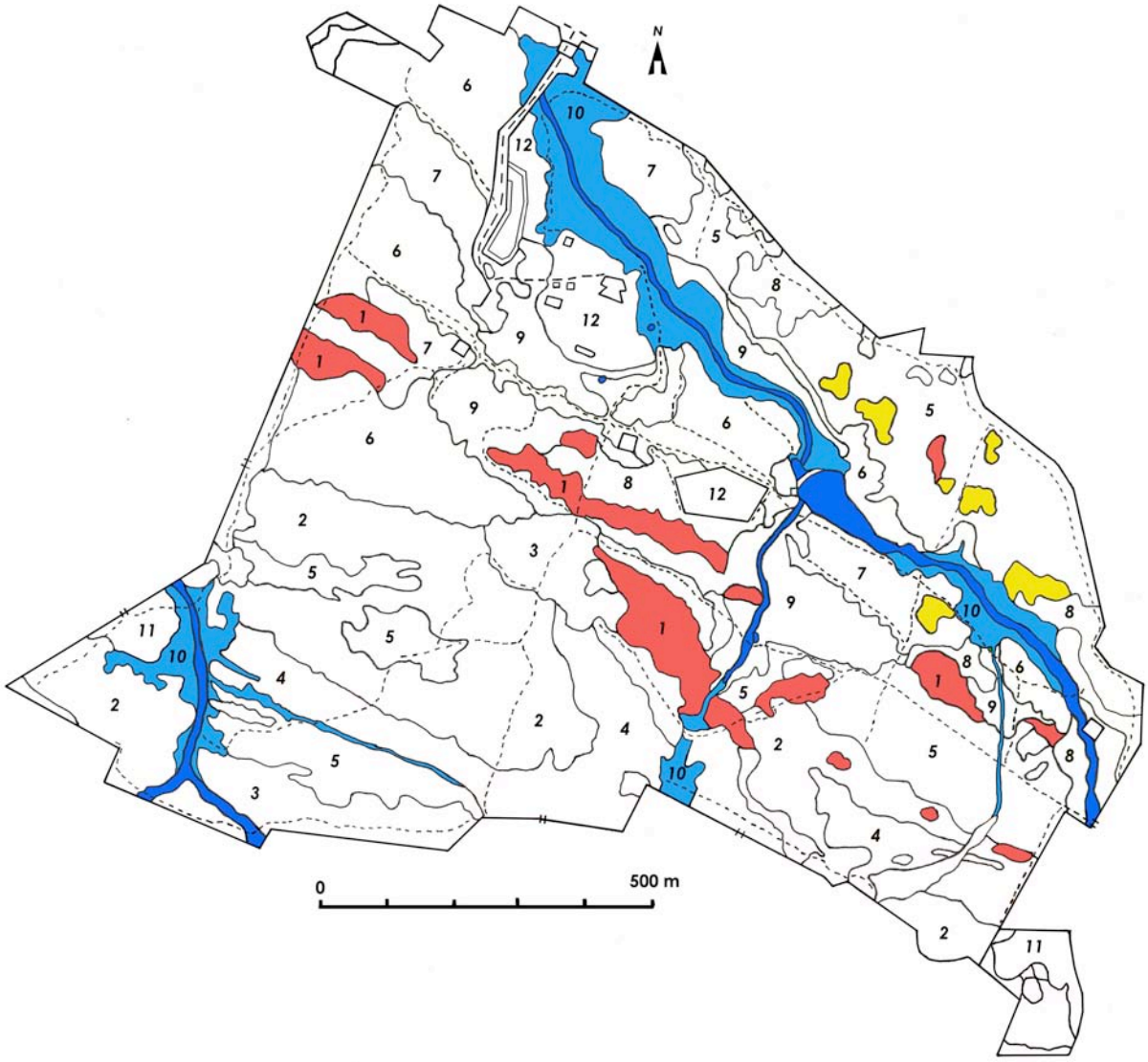

Figure 34. Map indicating the ecologically most sensitive communities in the Kloofendal Nature Reserve. See legend of Figure 11 for community names.

CHAPTER 11

CONSERVATION: FAUNA

11.1 Introduction

No detailed survey of fauna was carried out during the current study. Threatened mammalian fauna are generally highly secretive or nocturnal and it is unlikely that they would be located in surveys of short duration. All lists available, from the GDARD databank as well as the SANBI:SIBIS database, for the fauna of Kloofendal Nature Reserve are provided in Appendix G.

11.2 National Environmental Management: Biodiversity Act (No. 10 of 2004)(NEM:BA 2013)

The draft Threatened and Protected Species (TOPS) lists of 2013 were consulted. The mammals that **could occur naturally** in the region are categorized as follows:

Critically Endangered Mammal Species:

No species recorded on KDNR.

Endangered Mammal Species:

No species recorded on KDNR.

Vulnerable Mammal Species:

No species recorded on KDNR.

Protected Mammal Species - species with high conservation value:

Brown hyaena (recorded in 2628AC QDS)

Protected Mammal Species of National Importance:

No species currently present on KDNR

11.3 Gauteng Nature Conservation Bill 2013

According to the draft Gauteng Nature Conservation Bill (2013), the protected species are classified as follows:

11.3.1 Schedule 1: Protected Wild Animals

1. This category includes all mammals, birds, reptiles and amphibians indigenous to the Republic of South Africa, excluding the following:

   protected birds listed in Schedule 2; and
   species listed in terms of section 56 of the National Environmental Management: Biodiversity Act (No. 10 of 2004).

2. All species of snakes, excluding those listed in terms of section 56 of the National Environmental Management: Biodiversity Act (No. 10 of 2004).

3. Permits are required for the capture, transport and keeping of the following species:

*Common platanna	*Xenopus laevis*
*Guttural toad	*Amietophrynus gutturalis*
*Red toad	*Schismaderma carens*
*Common river frog	*Amietia angolensis*
*Boettger's/common caco	*Cacosternum boettgeri*
Warthog	*Phacochoerus aethiopicus*
Bushpig	*Potamochoerus porcus*
*Rock dassie	*Procavia capensis*
*Porcupine	*Hystrix africaeaustralis*
Banded mongoose	*Mungos mungo*
*Slender mongoose	*Galarella sanguinea*
Yellow mongoose	*Cynictis penicillata*
Blackbacked jackal	*Canis mesomelas*
Caracal	*Felis caracal*
Vervet monkey	*Chlorocebus pygerythrus*
Chacma baboon	*Papio ursinus*

*recorded in KDNR

11.3.2 Schedule 2: Protected Birds

*Die following birds are protected in Gauteng, those occurring in KDNR (GDARD database) are marked with an *asterisk (see Appendix G).*

Waterfowl:	
White-faced duck	*Dendrocygna viduata*
*Egyptian goose	*Alopochen aegyptiaca*
*Yellow-billed duck	*Anas undulata*
Hottentot teal	*Anas hottentota*
Red-billed teal	*Anas erythrorhyncha*
Cape shoveler	*Anas smithii*
Southern pochard	*Netta erythropthalma*
Spur-winged geese	*Plectropterus gambensis*
Comb/Knob-billed duck	*Sarkidiornis melanotos*
Terrestrial gamebirds:	
Coqui francolin	*Peliperdix coqui*
Crested francolin	*Peliperdix sephaena*
*Orange river francolin	*Scleroptila levaillantiodes*
*Swainson's spurfowl	*Pternistes swainsonii*
Common quail	*Coturnix coturnix*
*Helmeted guinea fowl	*Numida meleagris*
Doves and pigeons:	
*Speckled/Rock pigeon	*Columba guinea*
African olive-pigeon/Rameron pigeon	*Columba arquatrix*
*Red-eyed dove	*Streptopilia semitorquata*
*Cape Turtle dove	*Streptopilia capicola*
*Laughing dove	*Streptopilia senegalensis*
Namaqua dove	*Oena capensis*

Reptiles:

All species of snakes (excluding those listed in terms of section 56 of the National Environmental Management: Biodiversity Act (No. 10 of 2004).

11.3.3 Schedule 6: Protected fish

All fish indigenous to the RSA, excluding fish species listed in terms of section 56 of NEM:BA (No. 10 of 2004).

11.3.4 Schedule 8: Protected Invertebrates

All species of baboon spiders belonging to the genera referred to hereby:

Ceratogyrus spp.
Harpactira spp.
Pterinochilus spp.
Idiothele spp.
Trichognathella spp.

All species of scorpions belonging to the genera referred to hereby:

Hadogenes spp.
Opistophthalmus spp.
Opisthacanthus spp.
Cheloctonus spp.

Butterflies:

Heidelberg copper butterfly	*Chrysoritis aureus*
Highveld blue butterfly	*Lepidochrysops praeterita*

Insects:

Stobbia's fruit chafer beetle	*Ichnestoma stobbiai*

11.4 GDARD Red list mammal species KDNR and those of 2627BB grid

According to the GDARD databank, there are no records of **Red list mammal species** that have been recorded specifically for the KDNR. However, the following priority species have either been recorded or suitable habitat is available within the Quarter Degree Grid in which KDNR fall:

*Southern African hedgehog	(*Atelerix frontalis*)
Spotted-necked otter	(*Lutra maculicollis*)
*African clawless otter	(*Aonyx capensis*)
*Brown hyaena	(*Hyaena brunnea*)

*recorded in KDNR

Additionally the following mammal species have been observd in the reserve: scrubhare, common molerat, Highveld gerbil, Cape Serotine bat, Geoffroy's Horseshoe bat, yellow house bat, large spotted genet, rock dassie and slender mongoose.

CHAPTER 12

GUIDELINES FOR RE-INTRODUCTION OF WILDLIFE

12.1 Introduction

The aim of this chapter is to provide guidelines for the re-introduction of wildlife in general. Conservation areas are usually fenced, water supplies are provided and maintained, fire is controlled to a certain extent, and the numbers of certain types of wildlife are carefully managed.

The haphazard restocking of wildlife areas has often had calamitous results. In the past, too small and non-viable populations have been introduced to areas. Wildlife have also been introduced in areas where the habitat and climate were totally different from the area where they originated from, resulting in poor performance and even local extinction. Gemsbok, blesbok, eland, nyala and springbok introduced into areas out of their natural range usually result in high levels of mortality. In some instances there has been an undesirable mixing of species and subspecies with resultant crossbreeding, e.g. black wildebeest x blue wildebeest, and blesbok x bontebok, which produce fertile hybrids.

The limited availability of data on historical distribution has resulted in a number of wildlife types being introduced into game ranches and reserves without evidence that they formerly occurred there. These decisions may not have been in the best interests of either the property or types of wildlife concerned. The Department of Environmental Affairs is currently compiling maps of the historical distribution of the larger herbivores in southern Africa (DEA 2012).

When re-introducing wildlife that occurred historically in an area, animals should preferably be sourced from populations in the vicinity of the reserve, or from areas with similar vegetation and climate, and the principles of genetic conservation should be adhered to. This will minimise the adaptation period of the animals to the habitat and the risk of animals consuming poisonous plants. Viable populations should be established and their adaptation and growth monitored over time.

12.2 Guidelines for re-introduction of wildlife

The re-introduction of common types of wildlife is based more on the areas' requirements in the form of restoring species richness, reinstating ecological processes, providing hunting opportunities or providing game viewing, than on the conservation requirements of the type of wildlife *per se*. Besides ecological and biological criteria, other factors such as economical and recreational requirements are often important, particularly as they might relate to broader planning and development within the reserve.

In the case of the Kloofendal Nature Reserve, species not currently on the reserve, but which could be considered include: blesbok, red hartebeest, klipspringer, springbok, steenbok, plains zebra and oribi.

The introduction of a rare species to the reserve beyond its historic native range would normally require an impact assessment (consult GDARD). In the case of threatened types of wildlife decisions should be based very largely on the suitability of the area and other ecological criteria, and only in exceptional circumstances on economical (ecotourism) or socio-political considerations.

12.2.1 Feasibility study and background research

Assessing the feasibility of new introductions should take the following into consideration:

General information on the property:

- Size of property
- Description of the land-uses on neighbouring properties.
- Description of the type of fence, height, number of electrified strands, voltage and power source. Fence specifications are provided by the nature conservation authority (GDARD).
- Is there a release ramp and/or boma on the property? If so, is it according to specification?

Management objectives:

- Consider the main objectives of the property
- Objectives of re-introduction

The re-introduction of wildlife in an area should have the commitment of long-term financial, legal and, if necessary, political support. An assessment should be made of the taxonomic status of the type of wildlife to be re-established. The animals should be of the same genetic pool (subspecies, ecotype or race) and proof of this must be based on historical information, as well as molecular genetic studies, should there be doubt as to the taxonomic status.

To determine the critical needs of the species, descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases should be compiled. The build-up of the released population should be monitored and modelled to identify significant population and environmental variables to guide population management.

It is important that thorough research be conducted into previous attempts at re-introduction of the same or similar types of wildlife in the same area (e.g. Rietfontein Nature Reserve) and

wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing a re-introduction protocol.

Re-introductions should be made within the historic range of the type of wildlife (see Chapter 6). For supplementation or re-inforcement after the initial re-introduction, care should be taken to prevent disease spread, social disruption (fighting between bulls) and introduction of alien genes to the resident population.

12.2.2 Evaluation of re-introduction site

The landscape and habitat requirements of the species should be satisfied and sustained for the foreseeable future. The possibility of habitat change since extirpation must be considered, for example the increase in bushveld communities in the KDNR. The re-established population should be within the ecological capacity of the area to sustain growth and support a viable population. Previous causes of decline should be identified, eliminated or reduced to an acceptable level. These could include disease (rinderpest), over-hunting, over-utilization, poaching, poisoning, predation, habitat loss and competition with domestic livestock.

No re-introduction should be considered if the following conditions apply:

- It is a type of wildlife that used to occur in the area, but has declined or disappeared without the cause being identified and rectified.
- The habitat is unsuitable.
- The type of animal for re-introduction comes from a different or foreign gene pool.
- There is a conflict with current land-use, either within the reserve or in surrounding areas, such that animals are likely to decline or disappear.
- The boundary fence will not contain the species, and escape from the area would threaten its survival.
- The species will adversely affect populations of other types of wildlife or plant communities, which have a more critical conservation status.
- Natural ecological processes are likely to be seriously disrupted.
- The risk of disease transmission precludes the granting of a veterinary permit.

12.2.3 Criteria for selecting suitable stock

Source animals should come from a population that are closely related genetically to the original native stock and show similar morphological, physiological, behavioural and ecological characteristics to the original sub-population. The source population must not be endangered by the removal of individuals for re-introduction.

Re-introduction should not be carried out merely because captive stock is available. Animals must be subjected to a thorough veterinary screening process before translocation from the

original source. Stock must meet all health requirements prescribed by the veterinary authorities.

If the type of animal poses potential risk to life or property, they should not be considered for the KDNR. The black wildebeest could potentially threaten the safety of hikers.

12.3 Planning, preparation and release stages

Pre- and post-release monitoring programmes should be initiated to evaluate the health and survival of the population and their impact on the habitat. Indicators of the short- and long-term success of the re-introduction and/or introduction in terms of the agreed aims and objectives should be identified.

Care must be taken that animals will not be exposed to vectors of disease agents, e.g. ticks, which may be present at the release site and to which it may have no acquired immunity. If vaccination against local endemic or epidemic disease of wildlife at the release site is deemed appropriate prior to release, this must be carried out at an early stage so as to allow sufficient time for the development of the required immunity. The release strategy should incorporate aspects such as acclimatization of release stock to the release area, group composition and release techniques to be employed.

Transport arrangements should be made to deliver wildlife at the site of re-introduction, with special emphasis on ways to minimize stress on the animals during transport. The guidelines set out in the Code of Practice for (SABS 0331) for 'Translocation of certain species of wild herbivore' (South African Standards, February 2000) should be followed.

12.4 Post-release activities and research

Demographic, ecological and behavioural studies (adaptation) of released stock must be undertaken. Habitat protection should be practiced to ensure future favourable habitat. Introduction of a species should not be considered if permanent supplementary feeding is essential. Should such a requirement become evident after the release of the animals, the removal of the animals should be considered. Provision should be made for decisions to revise, reschedule or discontinue the programme where necessary.

It is critical to monitor behavioural aspects of the populations such as grouping behaviour, movements, and ranging changes. Each of these will give a measure of the response of existing animals. Assays should be made before, during, and after management interventions.

Stress levels can be measured separately using hormone analysis from dung samples, and should be implemented before, during, and after any management intervention.

12.5 Management of populations when they exceed the ecological capacity

The following management options are available to limit numbers of animals:

- Harvesting (live sales)
- Culling
- Translocation
- Contraception

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APPENDIX A

Plant species list of Kloofendal Nature Reserve

*Total = list combined of all sources
*NvR = Noel van Rooyen current report
*Friends = Friends of Kloofendal Nature Reserve (electronic photoguide provided by Karin Spottiswoode plus list of aliens off website)
*IMRG = IMR Garret MSc study NorthWest University

	Total	***NvR**
Trees	36	(36)
Shrubs	23	(20)
Dwarf shrubs	34	(28)
Climbers	3	(3)
Forbs	148	(110)
Geophytes	22	(15)
Grasses	62	(60)
Sedges & bulrushes	10	(10)
Parasites	10	(8)
Succulents	17	(16)
Ferns	6	(6)
Aliens	86	(68)
Total	457	(380)

Trees	***NvR**	***Friends**	***IMRG**
Acacia caffra (Senegalia caffra)	X	X	
Acacia karroo (Vachellia karroo)	X		
Afrocanthium gilfillanii	X	X	
Afrocanthium mundianum	X		
Berchemia zeyheri	X		
Brachylaena rotundata	X	X	
Buddleja saligna	X		
Celtis africana	X		
Combretum erythrophyllum	X		
Combretum molle	X		
Cussonia paniculata	X	X	
Dais cotinifolia	X		
Dombeya rotundifolia	X	X	
Dovyalis zeyheri	X		
Euclea crispa	X	X	
Ficus ingens	X	X	
Heteromorpha arborescens	X	X	
Kiggelaria africana	X	X	
Maytenus undata	X	X	
Nuxia congesta	X	X	
Olea europaea subsp. *africana*	X		
Ozoroa paniculosa	X	X	
Pittosporum viridiflorum	X	X	
Protea caffra	X	X	X
Protea roupelliae	X	X	
Prunus africana	X	X	
Pterocelastrus echinatus	X	X	
Rhamnus prinoides	X	X	
Scolopia zeyheri	X		

Searsia dentata	X	X	
Searsia lancea	X	X	
Searsia leptodictya	X	X	
Searsia pyroides	X	X	
Strychnos pungens	X	X	
Tarchonanthus camphoratus	X	X	
Ziziphus mucronata	X	X	
Shrubs			
Acokanthera oppositifolia	X	X	
Buddleja salviifolia	X	X	
Cliffortia linearifolia	X		
Cliffortia nitidula		X	
Diospyros lycioides	X	X	
Diospyros whyteana		X	
Ehretia rigida	X	X	
Englerophytum magalismontanum	X	X	
Grewia occidentalis	X	X	
Gymnosporia buxifolia	X	X	
Halleria lucida	X	X	
Leucosidea sericea	X	X	
Lopholaena coriifolia	X	X	
Mundulea sericea	X	X	
Myrsine africana	X	X	
Osyris lanceolata		X	
Pavetta gardeniifolia	X		
Searsia rigida	X	X	
Tecoma capensis	X		
Vangueria infausta	X	X	
Vangueria parvifolium	X	X	
Virgilia oroboides	X		
Zanthoxylum capense	X	X	
Dwarf shrubs			
Ancylobotrys capensis	X	X	
Asparagus asparagoides	X		
Asparagus flavicaulis		X	
Asparagus laricinus	X		
Asparagus suaveolens	X		
Asparagus virgatus	X		
Athrixia elata	X	X	
Cineraria austrotransvaalensis	X	X	
Clematopsis scabiosifolia	X		
Cryptolepis oblongifolia	X	X	
Elephantorrhiza elephantina	X	X	
Eriosema salignum	X		
Gnidia canoargentea		X	
Gnidia capitata		X	
Gnidia kraussiana		X	
Indigofera comosa	X	X	X
Laggera crispata		X	
Lannea edulis	X	X	
Lantana rugosa	X		
Lippia javanica	X	X	
Pachystigma pygmaeum	X		
Parinari capensis	X	X	
Phymaspermum athanasioides	X	X	
Plumbago zeylanica	X		
Pollichia campestris	X		
Polygala myrtifolia	X		

Pygmaeothamnus zeyheri		X	
Searsia discolor	X		
Searsia magalismontana	X	X	
Seriphium plumosum	X	X	X
Solanum rigescens	X	X	
Wahlenbergia oxyphylla	X		
Xerophyta retinervis	X	X	
Ziziphus zeyheriana	X		
Climbers			
Clematis brachiata	X	X	
Tecoma capensis	X		
Sphedamnocarpus pruriens	X		
Forbs			
Acalypha angustata	X	X	
Acalypha peduncularis		X	
Aeollanthus buchnerianus	X		
Afrosciadium magalismontanum		X	
Anthospermum hispidulum	X	X	
Anthospermum rigidum	X		
Aspidioglossum glabrescens		X	
Berkheya seminivea	X	X	
Callilepis leptophylla		X	
Centella asiatica	X		
Cephalaria zeyheriana		X	
Chaenostoma leve	X	X	
Chaetacanthus costatus	X	X	
Chamaecrista comosa	X	X	
Chascanum adenostachyum	X		
Chascanum hederaceum	X		
Cleome angustifolia	X		
Cleome monophylla	X	X	
Commelina africana	X	X	
Commelina erecta	X	X	
Conyza aegyptiaca		X	
Conyza podocephala	X		X
Cotula coronopifolia	X	X	
Crabbea acaulis	X	X	
Crabbea angustifolia	X	X	
Crabbea hirsuta	X		
Cucumis zeyheri	X	X	
Cyanotis speciosa	X	X	
Cyphia stenopetala	X		
Dianthus mooiensis	X		
Dicoma anomala	X	X	
Dimorphotheca spectabilis	X	X	
Eriosema burkei		X	
Eriosema cordatum	X		
Euphorbia inaequilatera	X		
Euryops chrysanthemoides	X	X	
Felicia filifolia		X	
Felicia muricata	X		
Gazania krebsiana	X	X	
Gazania sp.	X		
Geigeria burkei		X	
Gerbera ambigua		X	
Gerbera piloselloides	X		
Gerbera viridifolia	X	X	
Gisekia africana	X		

Gomphocarpus fruticosus	X	X		
Haplocarpha lyrata	X			
Haplocarpha scaposa		X		
Hebenstretia comosa		X		
Helichrysum acutatum	X	X		
Helichrysum aureonitens	X	X		
Helichrysum aureum	X	X		
Helichrysum caespititium	X			
Helichrysum cerastioides	X	X		
Helichrysum chionosphaerum		X		
Helichrysum coriaceum	X			
Helichrysum difficile		X		
Helichrysum kraussii	X			
Helichrysum lepidissimum	X			
Helichrysum mimetes		X		
Helichrysum nudifolium	X			
Helichrysum ruderale	X			
Helichrysum rugulosum	X			
Helichrysum setosum	X	X		
Hermannia depressa	X	X		
Hermannia floribunda	X			
Hermannia lancifolia	X	X		
Hibiscus microcarpus		X		
Hilliardiella aristata	X	X		X
Hilliardiella oligocephala	X	X		
Hypericum lalandii	X	X		
Hypoestes forskaolii	X			
Indigastrum burkeana		X		
Indigofera filipes	X			X
Inligofera hedyantha		X		X
Indigofera sp.	X			
Ipomoea bathycolpos			X	
Ipomoea crassipes	X	X		
Ipomoea ommaneyi	X	X		X
Jamesbrittennia burkeana	X	X		
Justicia anagalloides	X			
Kohautia amatymbica		X		
Leonotis intermedia		X		
Leonotis ocymifolia	X			
Leonotis randii		X		
Leucas martinicensis	X			
Leucas sexdentata		X		
Limeum viscosum	X	X		
Lotononis foliosa	X	X		
Lotononis sp.	X			
Macledium zeyheri	X	X		
Monsonia angustifolia	X	X		
Monsonia attenuata		X		
Nemesia fruticans		X		
Nidorella hottentotica	X	X		X
Ocimum obovatum		X		
Oldenlandia herbacea	X	X		
Oxalis depressa			X	
Oxalis obliquifolia	X	X		
Pachycarpus schinzianus		X		
Pavonia columella	X	X		
Pearsonia sessilifolia	X			X
Pelargonium luridum	X			
Pentanisia angustifolia	X	X		X
Pentarrhinum insipidum	X	X		
Phyllanthus parvulus	X			
Plantago lanceolata	X			

Plectranthus grallatus	X			
Plectranthus hereroensis	X		X	
Polydora poskeana	X		X	
Polygala hottentotta	X			
Polygala transvaalensis				X
Polygala uncinata	X		X	X
Psammotropha myriantha	X		X	
Pseudognaphalium luteo-album	X			X
Rhynchosia minima	X			
Rhynchosia totta	X			
Rotheca hirsuta			X	
Scabiosa columbaria	X		X	
Sebaea exigua	X			
Sebaea filiformis	X		X	
Selago densiflora	X		X	
Senecio coronatus	X		X	
Senecio erubescens				X
Senecio inaequidens			X	
Senecio inornatus	X			
Senecio lydenburgensis				X
Senecio oxyriifolius	X		X	
Senecio ruwenzoriensis			X	
Senecio sp.	X			
Senecio venosus	X		X	X
Sida dregei	X			
Sida rhombifolia	X		X	
Silene burchellii			X	
Sphenostylis angustifolia	X		X	X
Syncolostemon pretoriae	X		X	X
Tephrosia capensis	X			
Tephrosia longipes	X			X
Teucrium trifidum	X		X	
Ursinia nana	X		X	
Vernonia galpinii			X	
Vigna sp.	X			
Wahlenbergia caledonica	X			
Wahlenbergia virgata			X	
Wahlenbergia undulata	X		X	
Xysmalobium parviflorum			X	
Zaluzianskya katharinae	X		X	
Zornia linearis	X		X	
Geophytes				
Agapanthus sp. (planted)		X		
Bonatea antennifera	X		X	
Boophane disticha	X		X	
Chortolirion angolense			X	
Chlorophytum fasciculatum	X		X	
Eulophia hians			X	
Eulophia welwitschii			X	
Freesia grandiflora			X	
Gladiolus crassifolius	X			
Gladiolus permeabilis			X	
Gladiolus woodii			X	
Haemanthus humilis	X		X	
Hypoxis acuminata	X		X	
Hypoxis galpinii	X		X	
Hypoxis rigidula	X			
Hypoxis sp.	X			
Ledebouria marginata	X			
Ledebouria ovatifolia	X		X	

Ledebouria revoluta	X		X	
Ornithogalum saundersiae		X		
Raphionacme galpinii	X		X	
Raphionacme hirsuta			X	
Tritonia nelsonii			X	
Grasses				
Alloteropsis semialata	X			
Andropogon chinensis	X			X
Andropogon schirensis	X			
Aristida adscensionis	X			
Aristida congesta subsp. *congesta*	X			
Aristida diffusa	X			
Aristida junciformis	X			
Aristida transvaalensis	X			
Bewsia biflora	X			
Brachiaria serrata	X			X
Cymbopogon caesius	X			
Cymbopogon pospischilii	X			
Cynodon dactylon	X			
Digitaria brazzae	X			
Digitaria diagonalis	X			
Digitaria monodactyla	X			
Digitaria tricholaenoides	X			
Diheteropogon amplectens	X			X
Ehrharta erecta	X			
Elionurus muticus	X			
Enneapogon scoparius				X
Eragrostis chloromelas	X			
Eragrostis curvula	X			
Eragrostis echinochloidea	X			
Eragrostis gummiflua	X			
Eragrostis racemosa	X			X
Eragrostis sclerantha	X			
Eragrostis sp.	X			
Eulalia villosa				X
Harpechloa falx	X			
Heteropogon contortus	X			
Hyparrhenia dregeana	X			
Hyparrhenia hirta	X			
Hyparrhenia tamba	X			
Loudetia simplex	X			X
Melinis nerviglumis	X			
Melinis repens	X			X
Microchloa caffra	X			
Monocymbium ceresiiforme	X			
Panicum maximum	X			
Panicum natalense	X			X
Paspalum dilatatum	X			
Paspalum notatum	X			
Paspalum scrobiculatum	X			
Rendlia altera	X			
Schizachyrium sanguineum	X			
Setaria incrassata	X			
Setaria lindenbergiana	X			
Setaria megaphylla	X			
Setaria nigrirostris	X			
Setaria sphacelata	X			
Sporobolus africanus	X			
Sporobolus pectinatus	X			
Sporobolus sp.	X			

Themeda triandra	X		X
Trachypogon spicatus	X		X
Trichoneura grandiglumis	X		
Tristachya leucothrix	X		X
Tristachya rehmannii	X		
Urelytrum agropyroides	X		
Urochloa mosambicensis	X		
Urochloa panicoides	X		
Parasites			
Alectra sessiliflora	X		
Graderia subintegra		X	
Striga asiatica	X		
Striga bilabiata	X		
Striga elegans	X	X	
Striga gesnerioides	X		
Tapinanthus natalitius subsp. *zeyheri*	X		
Tapinanthus rubromarginatus	X	X	
Thesium sp.	X		
Thesium utile			X
Sedges & bulrushes			
Abildgaardia ovata	X		
Bulbostylis burchellii	X		
Bulbostylis hispidula	X		
Coleochloa setifera	X		
Cyperus esculentus	X	X	
Cyperus obtusiflorus	X	X	
Cyperus rupestris	X		X
Cyperus sp.	X		
Cyperus sphaerospermus	X		
Typha capensis	X		
Succulents			
Adromischus umbraticola	X	X	
Aloe arborescens	X		
Aloe greatheadii subsp. *davyana*	X	X	
Aloe marlothii	X		
Aloe verecunda	X	X	
Anacampseros subnuda	X	X	
Cissus sp.	X		
Cotyledon orbiculata	X	X	
Crassula capitella	X	X	
Crassula lanceolata	X		
Crassula sarcocaulis	X		
Crassula setulosa	X	X	
Crassula swaziensis	X	X	
Kalanchoe paniculata		X	
Kalanchoe thyrsiflora	X	X	
Khadia acutipetala	X	X	
Stapelia gigantea		X	
Ferns			
Cheilanthes hirta	X		
Cheilanthes viridis	X	X	
Pellaea calomelanos	X	X	
Pteridium aquilinum	X	X	
Microlepia speluncae	X	X	

Selaginella dregei	X	X	
Aliens			
Acacia elata	X		
Acacia dealbata	X	X	
Acacia mearnsii	X	X	
Acacia melanoxylon	X	X	X
Achyranthes aspera	X	X	
Agave americana	X	X	
Ageratina adenophora		X	
Amaranthus hybridus	X		
Amaranthus spinosus		X	
Araujia sericifera	X	X	
Argemone mexicana		X	
Bidens bipinnata	X		
Bidens pilosa	X	X	X
Bryophyllum delagoense	X		
Campuloclinium macrocephalum	X	X	
Celtis australis	X		
Cereus jamacaru	X	X	
Cestrum laevigatum	X	X	
Chenopodium album	X		
Chenopodium sp.	X		
Cirsium vulgare		X	
Conyza albida	X		
Conyza bonariensis	X		
Cortaderia selloana	X		
Cosmos bipinnatus	X		
Cotoneaster franchetii	X	X	
Crotalaria agatiflora	X		
Cuscuta campestris	X		
Cyathula cylindrica	X	X	
Cyathula uncinulata	X	X	
Cynoglossum hispidum	X	X	
Datura stramonium		X	
Dichondria micrantha	X		
Dietes cf. iridioides	X		
Einadia nutans	X	X	
Eucalyptus camaldulensis	X		
Eucalyptus cinerea	X		
Gomphrena celosioides	X		
Ipomoea indica		X	
Ipomoea purpurea	X		
Jacaranda mimosifolia	X		
Lactuca inermis	X	X	
Lantana camara	X	X	
Lavateria orbea		X	
Ligustrum japonicum	X	X	
Ligustrum ovalifolium		X	
Malva verticillata		X	
Melia azedarach	X	X	
Mirabilis jalapa	X	X	
Morus alba	X		
Myosotis amplexicaulis		X	
Oenothera tetraptera		X	
Opuntia aurantiaca		X	
Opuntia ficus-indica	X		X
Opuntia spinulifera	X		
Oxalis corniculata	X		
Pennisetum clandestinum	X		X
Persicaria capitata	X		

Persicaria lapathifolia		X	
Physalis peruviana	X	X	
Phytolacca icosandra	X		
Pinus sp.	X		
Plumbago aurantiaca	X		
Pyracantha angustifolia	X	X	
Rhus succedanea	X		
Richardia brasiliensis	X	X	
Robinia pseudoacacia	X	X	
Rumex sagittatus	X	X	
Schkuhria pinnata	X		
Solanum elaeagnifolium		X	
Solanum mauritianum	X	X	
Solanum pseudocapsicum	X	X	
Solanum sisymbrifolium		X	
Sonchus oleraceus	X		
Sonchus wilmsii	X	X	
Tagetes erecta	X		
Tagetes minuta	X	X	X
Taraxacum officinale	X		
Tecoma stans		X	
Tradescantia fluminense		X	
Trifolium repens	X		
Verbena bonariensis	X		
Verbena braziliensis		X	
Withania somnifera	X	X	
Zea mays	X		
Zinnia peruviana	X		

APPENDIX B

PLANT SPECIES OF THE 2627 BB ROODEPOORT QUARTER DEGREE GRID ACCORDING TO THE SANBI: SIBIS DATABASE

Family	ScientificName
CYPERACEAE	Abildgaardia ovata
MALVACEAE	Abutilon piloso-cinereum
MALVACEAE	Abutilon sonneratianum
FABACEAE	Acacia armata
FABACEAE	Acacia caffra
FABACEAE	Acacia cyclops
FABACEAE	Acacia dealbata
FABACEAE	Acacia decurrens
FABACEAE	Acacia karroo
EUPHORBIACEAE	Acalypha angustata
EUPHORBIACEAE	Acalypha caperonioides var. caperonioides
EUPHORBIACEAE	Acalypha glabrata var. pilosa
EUPHORBIACEAE	Acalypha peduncularis
EUPHORBIACEAE	Acalypha villicaulis
ASTERACEAE	Acanthospermum australe
ACERACEAE	Acer buergerianum
AMARANTHACEAE	Achyranthes aspera var. aspera
APOCYNACEAE	Acokanthera oppositifolia
LAMIACEAE	Acrotome hispida
ASTERACEAE	Adenostemma caffrum
PTERIDACEAE	Adiantum capillus-veneris
CRASSULACEAE	Adromischus umbraticola subsp. umbraticola
LAMIACEAE	Aeollanthus buchnerianus
AMARANTHACEAE	Aerva leucura
RUBIACEAE	Afrocanthium gilfillanii
RUBIACEAE	Afrocanthium mundianum
APIACEAE	Afrosciadium magalismontanum
LORANTHACEAE	Agelanthus natalitius subsp. zeyheri
ROSACEAE	Agrimonia bracteata
ROSACEAE	Agrimonia procera
POACEAE	Agrostis eriantha var. eriantha
POACEAE	Agrostis lachnantha var. lachnantha
SIMAROUBACEAE	Ailanthus altissima
HYACINTHACEAE	Albuca setosa
HYACINTHACEAE	Albuca shawii
OROBANCHACEAE	Alectra sessiliflora var. sessiliflora
ALISMATACEAE	Alisma plantago-aquatica
POACEAE	Alloteropsis semialata subsp. eckloniana
ASPHODELACEAE	Aloe arborescens
ASPHODELACEAE	Aloe cryptopoda
ASPHODELACEAE	Aloe greatheadii var. davyana
ASPHODELACEAE	Aloe maculata
ASPHODELACEAE	Aloe verecunda
FABACEAE	Alysicarpus rugosus subsp. perennirufus
AMARANTHACEAE	Amaranthus hybridus subsp. hybridus var. hybridus
AMARANTHACEAE	Amaranthus sp.
PORTULACACEAE	Anacampseros filamentosa subsp. filamentosa
PRIMULACEAE	Anagallis arvensis subsp. arvensis
BORAGINACEAE	Anchusa riparia
APOCYNACEAE	Ancylobotrys capensis
POACEAE	Andropogon appendiculatus

POACEAE	Andropogon chinensis
POACEAE	Andropogon eucomus
POACEAE	Andropogon huillensis
POACEAE	Andropogon schirensis
BRYACEAE	Anomobryum julaceum
POACEAE	Anthephora pubescens
RUBIACEAE	Anthospermum hispidulum
RUBIACEAE	Anthospermum rigidum subsp. pumilum
RUBIACEAE	Anthospermum rigidum subsp. rigidum
ICACINACEAE	Apodytes dimidiata subsp. dimidiata
APOCYNACEAE	Araujia sericifera
PAPAVERACEAE	Argemone mexicana forma mexicana
PAPAVERACEAE	Argemone ochroleuca subsp. ochroleuca
FABACEAE	Argyrolobium speciosum
FABACEAE	Argyrolobium tuberosum
IRIDACEAE	Aristea abyssinica
POACEAE	Aristida adscensionis
POACEAE	Aristida aequiglumis
POACEAE	Aristida bipartita
POACEAE	Aristida canescens subsp. canescens
POACEAE	Aristida congesta subsp. barbicollis
POACEAE	Aristida congesta subsp. congesta
POACEAE	Aristida diffusa subsp. burkei
POACEAE	Aristida junciformis subsp. junciformis
POACEAE	Aristida scabrivalvis subsp. borumensis
POACEAE	Aristida scabrivalvis subsp. scabrivalvis
POACEAE	Aristida stipitata subsp. graciliflora
POACEAE	Aristida transvaalensis
ASTERACEAE	Artemisia afra var. afra
POACEAE	Arundinella nepalensis
POACEAE	Arundo donax
APOCYNACEAE	Asclepias adscendens
APOCYNACEAE	Asclepias albens
APOCYNACEAE	Asclepias aurea
APOCYNACEAE	Asclepias brevipes
APOCYNACEAE	Asclepias eminens
APOCYNACEAE	Asclepias fallax
APOCYNACEAE	Asclepias sabulosa
APOCYNACEAE	Asclepias stellifera
ASPARAGACEAE	Asparagus africanus
ASPARAGACEAE	Asparagus angusticladus
ASPARAGACEAE	Asparagus asparagoides
ASPARAGACEAE	Asparagus cooperi
ASPARAGACEAE	Asparagus flavicaulis subsp. flavicaulis
ASPARAGACEAE	Asparagus laricinus
ASPARAGACEAE	Asparagus stipulaceus
ASPARAGACEAE	Asparagus suaveolens
ASPARAGACEAE	Asparagus virgatus
APOCYNACEAE	Aspidoglossum lamellatum
APOCYNACEAE	Aspidoglossum ovalifolium
ASPLENIACEAE	Asplenium aethiopicum
ASPLENIACEAE	Asplenium capense
ASPLENIACEAE	Asplenium cordatum
ASTERACEAE	Aster harveyanus
ASTERACEAE	Aster peglerae
ASTERACEAE	Aster squamatus
AYTONIACEAE	Asterella marginata
FABACEAE	Astragalus atropilosulus subsp. burkeanus var. burkeanus
ASTERACEAE	Athrixia elata
POACEAE	Avena fatua
IRIDACEAE	Babiana bainesii
ACANTHACEAE	Barleria macrostegia

ACANTHACEAE	Barleria obtusa
ELATINACEAE	Bergia decumbens
ASTERACEAE	Berkheya insignis
ASTERACEAE	Berkheya radula
ASTERACEAE	Berkheya seminivea
ASTERACEAE	Berkheya setifera
ASTERACEAE	Berkheya speciosa subsp. lanceolata
ASTERACEAE	Berkheya zeyheri subsp. zeyheri
POACEAE	Bewsia biflora
ASTERACEAE	Bidens bipinnata
ASTERACEAE	Bidens pilosa
ACANTHACEAE	Blepharis innocua
ACANTHACEAE	Blepharis squarrosa
ACANTHACEAE	Blepharis stainbankiae
ORCHIDACEAE	Bonatea antennifera
AMARYLLIDACEAE	Boophone disticha
POACEAE	Bothriochloa bladhii
HYACINTHACEAE	Bowiea volubilis subsp. volubilis
POACEAE	Brachiaria advena
POACEAE	Brachiaria brizantha
POACEAE	Brachiaria eruciformis
POACEAE	Brachiaria serrata
MALVACEAE	Brachychiton populneus
ORCHIDACEAE	Brachycorythis conica subsp. transvaalensis
ORCHIDACEAE	Brachycorythis tenuior
ASTERACEAE	Brachylaena rotundata
APOCYNACEAE	Brachystelma chloranthum
APOCYNACEAE	Brachystelma nanum
POACEAE	Briza minor
BRYACEAE	Bryum alpinum
BRYACEAE	Bryum argenteum
BRYACEAE	Bryum pycnophyllum
OROBANCHACEAE	Buchnera simplex
BUDDLEJACEAE	Buddleja saligna
BUDDLEJACEAE	Buddleja salviifolia
ASPHODELACEAE	Bulbine capitata
ASPHODELACEAE	Bulbine favosa
CYPERACEAE	Bulbostylis burchellii
CYPERACEAE	Bulbostylis contexta
CYPERACEAE	Bulbostylis humilis
CYPERACEAE	Bulbostylis oritrephes
CYPERACEAE	Bulbostylis oritrephes
CYPERACEAE	Bulbostylis schoenoides
APIACEAE	Bupleurum fruticosum
FABACEAE	Burkea africana
ASTERACEAE	Callilepis laureola
ASTERACEAE	Callilepis leptophylla
RUTACEAE	Calodendrum capense
ASTERACEAE	Campuloclinium macrocephalum
DICRANACEAE	Campylopus introflexus
DICRANACEAE	Campylopus pyriformis
CANNACEAE	Canna indica
APOCYNACEAE	Carissa bispinosa
FABACEAE	Cassia sp.
ICACINACEAE	Cassinopsis ilicifolia
CELTIDACEAE	Celtis africana
APIACEAE	Centella asiatica
DIPSACACEAE	Cephalaria zeyheriana
CARYOPHYLLACEAE	Cerastium arabidis
DITRICHACEAE	Ceratodon purpureus subsp. stenocarpus
APOCYNACEAE	Ceropegia rendallii
SOLANACEAE	Cestrum aurantiacum

SOLANACEAE	Cestrum parqui
SCROPHULARIACEAE	Chaenostoma leve
ACANTHACEAE	Chaetacanthus costatus
FABACEAE	Chamaecrista biensis
FABACEAE	Chamaecrista capensis var. flavescens
FABACEAE	Chamaecrista comosa var. capricornia
FABACEAE	Chamaecrista mimosoides
SINOPTERIDACEAE	Cheilanthes contracta
PTERIDACEAE	Cheilanthes deltoidea
SINOPTERIDACEAE	Cheilanthes dolomiticola
SINOPTERIDACEAE	Cheilanthes eckloniana
SINOPTERIDACEAE	Cheilanthes hirta var. brevipilosa
SINOPTERIDACEAE	Cheilanthes hirta var. hirta
SINOPTERIDACEAE	Cheilanthes involuta var. involuta
SINOPTERIDACEAE	Cheilanthes involuta var. obscura
SINOPTERIDACEAE	Cheilanthes multifida subsp. lacerata
SINOPTERIDACEAE	Cheilanthes multifida var. multifida
SINOPTERIDACEAE	Cheilanthes viridis var. glauca
SINOPTERIDACEAE	Cheilanthes viridis var. viridis
CHENOPODIACEAE	Chenopodium album
CHENOPODIACEAE	Chenopodium mucronatum
CHENOPODIACEAE	Chenopodium pumilio
GENTIANACEAE	Chironia palustris subsp. transvaalensis
GENTIANACEAE	Chironia purpurascens subsp. humilis
GENTIANACEAE	Chironia purpurascens subsp. purpurascens
POACEAE	Chloris pycnothrix
POACEAE	Chloris virgata
ANTHERICACEAE	Chlorophytum bowkeri
ANTHERICACEAE	Chlorophytum cooperi
ANTHERICACEAE	Chlorophytum fasciculatum
ANTHERICACEAE	Chlorophytum transvaalense
ASPHODELACEAE	Chortolirion angolense
THELYPTERIDACEAE	Christella gueinziana
ASTERACEAE	Cichorium intybus subsp. intybus
ASTERACEAE	Cineraria albicans
ASTERACEAE	Cineraria austrotransvaalensis
ASTERACEAE	Cineraria lobata subsp. lobata
ASTERACEAE	Cineraria sp.
ASTERACEAE	Cirsium vulgare
RANUNCULACEAE	Clematis brachiata
RANUNCULACEAE	Clematis oweniae
RANUNCULACEAE	Clematis villosa subsp. villosa
CAPPARACEAE	Cleome maculata
CAPPARACEAE	Cleome monophylla
ROSACEAE	Cliffortia linearifolia
ROSACEAE	Cliffortia nitidula subsp. pilosa
EUPHORBIACEAE	Clutia natalensis
EUPHORBIACEAE	Clutia pulchella var. pulchella
CUCURBITACEAE	Coccinia adoensis
COMBRETACEAE	Combretum apiculatum subsp. apiculatum
COMBRETACEAE	Combretum erythrophyllum
COMBRETACEAE	Combretum molle
COMMELINACEAE	Commelina africana var. africana
COMMELINACEAE	Commelina africana var. krebsiana
COMMELINACEAE	Commelina africana var. lancispatha
COMMELINACEAE	Commelina benghalensis
COMMELINACEAE	Commelina subulata
CONVOLVULACEAE	Convolvulus farinosus
CONVOLVULACEAE	Convolvulus ocellatus var. ocellatus
CONVOLVULACEAE	Convolvulus sagittatus
CONVOLVULACEAE	Convolvulus thunbergii
ASTERACEAE	Conyza albida

ASTERACEAE	Conyza bonariensis
ASTERACEAE	Conyza podocephala
ASTERACEAE	Conyza scabrida
ASTERACEAE	Conyza sumatrensis var. sumatrensis
POACEAE	Cortaderia selloana
ASTERACEAE	Cosmos bipinnatus
ROSACEAE	Cotoneaster franchetii
ASTERACEAE	Cotula hispida
CRASSULACEAE	Cotyledon orbiculata var. oblonga
ACANTHACEAE	Crabbea angustifolia
ACANTHACEAE	Crabbea hirsuta
ASTERACEAE	Crassocephalum x picridifolium
CRASSULACEAE	Crassula alba var. alba
CRASSULACEAE	Crassula expansa subsp. expansa
CRASSULACEAE	Crassula lanceolata subsp. transvaalensis
CRASSULACEAE	Crassula nodulosa var. nodulosa forma nodulosa
CRASSULACEAE	Crassula setulosa var. jenkinsii
CRASSULACEAE	Crassula setulosa var. setulosa forma setulosa
CRASSULACEAE	Crassula vaginata subsp. vaginata
FABACEAE	Crotalaria agatiflora subsp. agatiflora
FABACEAE	Crotalaria sphaerocarpa subsp. sphaerocarpa
APOCYNACEAE	Cryptolepis oblongifolia
CUCURBITACEAE	Cucumis hirsutus
CUCURBITACEAE	Cucumis zeyheri
CUPRESSACEAE	Cupressus sp.
CONVOLVULACEAE	Cuscuta campestris
ARALIACEAE	Cussonia paniculata subsp. paniculata
ARALIACEAE	Cussonia paniculata subsp. sinuata
COMMELINACEAE	Cyanotis speciosa
AMARANTHACEAE	Cyathula uncinulata
PILOTRICHACEAE	Cyclodictyon vallis-gratiae
APIACEAE	Cyclospermum leptophyllum
OROBANCHACEAE	Cycnium tubulosum subsp. tubulosum
POACEAE	Cymbopogon caesius
POACEAE	Cymbopogon dieterlenii
POACEAE	Cymbopogon excavatus
POACEAE	Cymbopogon marginatus
POACEAE	Cymbopogon nardus
POACEAE	Cymbopogon prolixus
POACEAE	Cymbopogon validus
POACEAE	Cynodon dactylon
POACEAE	Cynodon hirsutus
POACEAE	Cynodon transvaalensis
BORAGINACEAE	Cynoglossum lanceolatum
CYPERACEAE	Cyperus albostriatus
CYPERACEAE	Cyperus congestus
CYPERACEAE	Cyperus denudatus var. denudatus
CYPERACEAE	Cyperus eragrostis
CYPERACEAE	Cyperus esculentus var. esculentus
CYPERACEAE	Cyperus leptocladus
CYPERACEAE	Cyperus longus var. tenuiflorus
CYPERACEAE	Cyperus margaritaceus var. margaritaceus
CYPERACEAE	Cyperus marginatus
CYPERACEAE	Cyperus obtusiflorus var. flavissimus
CYPERACEAE	Cyperus obtusiflorus var. obtusiflorus
CYPERACEAE	Cyperus rupestris var. rupestris
CYPERACEAE	Cyperus semitrifidus
CYPERACEAE	Cyperus sexangularis
CYPERACEAE	Cyperus sp.
CYPERACEAE	Cyperus sphaerospermus
CYPERACEAE	Cyperus uitenhagensis
LOBELIACEAE	Cyphia stenopetala

VITACEAE	Cyphostemma cirrhosum subsp. transvaalense
VITACEAE	Cyphostemma lanigerum
EUPHORBIACEAE	Dalechampia capensis
SOLANACEAE	Datura ferox
SOLANACEAE	Datura stramonium
MESEMBRYANTHEMACEAE	Delosperma leendertziae
MESEMBRYANTHEMACEAE	Delosperma sp.
FABACEAE	Desmodium repandum
CARYOPHYLLACEAE	Dianthus mooiensis subsp. kirkii
CARYOPHYLLACEAE	Dianthus mooiensis subsp. mooiensis var. mooiensis
FABACEAE	Dichilus lebeckioides
FABACEAE	Dichilus pilosus
FABACEAE	Dichilus strictus
CONVOLVULACEAE	Dichondra repens
SCROPHULARIACEAE	Diclis rotundifolia
ASTERACEAE	Dicoma anomala subsp. anomala
POTTIACEAE	Didymodon tophaceus
URTICACEAE	Didymodoxa caffra
POACEAE	Digitaria ciliaris
POACEAE	Digitaria diagonalis var. diagonalis
POACEAE	Digitaria eriantha
POACEAE	Digitaria eylesii
POACEAE	Digitaria monodactyla
POACEAE	Digitaria ternata
POACEAE	Digitaria tricholaenoides
POACEAE	Digitaria velutina
POACEAE	Diheteropogon amplectens var. amplectens
ASTERACEAE	Dimorphotheca spectabilis
DIOSCOREACEAE	Dioscorea retusa
EBENACEAE	Diospyros lycioides subsp. guerkei
EBENACEAE	Diospyros lycioides subsp. lycioides
EBENACEAE	Diospyros scabrida var. cordata
EBENACEAE	Diospyros whyteana
ORCHIDACEAE	Disa patula var. transvaalensis
ORCHIDACEAE	Disperis anthoceros var. anthoceros
ORCHIDACEAE	Disperis micrantha
DITRICHACEAE	Ditrichum brachypodum
FABACEAE	Dolichos angustifolius
FABACEAE	Dolichos falciformis
MALVACEAE	Dombeya rotundifolia var. rotundifolia
SALICACEAE	Dovyalis zeyheri
CYPERACEAE	Dracoscirpoides surculosa
HYACINTHACEAE	Drimia calcarata
HYACINTHACEAE	Drimia multisetosa
HYACINTHACEAE	Drimiopsis burkei subsp. burkei
DROSERACEAE	Drosera collinsiae
DRYOPTERIDACEAE	Dryopteris athamantica
POACEAE	Echinochloa crus-galli
POACEAE	Echinochloa haploclada
BORAGINACEAE	Ehretia rigida subsp. nervifolia
POACEAE	Ehrharta erecta var. erecta
CYPERACEAE	Eleocharis dregeana
FABACEAE	Elephantorrhiza burkei
FABACEAE	Elephantorrhiza elephantina
POACEAE	Eleusine coracana subsp. africana
POACEAE	Elionurus muticus
ZAMIACEAE	Encephalartos eugene-maraisii
SAPOTACEAE	Englerophytum magalismontanum
POACEAE	Enneapogon pretoriensis
POACEAE	Enneapogon scoparius
ONAGRACEAE	Epilobium salignum
POACEAE	Eragrostis aspera

POACEAE	Eragrostis capensis
POACEAE	Eragrostis chloromelas
POACEAE	Eragrostis cilianensis
POACEAE	Eragrostis curvula
POACEAE	Eragrostis gummiflua
POACEAE	Eragrostis heteromera
POACEAE	Eragrostis lehmanniana var. lehmanniana
POACEAE	Eragrostis mexicana subsp. virescens
POACEAE	Eragrostis patentipilosa
POACEAE	Eragrostis plana
POACEAE	Eragrostis planiculmis
POACEAE	Eragrostis racemosa
POACEAE	Eragrostis sclerantha subsp. sclerantha
POACEAE	Eragrostis superba
POACEAE	Eragrostis tef
ERICACEAE	Erica alopecurus var. glabriflora
FABACEAE	Eriosema burkei var. burkei
FABACEAE	Eriosema cordatum
FABACEAE	Eriosema nutans
FABACEAE	Eriosema salignum
FABACEAE	Eriosema transvaalense
ERIOSPERMACEAE	Eriospermum cooperi var. cooperi
ERIOSPERMACEAE	Eriospermum flagelliforme
ERIOSPERMACEAE	Eriospermum porphyrium
BRASSICACEAE	Eruca sativa
FABACEAE	Erythrina lysistemon
MYRTACEAE	Eucalyptus calophylla
MYRTACEAE	Eucalyptus camaldulensis
MYRTACEAE	Eucalyptus cinerea
MYRTACEAE	Eucalyptus globulus subsp. maidenii
MYRTACEAE	Eucalyptus grandis
MYRTACEAE	Eucalyptus melliodora
MYRTACEAE	Eucalyptus radiata subsp. radiata
MYRTACEAE	Eucalyptus robusta
MYRTACEAE	Eucalyptus sideroxylon subsp. sideroxylon
MYRTACEAE	Eucalyptus viminalis subsp. cygnetensis
EBENACEAE	Euclea crispa subsp. crispa
EBENACEAE	Euclea undulata
HYACINTHACEAE	Eucomis autumnalis subsp. clavata
HYACINTHACEAE	Eucomis pallidiflora subsp. pallidiflora
ORCHIDACEAE	Eulophia calanthoides
ORCHIDACEAE	Eulophia hians var. hians
ORCHIDACEAE	Eulophia hians var. inaequalis
ORCHIDACEAE	Eulophia leontoglossa
ORCHIDACEAE	Eulophia ovalis var. bainesii
ORCHIDACEAE	Eulophia tuberculata
ORCHIDACEAE	Eulophia welwitschii
EUPHORBIACEAE	Euphorbia epicyparissias
EUPHORBIACEAE	Euphorbia hirta
EUPHORBIACEAE	Euphorbia inaequilatera var. inaequilatera
EUPHORBIACEAE	Euphorbia pseudotuberosa
EUPHORBIACEAE	Euphorbia pubescens
EUPHORBIACEAE	Euphorbia rhombifolia
EUPHORBIACEAE	Euphorbia striata var. cuspidata
EUPHORBIACEAE	Euphorbia striata var. striata
ASTERACEAE	Euryops laxus
POACEAE	Eustachys paspaloides
CONVOLVULACEAE	Evolvulus alsinoides
POLYGONACEAE	Fallopia convolvulus
ASTERACEAE	Felicia fruticosa subsp. brevipedunculata
ASTERACEAE	Felicia muricata subsp. cinerascens
ASTERACEAE	Felicia muricata subsp. muricata

POACEAE	Festuca caprina
CYPERACEAE	Ficinia stolonifera
MORACEAE	Ficus abutilifolia
MORACEAE	Ficus cordata subsp. cordata
MORACEAE	Ficus ingens
MORACEAE	Ficus salicifolia
CYPERACEAE	Fimbristylis complanata
FISSIDENTACEAE	Fissidens bryoides
APIACEAE	Foeniculum vulgare var. vulgare
OLEACEAE	Fraxinus americana
IRIDACEAE	Freesia grandiflora
IRIDACEAE	Freesia sp.
CYPERACEAE	Fuirena pubescens var. pubescens
CYPERACEAE	Fuirena stricta var. stricta
FUMARIACEAE	Fumaria muralis subsp. muralis
ASTERACEAE	Galinsoga parviflora
RUBIACEAE	Galium spurium subsp. africanum
ASTERACEAE	Gazania krebsiana subsp. serrulata
ASTERACEAE	Geigeria burkei subsp. burkei var. burkei
ASTERACEAE	Geigeria burkei subsp. burkei var. intermedia
ASTERACEAE	Geigeria burkei subsp. burkei var. zeyheri
ASTERACEAE	Gerbera ambigua
ASTERACEAE	Gerbera piloselloides
ASTERACEAE	Gerbera viridifolia
IRIDACEAE	Gladiolus antholyzoides
IRIDACEAE	Gladiolus crassifolius
IRIDACEAE	Gladiolus dalenii subsp. dalenii
IRIDACEAE	Gladiolus longicollis subsp. platypetalus
IRIDACEAE	Gladiolus papilio
IRIDACEAE	Gladiolus permeabilis subsp. edulis
IRIDACEAE	Gladiolus woodii
THYMELAEACEAE	Gnidia caffra
THYMELAEACEAE	Gnidia canoargentea
THYMELAEACEAE	Gnidia capitata
THYMELAEACEAE	Gnidia gymnostachya
THYMELAEACEAE	Gnidia kraussiana var. kraussiana
THYMELAEACEAE	Gnidia microcephala
THYMELAEACEAE	Gnidia sp.
APOCYNACEAE	Gomphocarpus fruticosus subsp. decipiens
APOCYNACEAE	Gomphocarpus fruticosus subsp. fruticosus
APOCYNACEAE	Gomphocarpus glaucophyllus
AMARANTHACEAE	Gomphrena celosioides
OROBANCHACEAE	Graderia scabra
OROBANCHACEAE	Graderia subintegra
PROTEACEAE	Grevillea robusta
MALVACEAE	Grewia occidentalis var. occidentalis
AMARANTHACEAE	Guilleminea densa
CELASTRACEAE	Gymnosporia buxifolia
CELASTRACEAE	Gymnosporia polyacanthus subsp. vaccinifolia
ORCHIDACEAE	Habenaria barbertoni
AMARYLLIDACEAE	Haemanthus humilis subsp. hirsutus
SCROPHULARIACEAE	Halleria lucida
ASTERACEAE	Haplocarpha scaposa
POACEAE	Harpochloa falx
OROBANCHACEAE	Harveya pumila
ZINGIBERACEAE	Hedychium gardnerianum
ASTERACEAE	Helichrysum acutatum
ASTERACEAE	Helichrysum allioides
ASTERACEAE	Helichrysum athrixiifolium
ASTERACEAE	Helichrysum aureonitens
ASTERACEAE	Helichrysum aureum var. monocephalum
ASTERACEAE	Helichrysum caespititium

ASTERACEAE	Helichrysum callicomum
ASTERACEAE	Helichrysum cephaloideum
ASTERACEAE	Helichrysum cerastioides var. aurosicum
ASTERACEAE	Helichrysum cerastioides var. cerastioides
ASTERACEAE	Helichrysum chionosphaerum
ASTERACEAE	Helichrysum coriaceum
ASTERACEAE	Helichrysum difficile
ASTERACEAE	Helichrysum kraussii
ASTERACEAE	Helichrysum lepidissimum
ASTERACEAE	Helichrysum mundtii
ASTERACEAE	Helichrysum niveum
ASTERACEAE	Helichrysum nudifolium var. nudifolium
ASTERACEAE	Helichrysum nudifolium var. oxyphyllum
ASTERACEAE	Helichrysum oreophilum
ASTERACEAE	Helichrysum paronychioides
ASTERACEAE	Helichrysum polycladum
ASTERACEAE	Helichrysum rugulosum
ASTERACEAE	Helichrysum setosum
ASTERACEAE	Helichrysum sp.
ASTERACEAE	Helichrysum stenopterum
POACEAE	Helictotrichon turgidulum
RHAMNACEAE	Helinus integrifolius
BRASSICACEAE	Heliophila rigidiuscula
BORAGINACEAE	Heliotropium nelsonii
POACEAE	Hemarthria altissima
LAMIACEAE	Hemizygia pretoriae subsp. heterotricha
MALVACEAE	Hermannia cordata
MALVACEAE	Hermannia depressa
MALVACEAE	Hermannia floribunda
MALVACEAE	Hermannia lancifolia
MALVACEAE	Hermannia umbratica
IRIDACEAE	Hesperantha candida
IRIDACEAE	Hesperantha coccinea
IRIDACEAE	Hesperantha leucantha
APIACEAE	Heteromorpha arborescens var. abyssinica
POACEAE	Heteropogon contortus
MALVACEAE	Hibiscus aethiopicus var. ovatus
MALVACEAE	Hibiscus engleri
MALVACEAE	Hibiscus lunarifolius
MALVACEAE	Hibiscus microcarpus
MALVACEAE	Hibiscus subreniformis
MALVACEAE	Hibiscus trionum
ASTERACEAE	Hilliardiella aristata
ASTERACEAE	Hilliardiella hirsuta
ASTERACEAE	Hilliardiella oligocephala
ARALIACEAE	Hydrocotyle verticillata
POACEAE	Hyparrhenia anamesa
POACEAE	Hyparrhenia dregeana
POACEAE	Hyparrhenia filipendula var. pilosa
POACEAE	Hyparrhenia hirta
POACEAE	Hyparrhenia tamba
HYPERICACEAE	Hypericum aethiopicum subsp. aethiopicum
HYPERICACEAE	Hypericum aethiopicum subsp. sonderi
HYPERICACEAE	Hypericum lalandii
HYPERICACEAE	Hypericum revolutum subsp. revolutum
ASTERACEAE	Hypochaeris microcephala var. albiflora
ASTERACEAE	Hypochaeris radicata
ACANTHACEAE	Hypoestes forskaolii
HYPOXIDACEAE	Hypoxis acuminata
HYPOXIDACEAE	Hypoxis argentea var. argentea
HYPOXIDACEAE	Hypoxis filiformis
HYPOXIDACEAE	Hypoxis galpinii

HYPOXIDACEAE	Hypoxis hemerocallidea
HYPOXIDACEAE	Hypoxis interjecta
HYPOXIDACEAE	Hypoxis iridifolia
HYPOXIDACEAE	Hypoxis oblonga
HYPOXIDACEAE	Hypoxis rigidula var. pilosissima
HYPOXIDACEAE	Hypoxis rigidula var. rigidula
AQUIFOLIACEAE	Ilex mitis var. mitis
POACEAE	Imperata cylindrica
FABACEAE	Indigastrum burkeanum
FABACEAE	Indigastrum fastigiatum
FABACEAE	Indigofera comosa
FABACEAE	Indigofera confusa
FABACEAE	Indigofera cryptantha var. cryptantha
FABACEAE	Indigofera dimidiata
FABACEAE	Indigofera frondosa
FABACEAE	Indigofera hedyantha
FABACEAE	Indigofera hilaris var. hilaris
FABACEAE	Indigofera melanadenia
FABACEAE	Indigofera oxalidea
FABACEAE	Indigofera oxytropis
FABACEAE	Indigofera zeyheri
CONVOLVULACEAE	Ipomoea alba
CONVOLVULACEAE	Ipomoea bathycolpos
CONVOLVULACEAE	Ipomoea crassipes var. crassipes
CONVOLVULACEAE	Ipomoea indica
CONVOLVULACEAE	Ipomoea obscura var. obscura
CONVOLVULACEAE	Ipomoea ommanneyi
CONVOLVULACEAE	Ipomoea purpurea
CONVOLVULACEAE	Ipomoea simplex
IRIDACEAE	Iris pseudacorus
POACEAE	Ischaemum fasciculatum
CYPERACEAE	Isolepis costata
HYPNACEAE	Isopterygium sp.
SCROPHULARIACEAE	Jamesbrittenia aurantiaca
SCROPHULARIACEAE	Jamesbrittenia burkeana
OLEACEAE	Jasminum angulare
OLEACEAE	Jasminum nudiflorum
JUNCACEAE	Juncus dregeanus subsp. dregeanus
JUNCACEAE	Juncus effusus
JUNCACEAE	Juncus exsertus
JUNCACEAE	Juncus lomatophyllus
JUNCACEAE	Juncus oxycarpus
ACANTHACEAE	Justicia anagalloides
CRASSULACEAE	Kalanchoe paniculata
CRASSULACEAE	Kalanchoe rotundifolia
CRASSULACEAE	Kalanchoe thyrsiflora
MESEMBRYANTHEMACEAE	Khadia acutipetala
ACHARIACEAE	Kiggelaria africana
ASPHODELACEAE	Kniphofia porphyrantha
POACEAE	Koeleria capensis
RUBIACEAE	Kohautia amatymbica
RUBIACEAE	Kohautia caespitosa subsp. brachyloba
RUBIACEAE	Kohautia virgata
CYPERACEAE	Kyllinga alata
CYPERACEAE	Kyllinga erecta var. erecta
CYPERACEAE	Kyllinga melanosperma
FABACEAE	Lablab purpureus subsp. uncinatus
ASTERACEAE	Lactuca inermis
HYDROCHARITACEAE	Lagarosiphon muscoides
ASTERACEAE	Laggera crispata
ANACARDIACEAE	Lannea edulis var. edulis
VERBENACEAE	Lantana camara

VERBENACEAE	Lantana rugosa
HALORAGACEAE	Laurembergia repens subsp. brachypoda
MALVACEAE	Lavatera arborea
HYACINTHACEAE	Ledebouria burkei
HYACINTHACEAE	Ledebouria cooperi
HYACINTHACEAE	Ledebouria luteola
HYACINTHACEAE	Ledebouria marginata
HYACINTHACEAE	Ledebouria revoluta
POACEAE	Leersia hexandra
FABACEAE	Leobordea carinata
FABACEAE	Leobordea divaricata
FABACEAE	Leobordea eriantha
FABACEAE	Leobordea foliosa
FABACEAE	Leobordea mucronata
LAMIACEAE	Leonotis nepetifolia
LAMIACEAE	Leonotis ocymifolia
LAMIACEAE	Leonotis ocymifolia var. schinzii
LAMIACEAE	Leonotis schinzii
BRASSICACEAE	Lepidium africanum subsp. africanum
BRASSICACEAE	Lepidium bonariense
POLYPODIACEAE	Lepisorus schraderi
FABACEAE	Lessertia stricta
FABACEAE	Leucaena leucocephala subsp. leucocephala
LAMIACEAE	Leucas martinicensis
ROSACEAE	Leucosidea sericea
LINACEAE	Linum thunbergii
ASTERACEAE	Linzia glabra
VERBENACEAE	Lippia javanica
FABACEAE	Listia heterophylla
BORAGINACEAE	Lithospermum cinereum
LOBELIACEAE	Lobelia erinus
POACEAE	Lolium multiflorum
POACEAE	Lolium perenne
POACEAE	Lophacme digitata
ASTERACEAE	Lopholaena coriifolia
FABACEAE	Lotononis adpressa subsp. leptantha
FABACEAE	Lotononis calycina
FABACEAE	Lotononis eriantha
FABACEAE	Lotononis foliosa
FABACEAE	Lotononis laxa
FABACEAE	Lotononis wilmsii
FABACEAE	Lotus discolor subsp. discolor
POACEAE	Loudetia simplex
LUNULARIACEAE	Lunularia cruciata
ASTERACEAE	Macledium zeyheri subsp. argyrophyllum
ASTERACEAE	Macledium zeyheri subsp. zeyheri
CAPPARACEAE	Maerua cafra
SCROPHULARIACEAE	Manulea paniculata
SCROPHULARIACEAE	Manulea parviflora var. parviflora
MARCHANTIACEAE	Marchantia polymorpha subsp. ruderalis
CYPERACEAE	Mariscus dregeanus
CELASTRACEAE	Maytenus heterophylla subsp. heterophylla
CELASTRACEAE	Maytenus undata
OROBANCHACEAE	Melasma scabrum var. scabrum
MELIANTHACEAE	Melianthus comosus
FABACEAE	Melilotus albus
FABACEAE	Melilotus indicus
POACEAE	Melinis nerviglumis
POACEAE	Melinis repens subsp. repens
FABACEAE	Melolobium subspicatum
OLEACEAE	Menodora africana
LAMIACEAE	Mentha aquatica

POACEAE	Microchloa caffra
SCROPHULARIACEAE	Mimulus gracilis
NYCTAGINACEAE	Mirabilis jalapa
POACEAE	Miscanthus junceus
ANEMIACEAE	Mohria vestita
MOLLUGINACEAE	Mollugo cerviana var. cerviana
POACEAE	Monocymbium ceresiiforme
LOBELIACEAE	Monopsis decipiens
GERANIACEAE	Monsonia angustifolia
GERANIACEAE	Monsonia attenuata
IRIDACEAE	Moraea pallida
IRIDACEAE	Moraea stricta
MYRICACEAE	Morella serrata
FABACEAE	Mundulea sericea subsp. sericea
MYRICACEAE	Myrica sp.
HALORAGACEAE	Myriophyllum aquaticum
CELASTRACEAE	*Mystroxylon aethiopicum* subsp. *burkeanum*
BRASSICACEAE	Nasturtium officinale
SCROPHULARIACEAE	Nemesia fruticans
SCROPHULARIACEAE	Nemesia rupicola
NEPHROLEPIDACEAE	Nephrolepis exaltata
AMARYLLIDACEAE	Nerine angustifolia
APOCYNACEAE	Nerium oleander
LYTHRACEAE	Nesaea sagittifolia var. sagittifolia
LYTHRACEAE	Nesaea schinzii
ASTERACEAE	Nidorella anomala
ASTERACEAE	Nidorella hottentotica
ASTERACEAE	Nolletia rarifolia
BUDDLEJACEAE	Nuxia congesta
BUDDLEJACEAE	Nuxia glomerulata
LAMIACEAE	Ocimum obovatum subsp. obovatum var. obovatum
ONAGRACEAE	Oenothera jamesii
ONAGRACEAE	Oenothera rosea
ONAGRACEAE	Oenothera stricta subsp. stricta
RUBIACEAE	Oldenlandia herbacea var. herbacea
RUBIACEAE	Oldenlandia rupicola var. rupicola
RUBIACEAE	Oldenlandia tenella
OLEACEAE	Olea europaea subsp. africana
OLINIACEAE	Olinia emarginata
APOCYNACEAE	Orbea lutea subsp. lutea
HYACINTHACEAE	Ornithogalum juncifolium var. juncifolium
HYACINTHACEAE	Ornithogalum tenuifolium subsp. tenuifolium
COLCHICACEAE	Ornithoglossum vulgare
OSMUNDACEAE	Osmunda regalis
ASTERACEAE	Osteospermum muricatum subsp. muricatum
SANTALACEAE	Osyris lanceolata
ASTERACEAE	Othonna natalensis
OXALIDACEAE	Oxalis corniculata
OXALIDACEAE	Oxalis depressa
OXALIDACEAE	Oxalis latifolia
ANACARDIACEAE	Ozoroa paniculosa var. paniculosa
APOCYNACEAE	Pachycarpus schinzianus
RUBIACEAE	Pachystigma pygmaeum
RUBIACEAE	Pachystigma triflorum
POACEAE	Panicum coloratum var. coloratum
POACEAE	Panicum natalense
POACEAE	Panicum schinzii
SAPINDACEAE	Pappea capensis
CHRYSOBALANACEAE	Parinari capensis subsp. capensis
POACEAE	Paspalum dilatatum
POACEAE	Paspalum scrobiculatum
POACEAE	Paspalum urvillei

POACEAE	Paspalum vaginatum
RUBIACEAE	Pavetta eylesii
RUBIACEAE	Pavetta gardeniifolia var. gardeniifolia
RUBIACEAE	Pavetta gardeniifolia var. subtomentosa
RUBIACEAE	Pavetta zeyheri
RUBIACEAE	Pavetta zeyheri subsp. zeyheri
MALVACEAE	Pavonia burchellii
MALVACEAE	Pavonia columella
MALVACEAE	Pavonia sp.
FABACEAE	Pearsonia aristata
FABACEAE	Pearsonia bracteata
FABACEAE	Pearsonia cajanifolia subsp. cajanifolia
FABACEAE	Pearsonia sessilifolia subsp. filifolia
FABACEAE	Pearsonia sessilifolia subsp. sessilifolia
GERANIACEAE	Pelargonium luridum
SINOPTERIDACEAE	Pellaea calomelanos var. calomelanos
FABACEAE	Peltophorum africanum
POACEAE	Pennisetum thunbergii
RUBIACEAE	Pentanisia angustifolia
RUBIACEAE	Pentanisia prunelloides subsp. latifolia
ASTERACEAE	Pentzia monocephala
CUCURBITACEAE	Peponium caledonicum
POLYGONACEAE	Persicaria attenuata subsp. africana
POLYGONACEAE	Persicaria decipiens
POLYGONACEAE	Persicaria lapathifolia
POLYGONACEAE	Persicaria limbata
POLYGONACEAE	Persicaria meisneriana
POACEAE	Phalaris arundinacea
BARTRAMIACEAE	Philonotis falcata
POACEAE	Phragmites mauritianus
RHAMNACEAE	Phylica paniculata
PHYLLANTHACEAE	Phyllanthus glaucophyllus
PHYLLANTHACEAE	Phyllanthus incurvus
ASTERACEAE	Phymaspermum athanasioides
ASTERACEAE	Phymaspermum montanum
SOLANACEAE	Physalis angulata
PHYTOLACCACEAE	Phytolacca dioica
PHYTOLACCACEAE	Phytolacca octandra
PINACEAE	Pinus patula var. patula
PITTOSPORACEAE	Pittosporum viridiflorum
AYTONIACEAE	Plagiochasma rupestre var. rupestre
PLANTAGINACEAE	Plantago longissima
PLANTAGINACEAE	Plantago major
PLANTAGINACEAE	Plantago sp.
LAMIACEAE	Plectranthus cylindraceus
LAMIACEAE	Plectranthus grallatus
LAMIACEAE	Plectranthus hereroensis
LAMIACEAE	Plectranthus hereroensis 'Witpoortjie'
LAMIACEAE	Plectranthus sp.
PLUMBAGINACEAE	Plumbago zeylanica
POACEAE	Poa annua
POACEAE	Pogonarthria squarrosa
POLYTRICHACEAE	Pogonatum capense
MNIACEAE	Pohlia elongata
CARYOPHYLLACEAE	Pollichia campestris
POLYGALACEAE	Polygala gerrardii
POLYGALACEAE	Polygala gracilenta
POLYGALACEAE	Polygala hottentotta
POLYGALACEAE	Polygala ohlendorfiana
POLYGALACEAE	Polygala rehmannii
POLYGALACEAE	Polygala transvaalensis subsp. transvaalensis
POLYGALACEAE	Polygala virgata var. virgata

POACEAE	Polypogon monspeliensis
POACEAE	Polypogon viridis
POLYTRICHACEAE	Polytrichum commune
SALICACEAE	Populus deltoides subsp. deltoides forma deltoides
POTAMOGETONACEAE	Potamogeton nodosus
POTAMOGETONACEAE	Potamogeton octandrus
VERBENACEAE	Priva cordifolia var. abyssinica
PROTEACEAE	Protea caffra
PROTEACEAE	Protea caffra subsp. caffra
PROTEACEAE	Protea gaguedi
PROTEACEAE	Protea gaguedi X welwitschii
PROTEACEAE	Protea mundii
PROTEACEAE	Protea roupelliae
PROTEACEAE	Protea roupelliae subsp. roupelliae
PROTEACEAE	Protea welwitschii
ROSACEAE	Prunus africana
ROSACEAE	Prunus salicifolia
MOLLUGINACEAE	Psammotropha myriantha
ASTERACEAE	Pseudognaphalium luteo-album
ASTERACEAE	Pseudognaphalium oligandrum
DENNSTAEDTIACEAE	Pteridium aquilinum subsp. aquilinum
PTERIDACEAE	Pteris cretica
CELASTRACEAE	Pterocelastrus echinatus
ASTERACEAE	Pulicaria scabra
AMARANTHACEAE	Pupalia lappacea var. lappacea
LAMIACEAE	Pycnostachys reticulata
CYPERACEAE	Pycreus macranthus
CYPERACEAE	Pycreus mundii
RUBIACEAE	Pygmaeothamnus zeyheri var. rogersii
RUBIACEAE	Pygmaeothamnus zeyheri var. zeyheri
ROSACEAE	Pyracantha angustifolia
RANUNCULACEAE	Ranunculus meyeri
RANUNCULACEAE	Ranunculus multifidus
APOCYNACEAE	Raphionacme galpinii
APOCYNACEAE	Raphionacme hirsuta
POACEAE	Rendlia altera
RHAMNACEAE	Rhamnus prinoides
VITACEAE	Rhoicissus tridentata subsp. tridentata
ANACARDIACEAE	Rhus dentata
ANACARDIACEAE	Rhus magalismontana subsp. magalismontana
ANACARDIACEAE	Rhus pyroides var. gracilis
ANACARDIACEAE	Rhus zeyheri
FABACEAE	Rhynchosia caribaea
FABACEAE	Rhynchosia confusa
FABACEAE	Rhynchosia monophylla
FABACEAE	Rhynchosia nervosa var. nervosa
FABACEAE	Rhynchosia sordida
FABACEAE	Rhynchosia totta var. totta
FABACEAE	Rhynchosia venulosa
CYPERACEAE	Rhynchospora brownii
RICCIACEAE	Riccia atropurpurea
RUBIACEAE	Richardia brasiliensis
APOCYNACEAE	Riocreuxia polyantha
FABACEAE	Robinia pseudoacacia
BRASSICACEAE	Rorippa fluviatilis var. fluviatilis
BRASSICACEAE	Rorippa nudiuscula
LAMIACEAE	Rotheca hirsuta
RUBIACEAE	Rothmannia capensis
RUBIACEAE	Rubia horrida
RUBIACEAE	Rubia petiolaris
ROSACEAE	Rubus rigidus
ROSACEAE	Rubus x proteus

POLYGONACEAE	Rumex acetosella subsp. angiocarpus
POLYGONACEAE	Rumex conglomeratus
POLYGONACEAE	Rumex crispus
POLYGONACEAE	Rumex dregeanus subsp. montanus
POLYGONACEAE	Rumex sagittatus
SALICACEAE	Salix babylonica var. babylonica
SALICACEAE	Salix mucronata subsp. woodii
LAMIACEAE	Salvia radula
LAMIACEAE	Salvia runcinata
LAMIACEAE	Salvia tiliifolia
CAPRIFOLIACEAE	Sambucus sp.
LAMIACEAE	Satureja biflora
ORCHIDACEAE	Satyrium cristatum var. cristatum
ORCHIDACEAE	Satyrium hallackii subsp. ocellatum
DIPSACACEAE	Scabiosa columbaria
AMARYLLIDACEAE	Scadoxus puniceus
ANACARDIACEAE	Schinus molle
ASTERACEAE	Schistostephium crataegifolium
ASTERACEAE	Schistostephium heptalobum
POACEAE	Schizachyrium sanguineum
HYACINTHACEAE	Schizocarphus nervosus
ASTERACEAE	Schkuhria pinnata
CYPERACEAE	Schoenoplectus brachyceras
CYPERACEAE	Schoenoplectus corymbosus
CYPERACEAE	Schoenoplectus muricinux
CYPERACEAE	Schoenoxiphium sp.
CYPERACEAE	Schoenoxiphium sparteum
CYPERACEAE	Scleria bulbifera
SALICACEAE	Scolopia zeyheri
ANACARDIACEAE	Searsia dentata
ANACARDIACEAE	Searsia discolor
ANACARDIACEAE	Searsia leptodictya forma leptodictya
ANACARDIACEAE	Searsia magalismontana subsp. magalismontana
ANACARDIACEAE	Searsia pyroides var. integrifolia
ANACARDIACEAE	Searsia pyroides var. pyroides
ANACARDIACEAE	Searsia rigida var. dentata
ANACARDIACEAE	Searsia rigida var. margaretae
ANACARDIACEAE	Searsia rigida var. rigida
ANACARDIACEAE	Searsia zeyheri
GENTIANACEAE	Sebaea exigua
GENTIANACEAE	Sebaea grandis
GENTIANACEAE	Sebaea junodii
APOCYNACEAE	Secamone alpini
SELAGINELLACEAE	Selaginella dregei
SCROPHULARIACEAE	Selago capitellata
SCROPHULARIACEAE	Selago densiflora
SCROPHULARIACEAE	Selago sp.
ASTERACEAE	Senecio affinis
ASTERACEAE	Senecio consanguineus
ASTERACEAE	Senecio coronatus
ASTERACEAE	Senecio erubescens var. erubescens
ASTERACEAE	Senecio glanduloso-pilosus
ASTERACEAE	Senecio gregatus
ASTERACEAE	Senecio harveianus
ASTERACEAE	Senecio hieracioides
ASTERACEAE	Senecio inaequidens
ASTERACEAE	Senecio inornatus
ASTERACEAE	Senecio isatideus
ASTERACEAE	Senecio laevigatus var. integrifolius
ASTERACEAE	Senecio laevigatus var. laevigatus
ASTERACEAE	Senecio latifolius
ASTERACEAE	Senecio lydenburgensis

ASTERACEAE	Senecio oxyriifolius
ASTERACEAE	Senecio oxyriifolius subsp. oxyriifolius
ASTERACEAE	Senecio scitus
ASTERACEAE	Senecio venosus
FABACEAE	Senna italica subsp. arachoides
ASTERACEAE	Seriphium plumosum
POACEAE	Setaria lindenbergiana
POACEAE	Setaria megaphylla
POACEAE	Setaria nigrirostris
POACEAE	Setaria plicatilis
POACEAE	Setaria pumila
POACEAE	Setaria sphacelata
POACEAE	Setaria sphacelata var. sericea
POACEAE	Setaria sphacelata var. sphacelata
POACEAE	Setaria sphacelata var. torta
POACEAE	Setaria verticillata
MALVACEAE	Sida alba
MALVACEAE	Sida chrysantha
MALVACEAE	Sida dregei
MALVACEAE	Sida rhombifolia subsp. rhombifolia
MALVACEAE	Sida ternata
CARYOPHYLLACEAE	Silene burchellii var. angustifolia
CARYOPHYLLACEAE	Silene gallica
CARYOPHYLLACEAE	Silene undulata
BRASSICACEAE	Sisymbrium orientale
APOCYNACEAE	Sisyranthus randii
APIACEAE	Sium repandum
SOLANACEAE	Solanum capense
SOLANACEAE	Solanum chenopodioides
SOLANACEAE	Solanum giganteum
SOLANACEAE	Solanum lichtensteinii
SOLANACEAE	Solanum mauritianum
SOLANACEAE	Solanum nigrum
SOLANACEAE	Solanum panduriforme
SOLANACEAE	Solanum pseudocapsicum
SOLANACEAE	Solanum seaforthianum var. disjunctum
SOLANACEAE	Solanum sisymbriifolium
SOLANACEAE	Solanum supinum var. supinum
ASTERACEAE	Sonchus dregeanus
ASTERACEAE	Sonchus integrifolius var. integrifolius
ASTERACEAE	Sonchus oleraceus
POACEAE	Sorghum bicolor subsp. drummondii
MALPIGHIACEAE	Sphedamnocarpus pruriens subsp. galphimiifolius
FABACEAE	Sphenostylis angustifolia
POACEAE	Sporobolus africanus
POACEAE	Sporobolus centrifugus
POACEAE	Sporobolus festivus
POACEAE	Sporobolus fimbriatus
POACEAE	Sporobolus pectinatus
POACEAE	Sporobolus stapfianus
LAMIACEAE	Stachys natalensis var. natalensis
APOCYNACEAE	Stapelia gigantea
POACEAE	Stipa dregeana var. elongata
OROBANCHACEAE	Striga asiatica
OROBANCHACEAE	Striga elegans
OROBANCHACEAE	Striga gesnerioides
STRYCHNACEAE	Strychnos pungens
STRYCHNACEAE	Strychnos pungens
FABACEAE	Sutherlandia frutescens
PALLAVICINIACEAE	Symphyogyna brasiliensis
LAMIACEAE	Syncolostemon pretoriae
ASTERACEAE	Tagetes minuta

LORANTHACEAE	Tapinanthus natalitius subsp. zeyheri
LORANTHACEAE	Tapinanthus rubromarginatus
LORANTHACEAE	Tapinanthus rubromarginatus
LORANTHACEAE	Tapinanthus rubromarginatus
ASTERACEAE	Taraxacum officinale
ASTERACEAE	Tarchonanthus camphoratus
ASTERACEAE	Tarchonanthus parvicapitulatus
BIGNONIACEAE	Tecoma stans var. stans
FABACEAE	Tephrosia capensis var. acutifolia
FABACEAE	Tephrosia elongata var. elongata
FABACEAE	Tephrosia longipes subsp. longipes var. longipes
FABACEAE	Tephrosia multijuga
FABACEAE	Tephrosia semiglabra
LAMIACEAE	Teucrium trifidum
THELYPTERIDACEAE	Thelypteris confluens
POACEAE	Themeda triandra
SANTALACEAE	Thesium burkei
SANTALACEAE	Thesium costatum var. costatum
SANTALACEAE	Thesium cytisoides
SANTALACEAE	Thesium deceptum
SANTALACEAE	Thesium racemosum
SANTALACEAE	Thesium translucens
SANTALACEAE	Thesium transvaalense
SANTALACEAE	Thesium utile
FABACEAE	Tipuana tipu
ASTERACEAE	Tithonia diversifolia
ASTERACEAE	Tolpis capensis
ASPHODELACEAE	Trachyandra asperata var. swaziensis
ASPHODELACEAE	Trachyandra saltii var. saltii
BALANTIOPSIDACEAE	Trachyphyllum gastrodes
POACEAE	Trachypogon spicatus
EUPHORBIACEAE	Tragia minor
EUPHORBIACEAE	Tragia okanyua
POACEAE	Tragus berteronianus
ZYGOPHYLLACEAE	Tribulus terrestris
POACEAE	Trichoneura grandiglumis
FABACEAE	Trifolium sp.
POACEAE	Triraphis andropogonoides
POACEAE	Tristachya leucothrix
POACEAE	Tristachya rehmannii
IRIDACEAE	Tritonia nelsonii
IRIDACEAE	Tritonia securigera
MALVACEAE	Triumfetta sonderi
CUCURBITACEAE	Trochomeria macrocarpa subsp. macrocarpa
TROPAEOLACEAE	Tropaeolum majus
ALLIACEAE	Tulbaghia acutiloba
ALLIACEAE	Tulbaghia leucantha
TYPHACEAE	Typha capensis
POACEAE	Urelytrum agropyroides
HYACINTHACEAE	Urginea multisetosa
HYACINTHACEAE	Urginea sp.
POACEAE	Urochloa panicoides
ASTERACEAE	Ursinia nana subsp. leptophylla
ASTERACEAE	Ursinia nana subsp. nana
ASTERACEAE	Ursinia tenuiloba
VAHLIACEAE	Vahlia capensis subsp. capensis
RUBIACEAE	Vangueria infausta subsp. infausta
RUBIACEAE	Vangueria parvifolia
VERBENACEAE	Verbena aristigera
VERBENACEAE	Verbena bonariensis
VERBENACEAE	Verbena brasiliensis
ASTERACEAE	Vernonia galpinii

ASTERACEAE	Vernonia myriantha
ASTERACEAE	Vernonia oligocephala
ASTERACEAE	Vernonia poskeana subsp. botswanica
ASTERACEAE	Vernonia staehelinoides
ASTERACEAE	Vernonia steetziana
ASTERACEAE	Vernonia sutherlandii
SCROPHULARIACEAE	Veronica anagallis-aquatica
FABACEAE	Vigna vexillata var. davyi
FABACEAE	Vigna vexillata var. vexillata
APOCYNACEAE	Vinca major
VISCACEAE	Viscum rotundifolium
CAMPANULACEAE	Wahlenbergia lycopodioides
CAMPANULACEAE	Wahlenbergia magaliesbergensis
CAMPANULACEAE	Wahlenbergia undulata
CAMPANULACEAE	Wahlenbergia virgata
SOLANACEAE	Withania somnifera
ASTERACEAE	Xanthium strumarium
VELLOZIACEAE	Xerophyta retinervis
OLACACEAE	Ximenia caffra var. caffra
APOCYNACEAE	Xysmalobium undulatum var. undulatum
SCROPHULARIACEAE	Zaluzianskya elongata
SCROPHULARIACEAE	Zaluzianskya katharinae
RUTACEAE	Zanthoxylum capense
RUTACEAE	Zanthoxylum humile
ASTERACEAE	Zinnia peruviana
RHAMNACEAE	Ziziphus mucronata subsp. mucronata
RHAMNACEAE	Ziziphus zeyheriana
FABACEAE	Zornia linearis

APPENDIX C

ALPHABETICAL LIST OF PROTECTED PLANT SPECIES OF GAUTENG PROVINCE ACCORDING TO THE DRAFT GAUTENG NATURE CONSERVATION BILL OF 2013

Adromischus umbraticola subsp. *umbraticola*
Alepidea attenuata
Argyrolobium campicola
Argyrolobium megarrhizum
Blepharis uniflora
Bowiea volubilis subsp. *volubilis*
Brachycorythis conica subsp. *transvaalensis*
Brachystelma discoideum
Ceropegia decidua subsp.*pretoriensis*
Ceropegia turricula
Cheilanthes deltoidea subsp. nov. Gauteng form
Cineraria austrotransvaalensis
Cineraria longipes
Cleome conrathii
Cucumis humifructus
Delosperma gautengense
Delosperma leendertziae
Delosperma macellum
Delosperma purpureum
Dioscorea sylvatica
Drimia sanguinea
Eulophia coddii
Frithia humilis
Frithia pulchra
Gladiolus pole-evansii
Gladiolus robertsoniae
Gnaphalium nelsonii
Habenaria barbertoni
Habenaria bicolor
Habenaria kraenzliniana
Habenaria mossii
Holothrix micrantha
Holothrix randii
Khadia beswickii
Kniphofia typhoides
Lepidium mossii
Lithops lesliei subsp. *lesliei* var. *rubrobrunnea*
Lithops lesliei subsp. *lesliei*
Macledium pretoriense
Melolobium subspicatum
Nerine gracilis
Prunus africana
Searsia gracillima var. *gracillima*
Stenostelma umbelluliferum
Trachyandra erythrorrhiza

*species recorded on Kloofendal Nature Reserve

According to the GDARD database, the following Red/Orange List plant taxa have been recorded from the property on which the study site is situated / within 5 km of the study site.

Delosperma leendertziae (1km NW)

According to the GDARD database, the following Red/Orange List plant taxa have been recorded from the quarter degree grid **2627BB ROODEPOORT** in which the study site is situated.

Alepidea attenuata
Aloe peglerae
Boophane disticha
Bowiea volubilis subsp. *volubilis*
Brachycorythis conica subsp. *transvaalensis*
Callilepis leptophylla
Cineraria austrotransvaalensis
Delosperma leendertziae
Eucomis autumnalis
Habenaria barbertoni
Holothrix randii
Hypoxis hemerocallidea
Ilex mitis var. *mitis*
Melolobium subspicatum
Pearsonia bracteata

APPENDIX D

GPS COORDINATES OF ALL SAMPLE PLOTS

Plot no.	GPS coordinate
1	S26 08 06.6 E27 53 00.8
2	S26 08 03.5 E27 52 51.5
3	S26 08 04.8 E27 52 49.8
4	S26 08 06.9 E27 52 46.1
5	S26 08 12.5 E27 52 42.9
6	S26 08 13.6 E27 52 41.0
7	S26 08 15.5 E27 52 39.6
8	S26 08 14.7 E27 52 48.7
9	S26 08 13.3 E27 52 54.1
10	S26 08 12.1 E27 52 57.3
11	S26 08 13.5 E27 52 59.4
12	S26 08 12.8 E27 53 00.7
13	S26 08 16.7 E27 53 05.0
14	S26 08 18.5 E27 53 06.7
15	S26 08 19.5 E27 53 09.1
16	S26 08 15.2 E27 53 10.4
17	S26 07 52.9 E27 52 42.4
18	S26 07 53.3 E27 52 39.5
19	S26 07 53.6 E27 52 37.4
20	S26 07 55.6 E27 52 37.3
21	S26 07 57.6 E27 52 33.9
22	S26 08 04.0 E27 52 31.8
23	S26 08 06.0 E27 52 30.5
24	S26 08 08.7 E27 52 24.7
25	S26 08 10.2 E27 52 30.7
26	S26 08 08.1 E27 52 41.6
27	S26 08 05.6 E27 52 44.8
28	S26 08 10.3 E27 52 30.6
29	S26 08 01.1 E27 52 50.1
30	S26 07 56.4 E27 52 48.6
31	S26 08 00.3 E27 52 53.0
32	S26 08 00.0 E27 52 58.1
33	S26 07 58.6 E27 52 59.6
34	S26 08 03.5 E27 53 04.7
35	S26 08 06.2 E27 53 04.5
36	S26 08 06.1 E27 53 04.6
37	S26 08 08.3 E27 53 11.5
38	S26 08 09.7 E27 53 14.5
39	S26 08 10.0 E27 53 15.8
40	S26 08 09.0 E27 53 16.8
41	S26 08 05.8 E27 53 15.1
42	S26 08 00.9 E27 53 14.0
43	S26 07 58.5 E27 53 09.1
44	S26 07 57.6 E27 53 06.1
45	S26 07 53.7 E27 53 04.5
46	S26 07 50.8 E27 53 02.9
47	S26 07 47.2 E27 52 57.2
48	S26 07 46.6 E27 52 56.4
49	S26 07 42.6 E27 52 53.1
50	S26 07 51.6 E27 52 52.0

APPENDIX E

GRASS SPECIES OF KLOOFENDAL NATURE RESERVE AND THEIR PERCEIVED ECOLOGICAL STATUS (CLASSES 1 – 5)(SEE CHAPTERS 3 & 5)

Species	Ecological status Class
Alloteropsis semialata	3
Andropogon chinensis	3
Andropogon schirensis	3
Aristida adscensionis	5
Aristida congesta subsp. *congesta*	5
Aristida diffusa	5
Aristida junciformis	5
Aristida transvaalensis	5
Bewsia biflora	3
Brachiaria serrata	4
Cymbopogon caesius	3
Cymbopogon pospischilii	3
Cynodon dactylon	4
Digitaria brazzae	2
Digitaria diagonalis	3
Digitaria monodactyla	4
Digitaria tricholaenoides	2
Diheteropogon amplectens	2
Ehrharta erecta	5
Elionurus muticus	4
Enneapogon scoparius	5
Eragrostis chloromelas	3
Eragrostis curvula	2
Eragrostis echinochloidea	4
Eragrostis gummiflua	5
Eragrostis racemosa	4
Eragrostis sclerantha	4
Eragrostis sp.	4
Eulalia villosa	3
Harpechloa falx	4
Heteropogon contortus	3
Hyparrhenia dregeana	3
Hyparrhenia hirta	3
Hyparrhenia tamba	3
Loudetia simplex	4
Melinis nerviglumis	5
Melinis repens	5
Microchloa caffra	5
Monocymbium ceresiiforme	4
Panicum maximum	1
Panicum natalense	5
Paspalum dilatatum	2
Paspalum notatum	3
Paspalum scrobiculatum	2
Rendlia altera	5
Schizachyrium sanguineum	3
Setaria incrassata	2
Setaria lindenbergiana	3
Setaria megaphylla	2

Setaria nigrirostris	2
Setaria sphacelata	2
Sporobolus africanus	4
Sporobolus pectinatus	2
Sporobolus sp.	2
Themeda triandra	1
Trachypogon spicatus	3
Trichoneura grandiglumis	5
Tristachya leucothrix	5
Tristachya rehmannii	5
Urelytrum agropyroides	3
Urochloa mosambicensis	2
Urochloa panicoides	4

APPENDIX F

FAUNAL SPECIES LISTS

Mammal list (provide by K Theunissen & K Spottiswoode)

Brown hyaena
Bushbaby
Cape clawless otter
Cape serotine bat
Geoffroy's horseshoe bat
Grey duiker
Hedgehog
Highveld gerbil
Large spotted genet
Mole rat
Mountain reedbuck
Porcupine
Rock dassie
Scrub hare
Slender Mongoose
Small spotted genet
Yellow house bat

Bird list of the Kloofendal Nature Reserve, compiled from GDARD databank & FroK (the latter a combination of lists of Wildlife Society of Southern Africa; Southern African Bird Atlas Project; Birds in Reserves put together by J D van Dyk)

*Acacia Pied Barbet
*African Black Duck
*African Black Swift
*African Darter
*African Grey Hornbill
*African Hoopoe
*African Olive-Pigeon
*African Palm-Swift
*African Paradise-Flycatcher
*African Pipit
*African Red-eyed Bulbul
*African Sacred Ibis
*African Stonechat
*African Wattled Lapwing
*Amethyst Sunbird
*Ashy Tit
*Bar-Throated Apalis
*Barn Owl
*Barn Swallow
*Black-backed Puffback
*Black-chested Snake-eagle
*Black Cuckoo
*Black Cuckooshrike
*Black Kite
*Black Sparrowhawk
*Black-chested Prinia
*Black-collared Barbet
*Black-crowned Tchagra
*Black-headed Heron
*Black-headed Oriole
*Black-shouldered Kite
*Black-throated Canary
*Blacksmith Lapwing
*Blue Waxbill
*Bokmakierie
*Bronze Mannikin
*Brown-backed Honeybird
*Brown-crowned Tchagra
*Brown-hooded Kingfisher
*Brown-throated Martin
*Brubru
*Buffy pipit
*Burchell's Coucal
*Cape Bunting
*Cape Clapper Lark
*Cape Crow
*Cape Glossy Starling
*Cape Grassbird
*Cape Longclaw
Cape Robin-chat
*Cape Rock-Thrush
*Cape Sparrow
*Cape Turtle-Dove
*Cape Wagtail
*Cape Weaver
*Cape White-eye
*Cardinal Woodpecker
*Cattle Egret
*Chestnut-vented Tit-Babbler
*Chinspot Batis
*Cinnamon-breasted Bunting
*Common Fiscal
*Common House-Martin
*Common Myna
*Common Waxbill
*Crested Barbet
*Crowned Lapwing
*Dark-capped Bulbul

*Diderick Cuckoo
*Eastern Long-billed Lark
*Egyptian Goose
*European Bee-eater
*Fairy Flycatcher
*Familiar Chat
Feral Pigeon
*Fiery-necked nightjar
*Fiscal Flycatcher
*Fork-tailed Drongo
*Garden Warbler
*Glossy Ibis
*Golden-tailed woodpecker
*Greater Double-Collared Sunbird
*Greater Honeyguide
*Greater Striped Swallow
**Green Wood-hoopoe
*Grey Go-away-bird
*Grey Heron
Grey Turaco
*Hadeda Ibis
*Hamerkop
*Helmeted Guineafowl
*House Sparrow
*Jackal Buzzard
*Karoo Thrush
*Klaas's Cuckoo
*Kurrichane Thrush
*Laughing Dove
*Lazy Cisticola
*Lesser Grey Shrike
*Lesser Honeyguide
*Lesser Striped Swallow
*Little Bee-eater
*Little Egret
*Little Grebe
*Little Swift
*Long-billed Crombek
Long-billed Lark
*Long-billed Pipit
*Malachite Sunbird
*Marico Flycatcher
*Marsh Warbler
*Mocking Cliff-Chat
*Mountain Wheatear
**Namaqua Dove
*Neddicky
Olive Thrush
*Orange-breasted bush-shrike
*Orange River Francolin
*Ovambo Sparrow-hawk
*Pale-winged Starling
*Pied Crow
*Pied Kingfisher
*Pied Starling
*Pin-Tailed Whydah
*Rattling Cisticola
*Red-billed Hornbill
*Red-billed Quelea
*Red-chested Cuckoo
*Red-collared Widowbird
*Red-eyed Dove
*Red-faced Mousebird
*Red-knobbed Coot
*Red-throated Wryneck
*Red-winged Starling
*Reed Cormorant
*Rock Dove
*Rock Martin
*Shikra
*Short-toed Rock-thrush
*Southern Boubou
*Southern Grey-Headed Sparrow
*Southern Masked Weaver
*Southern Red Bishop
*Speckled Mousebird
*Speckled Pigeon
*Spotted Eagle-Owl
*Spotted Flycatcher
*Spotted-Thick-knee
*Steppe Buzzard
*Streaky-headed Seedeater
*Swainson's Spurfowl
*Tawny-flanked Prinia
Thick-billed Weaver
*Three-banded Plover
*Verreaux's Eagle
*Violet-backed Starling
Violet-eared Starling
*Violet-eared Waxbill
*Wailing Cisticola
*White-backed Mousebird
*White-bellied Sunbird
*White-fronted Bee-eater
*White-rumped Swift
*White-Throated swallow
*White-winged Widowbird
*Willow Warbler
*Wood Sandpiper
*Yellow Bishop
*Yellow Canary
*Yellow-billed Duck
*Yellow-billed Kite
*Yellow-fronted Canary
*Yellow-fronted Tinkerbird
*Yellow-throated Petronia
*Zitting Cisticola

* from FROK list

The following faunal lists were obtained from the SANBI:SIBIS database for the 2627BB quarter degree GRID.

AMPHIBIANS & REPTILES (Transvaal Museum & SARCA databases & FroK (provided by K Spottiswoode))

Ranidae	**Afrana angolensis*
Agamidae	*Agama atra*
Atractaspididae	*Atractaspis bibronii*
Viperidae	*Causus rhombeatus*
Chamaeleonidae	*Chamaeleo dilepis*
Cordylidae	*Cordylus vittifer*
Colubridae	**Crotaphopeltis hotamboeia*
Colubridae	*Dasypeltis scabra*
Colubridae	*Dispholidus typus*
Gerrhosauridae	*Gerrhosaurus flavigularis*
Elapidae	*Hemachatus haemachatus*
Hyperoliidae	**Kassina senegalensis*
Colubridae	*Lamprophis inornatus*
Leptotyphlopidae	*Leptotyphlops scutifrons*
Colubridae	*Lycophidion capense*
Gekkonidae	*Lygodactylus capensis*
Scincidae	*Mabuya varia*
Lacertidae	*Nucras ornata*
Gekkonidae	*Pachydactylus affinis*
Gekkonidae	*Pachydactylus capensis*
Pelomedusidae	**Pelomedusa subrufa*
Colubridae	*Psammophis mossambicus*
Colubridae	*Psammophylax rhombeatus*
Bufonidae	**Schismaderma carens*
Testidinae	**Stygmochelys pardalis*
Scincidae	*Trachylepis capensis*
Scincidae	*Trachylepis varia*
Typhlopidae	*Typhlops bibronii*
Pipidae	**Xenopus laevis*

***confirmed for Kloofendal Nature Reserve by K Spottiswoode (FroK)**

SCORPIONS (SA MUSEUM database & FroK – J Leeming)

Scorpionidae	**Opistophthalmus pugnax*
Buthidae	**Pseudolychas ochraceus*
Ischnuridae	**Hadogenes gunningi*
Scorpionidae	**Opistophthalmus longicauda*
Buthidae	**Pseudolychas ochraceus*
Buthidae	**Uroplectes triangulifer*

***confirmed for Kloofendal Nature Reserve by J Leeming (FroK)**

SPIDERS (ARC database)

Clubionidae	*Clubiona* sp.
Araneidae	*Hypsosinga* sp.
Ammoxenidae	*Ammoxenus amphalodes*
Amaurobiidae	*Chresiona* sp.
Araneidae	*Neoscona subfusca*
Araneidae	*Pycnacantha tribulus*
Araneidae	*Argiope australis*
Agelenidae	*Benoitia ocellata*
Agelenidae	*Benoitia raymondeae*
Caponiidae	*Caponia* sp.
Araneidae	*Neoscona blondeli*
Araneidae	*Nemoscolus* sp.
Araneidae	*Pararaneus spectator*
Araneidae	*Argiope lobata*
Clubionidae	*Clubiona pongolensis*

Araneidae	*Argiope* sp.

BUTTERFLIES (SABCA database & FroK – G Eden)

NYMPHALIDAE	**Acraea horta*
NYMPHALIDAE	**Acraea natalica*
NYMPHALIDAE	**Acraea neobule* subsp. *neobule*
LYCAENIDAE	**Actizera lucida*
NYMPHALIDAE	*Aeropetes tulbaghia*
LYCAENIDAE	**Aloeides aranda*
LYCAENIDAE	*Aloeides dentatis* subsp. *dentatis*
LYCAENIDAE	**Aloeides henningi*
LYCAENIDAE	*Aloeides molomo* subsp. *coalescens*
LYCAENIDAE	*Aloeides plowesi*
LYCAENIDAE	*Aloeides susanae*
LYCAENIDAE	**Aloeides taikosama*
LYCAENIDAE	*Aloeides trimeni* subsp. *trimeni*
LYCAENIDAE	**Anthene amarah* subsp. *amarah*
LYCAENIDAE	*Anthene butleri* subsp. *livida*
LYCAENIDAE	**Anthene definita* subsp. *definita*
LYCAENIDAE	*Axiocerses amanga* subsp. *amanga*
LYCAENIDAE	**Axiocerses tjoane* subsp. *tjoane*
LYCAENIDAE	**Azanus jesous* subsp. *jesous*
LYCAENIDAE	**Azanus moriqua*
LYCAENIDAE	**Azanus ubaldus*
PIERIDAE	**Belenois aurota* subsp. *aurota*
PIERIDAE	**Belenois creona* subsp. *severina*
PIERIDAE	**Belenois zochalia* subsp. *zochalia*
HESPERIIDAE	**Borbo fallax*
NYMPHALIDAE	**Byblia ilithyia*
LYCAENIDAE	**Cacyreus lingeus*
LYCAENIDAE	**Cacyreus marshalli*
LYCAENIDAE	**Cacyreus virilis*
PIERIDAE	**Calotis subfasciatus* subsp. *subfasiatus*
LYCAENIDAE	**Capys disjunctus* subsp. *disjunctus*
NYMPHALIDAE	**Catacroptera cloanthe* subsp. *cloanthe*
PIERIDAE	**Catopsilia florella*
NYMPHALIDAE	**Charaxes brutus* subsp. *natalensis*
NYMPHALIDAE	**Charaxes candiope*
NYMPHALIDAE	**Charaxes jasius* subsp. *saturnus*
LYCAENIDAE	**Chilades trochylus*
LYCAENIDAE	**Cigaritis ella*
LYCAENIDAE	**Cigaritis mozambica*
LYCAENIDAE	**Cigaritis natalensis*
HESPERIIDAE	**Coeliades pisistratus*
PIERIDAE	**Colias electo* subsp. *electo*
PIERIDAE	*Colotis agoye* subsp. *bowkeri*
PIERIDAE	**Colotis euippe* subsp. *omphale*
PIERIDAE	*Colotis pallene*
LYCAENIDAE	**Cupidopsis cissus* subsp. *cissus*
LYCAENIDAE	**Cupidopsis jobates* subsp. *jobates*
NYMPHALIDAE	**Danaus chrysippus* subsp. *orientis*
LYCAENIDAE	**Virachola antalus (=Deudorix antalus)*
LYCAENIDAE	**Eicochrysops messapus* subsp. *messapus*
HESPERIIDAE	**Eretis umbra* subsp. *umbra*
LYCAENIDAE	**Euchrysops dolorosa*
LYCAENIDAE	*Euchrysops subpallida*
PIERIDAE	**Eurema brigitta* subsp. *brigitta*
HESPERIIDAE	**Gegenes niso* subsp. *niso*
HESPERIIDAE	**Gegenes pumilio* subsp. *gambica*
NYMPHALIDAE	**Hamanumida daedalus*

NYMPHALIDAE	*Heteropsis perspicua* subsp. *perspicua*
NYMPHALIDAE	**Hypolimnas missippus*
LYCAENIDAE	**Hypolycaena philippus* subsp. *philippus*
LYCAENIDAE	*Iolaus silarus* subsp. *silarus*
LYCAENIDAE	**Iolaus trimeni*
NYMPHALIDAE	**Junonia hierta* subsp. *cebrene*
NYMPHALIDAE	**Junonia oenone* subsp. *oenone*
NYMPHALIDAE	**Junonia orithya* subsp. *madagascariensis*
NYMPHALIDAE	*Junonia touhilimasa*
HESPERIIDAE	**Kedestes nerva* subsp. *nerva*
HESPERIIDAE	**Kedrestes mohozutza*
HESPERIIDAE	**Kedrestes wallengrenii* subsp. *wallengrenii*
HESPERIIDAE	*Lachnocnema durbani
LYCAENIDAE	**Lampides boeticus*
LYCAENIDAE	**Lepidochrysops ignota*
LYCAENIDAE	*Lepidochrysops ortygia*
LYCAENIDAE	**Lepidochrysops patricia*
LYCAENIDAE	**Lepidochrysops plebeia* subsp. *plebeia*
LYCAENIDAE	**Leptomyrina henningi*
LYCAENIDAE	**Leptotes pirithous* subsp. *pirithous*
PIERIDAE	**Mylothris agathina* subsp. *agathina*
PIERIDAE	**Mylothris rueppellii* subsp. *haemus*
LYCAENIDAE	**Myrina silenus* subsp. *ficedula*
NYMPHALIDAE	**Neptis saclava* subsp. *marpessa*
PAPILIONIDAE	**Papilio demodocus* subsp. *demodocus*
PAPILIONIDAE	**Papilio nireus* subsp. *lyaeus*
NYMPHALIDAE	**Paternympha narycia*
HESPERIIDAE	**Pelopidas mathias*
NYMPHALIDAE	**Phalanta phalantha* subsp. *aethiopica*
PIERIDAE	**Pinacopteryx eriphia* subsp. *eriphia*
HESPERIIDAE	**Platylesches ayresii*
HESPERIIDAE	*Platylesches neba*
PIERIDAE	**Pontia helice* subsp. *helice*
NYMPHALIDAE	*Precis antilope*
NYMPHALIDAE	**Precis archesia* subsp. *archesia*
NYMPHALIDAE	**Precis archesia* subsp. *pelaspis*
NYMPHALIDAE	*Precis ceryne* subsp. *ceryne*
NYMPHALIDAE	**Precis octavia* subsp. *sesamus*
HESPERIIDAE	*Sarangesa ruona*
HESPERIIDAE	**Spialia asterodia*
HESPERIIDAE	**Spialia diomus* subsp. *ferax*
HESPERIIDAE	*Spialia mafa* subsp. *mafa*
HESPERIIDAE	**Spialia spio*
NYMPHALIDAE	**Stygionympha wichgrafi* subsp. *wichgrafi*
LYCAENIDAE	**Tarucus sybaris* subsp. *sybaris*
NYMPHALIDAE	*Telchinia alalonga*
NYMPHALIDAE	*Telchinia anacreon*
NYMPHALIDAE	*Telchinia encedon* subsp. *encedon*
NYMPHALIDAE	**Telchinia serena*
NYMPHALIDAE	**Telchinia rahira* subsp. *rahira*
HESPERIIDAE	**Tsitana tsita*
LYCAENIDAE	**Tuxentius melaena* subsp. *melaena*
LYCAENIDAE	**Uranothauma nubifer* subsp. *nubifer*
NYMPHALIDAE	**Vanessa cardui*
NYMPHALIDAE	*Ypthima asterope* subsp. *asterope*
LYCAENIDAE	**Zintha hintza* subsp. *hintza*
LYCAENIDAE	**Zizeeria knysna*
LYCAENIDAE	**Zizula hylax*

***Confirmed for Kloofendal Nature Reserve by G Eden (G Eden)**

INVERTEBRATES (Albany Museum & SA Museum database)

Actinolaimidae	*Neoactinolaimus vaalensis*
Aeshnidae	*Aeshna sp.*
Aeshnidae	*Anax sp.*
Ancylidae	*Ancylus sp.*
Ancylidae	*Ferrissia sp.*
Anostostomatidae	*Onosandridus calcaratus*
Apidae	*Meliponula bocandei*
Apidae	*Tetralonia nigropilosa*
Apidae	*Tetraloniella nubilis*
Araneidae	*Nephilinae*
Asilidae	*Promachus philodichoides*
Baetidae	*Austrocloeon africanum*
Baetidae	*Austrocloeon sp.*
Baetidae	*Austrocloeon virgiliae*
Baetidae	*Baetis harrisoni*
Baetidae	*Baetis latus*
Baetidae	*Baetis sp.*
Baetidae	*Centroptilum excisum*
Baetidae	*Centroptilum sp.*
Baetidae	*Cloeon sp.*
Baetidae	*Pseudocloeon sp.*
Belostomatidae	*Ctenipocoris africana*
Belostomatidae	*Diplonychus capensis*
Belostomatidae	*Diplonychus nepoides*
Bethylidae	*Holepyris semiruber*
Bombyliidae	*Gonarthrus citrinus*
Bombyliidae	*Petrorossia plerophaia*
Brachyceridae	*Microcerus spiniger cavirostris*
Braconidae	*Microchelorus curvimaculatus*
Braconidae	*Zelomorpha iridipennis*
Carabidae	*Melanchiton abberrans*
Carabidae	*Thermophilum homoplatum mellyi*
Ceratopogonidae	*Culicoides sp.*
Chironomidae	*Bryophaenocladius productus*
Chironomidae	*Chironomus calipterus*
Chironomidae	*Chironomus formosipennis*
Chironomidae	*Chironomus leucochlorus*
Chironomidae	*Chironomus pilosimanus*
Chironomidae	*Cricotopus bizonatus*
Chironomidae	*Cricotopus flavozonatus*
Chironomidae	*Limnophyes natalensis*
Chironomidae	*Orthocladius sp.*
Chironomidae	*Paratrichocladius micans*
Chironomidae	*Pentaneura sp.*
Chironomidae	*Tanypus guttatipennis*
Chrysomelidae	*Sphaeroderma sp.*
Chydoridae	*Chydorus sp.*
Chydoridae	*Chydorus sphaericus*
Chydoridae	*Pleuroxus aduncus*
Cicadidae	*Melampsalta cadisia*
Cicadidae	*Severiana severini*
Coenagrionidae	*Pseudagrion citricola*
Coenagrionidae	*Pseudagrion salisburyense*
Coenagrionidae	*Pseudagrion sp.*
Corinnidae	*Graptartia tropicalis*
Culicidae	*Anopheles sp.*
Cyclopidae	*Eucyclops sp.*
Cyclopidae	*Macrocyclops albidus*
Cyclopidae	*Mesocyclops leukarti*
Cyclopidae	*Mesocyclops sp.*
Cyclopidae	*Microcyclops sp.*

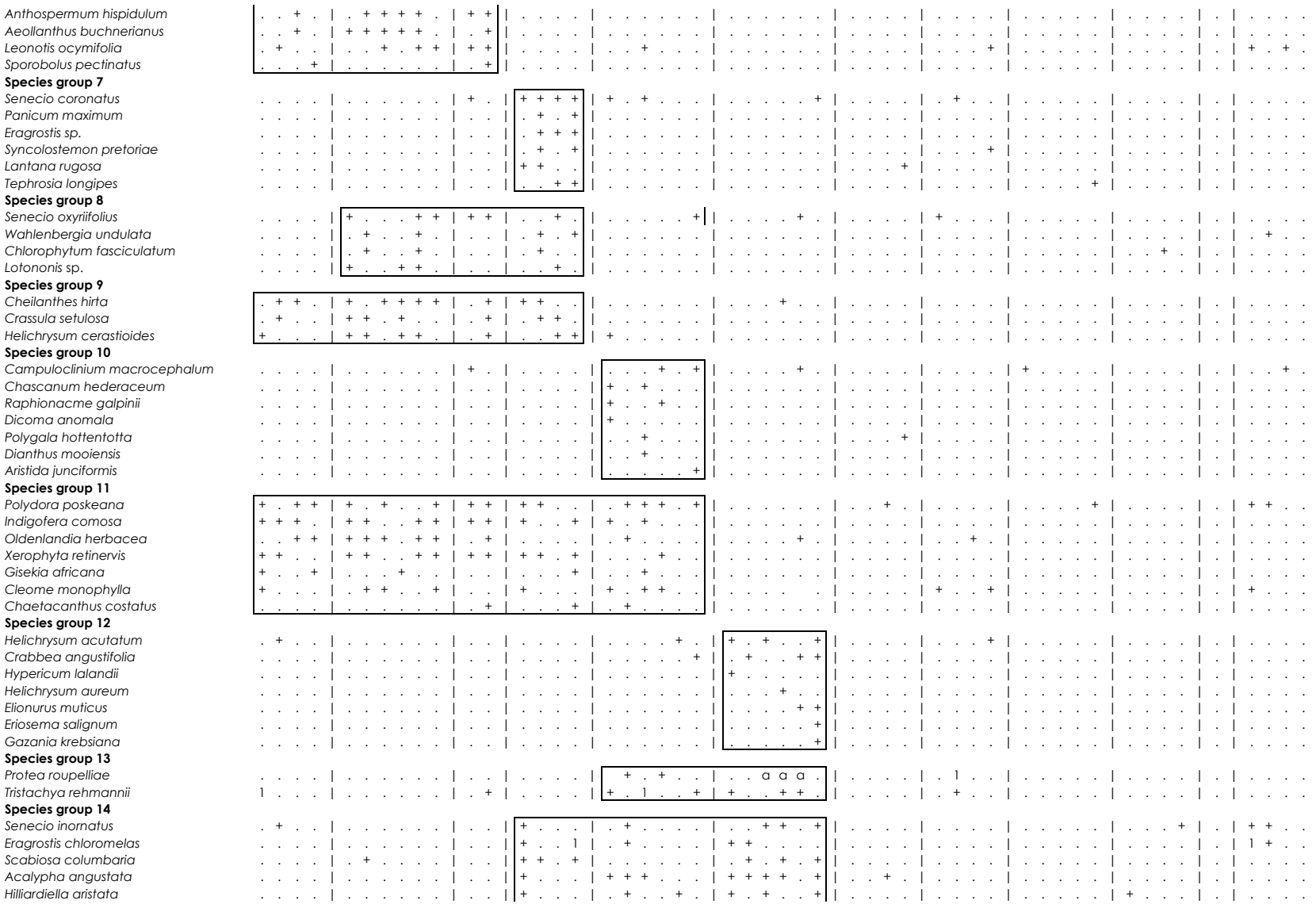
Cyclopidae	*Thermocyclops oblongatus*
Cypridae	*Isocypris prionema*
Cyprididae	*Cypridopsis africana*
Cyprididae	*Cypridopsis vidua*
Cyprididae	*Paracypretta sp.*
Cyprididae	*Parastenocypris hodgsoni*
Cyprididae	*Parastenocypris sp.*
Daphniidae	*Scapholeberis kingi*
Daphniidae	*Simocephalus serrulatus*
Daphniidae	*Simocephalus sp.*
Daphniidae	*Simocephalus vetulus*
Dytiscidae	*Bidessus fraudator*
Dytiscidae	*Clypeodytes sp.*
Dytiscidae	*Copelatus marginalis*
Dytiscidae	*Guignotus infirmus*
Dytiscidae	*Herophydrus oscillator*
Dytiscidae	*Hydrocoptus aethiopicus*
Dytiscidae	*Laccophilus adspersus*
Dytiscidae	*Laccophilus congener*
Dytiscidae	*Laccophilus cyclopis*
Dytiscidae	*Laccophilus lineatus*
Dytiscidae	*Laccophilus pilitarsis*
Dytiscidae	*Laccophilus vermiculosus*
Ecnomidae	*Ecnomus sp.*
Gerridae	*Gerris sp.*
Gerridae	*Limnogonus hypoleuca*
Gyrinidae	*Aulonogyrus abdominalis*
Gyrinidae	*Aulonogyrus sp.*
Gyrinidae	*Orectogyrus sedelloti*
Halictidae	*Halictus shanganiensis*
Henicopidae	*Lamyctes castenea*
Heptageniidae	*Afronurus barnardi*
Heptageniidae	*Afronurus harrisoni*
Heptageniidae	*Afronurus sp.*
Histeridae	*Rhypochares saprinoides*
Histeridae	*Zabromorphus holubi*
Hydraenidae	*Hydraena accurata*
Hydropsychidae	*Cheumatopsyche afra*
Hydropsychidae	*Cheumatopsyche thomasseti*
Hydroptilidae	*Hydroptila sp.*
Ichneumonidae	*Phorotrophus bivittatus*
Idiopidae	*Idiops kentanicus*
Ilyocyprididae	*Ilyocypris sp.*
Lentulidae	*Shelfordites*
Lepidostomatidae	*Goerodes sp.*
Leptophlebiidae	*Choroterpes elegans*
Lestidae	*Lestes sp.*
Libellulidae	*Crocothemis sp.*
Libellulidae	*Trithemis sp.*
Lycaenidae	*Laesopsis roboris*
Lymnaeidae	*Lymnaea columella*
Lymnaeidae	*Lymnaea natalensis*
Lymnaeidae	*Lymnaea sp.*
Membracidae	*Oxyrhachis tuberculatus*
Micronectidae	*Micronecta butleriana*
Micronectidae	*Micronecta sp.*
Naididae	*Nais simplex*
Naucoridae	*Laccocoris limigenus*
Nemestrinidae	*Prosoeca zuluensis*
Nepidae	*Ranatra parvipes*
Notonectidae	*Anisops gracilis*
Notonectidae	*Anisops sp.*

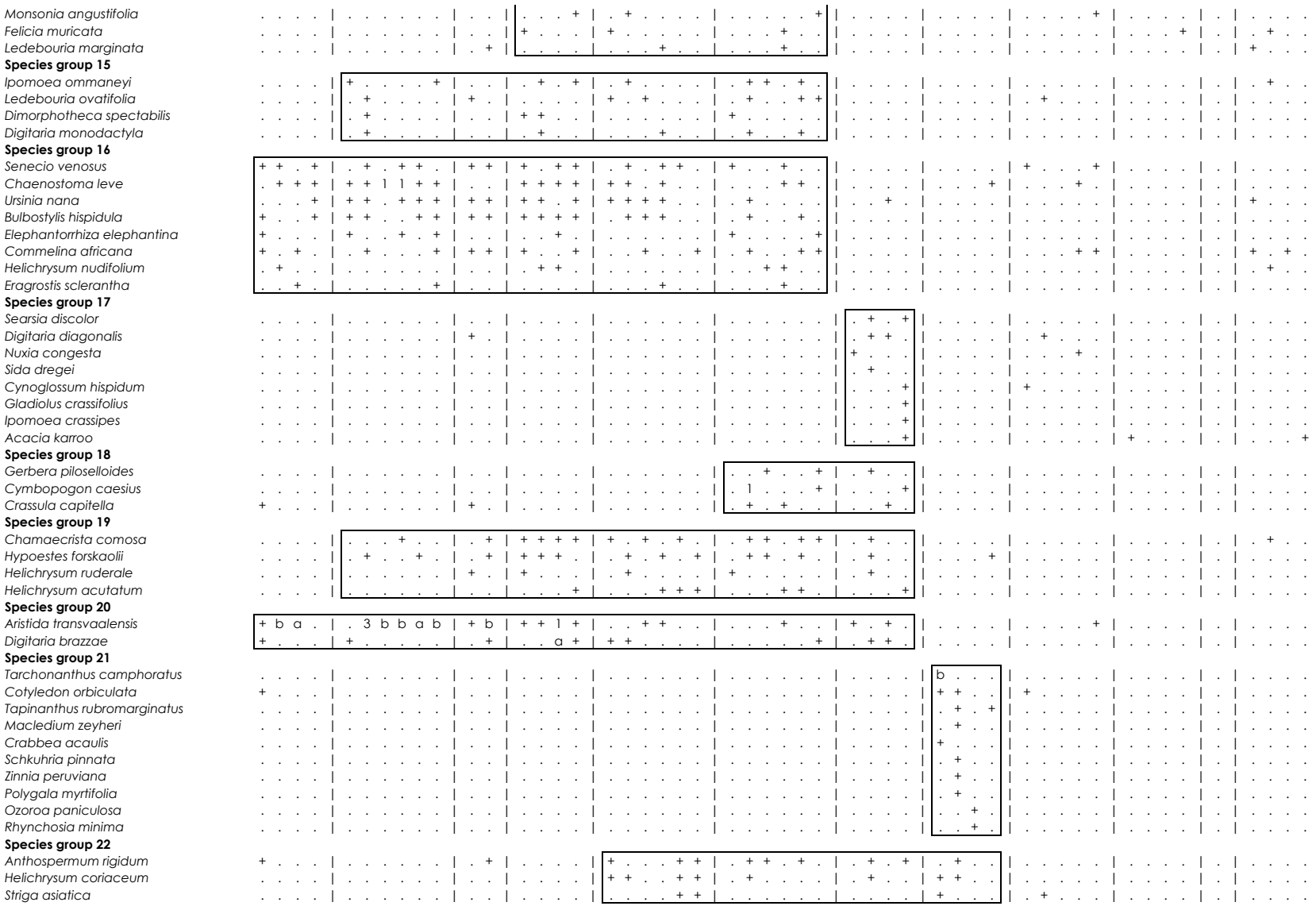
Notonectidae	*Enithares sobria*
Notonectidae	*Enithares sp.*
Nymphalidae	*Melitaea cinxia*
Papilionidae	*Troides hypolitus*
Planorbidae	*Biomphalaria sp.*
Planorbidae	*Bulinus africanus*
Planorbidae	*Bulinus sp.*
Planorbidae	*Bulinus tropicus*
Planorbidae	*Gyraulus sp.*
Planorbidae	*Physopsis africana*
Planorbidae	*Physopsis sp.*
Planorbidae	*Planorbis costulatus*
Planorbidae	*Planorbis sp.*
Pompilidae	*Hemipepsis caelebs*
Potamididae	*Potamon sp.*
Potamididae	*Potamon warreni*
Ranidae	*Rana angolense*
Ranidae	*Rana sp.*
Rhabditidae	*Rhabditis sp.*
Scarabaeidae	*Heliocopris neptunus*
Scarabaeidae	*Heterochelus persimilis*
Scarabaeidae	*Heteroclitopus remipes*
Schendylidae	*Schendylurus caledonicus*
Scoliidae	*Scolia fulvofimbriata cinerata*
Simuliidae	*Simulium adersi*
Simuliidae	*Simulium medusaeforme*
Simuliidae	*Simulium nigritarse*
Simuliidae	*Simulium sp.*
Sphaeriidae	*Pisidium costulosum*
Sphaeriidae	*Pisidium sp.*
Sphecidae	*Gastrosericus madecassus*
Sphecidae	*Tachytes labilis*
Sphecidae	*Tachytes midas*
Sphecidae	*Trypoxylon turbulentum*
Tabanidae	*Tabanus unilineatus*
Tenebrionidae	*Onymacris candidipennis*
Tenebrionidae	*Platydema signatum*
Tenebrionidae	*Psammodes similis*
Tenebrionidae	*Somaticus (Bechuanitis) bohemani bohemani*
Tephritidae	*Trupanea mutabilis*
Tertastemmatidae	*Prostoma sp.*
Tubificidae	*Bothrioneurum sp.*
Tubificidae	*Branchiura sowerbyi*
Tubificidae	*Limnodrilus hoffmeisteri*
Tubificidae	*Tubifex tubifex*
Veliidae	*Microvelia major*

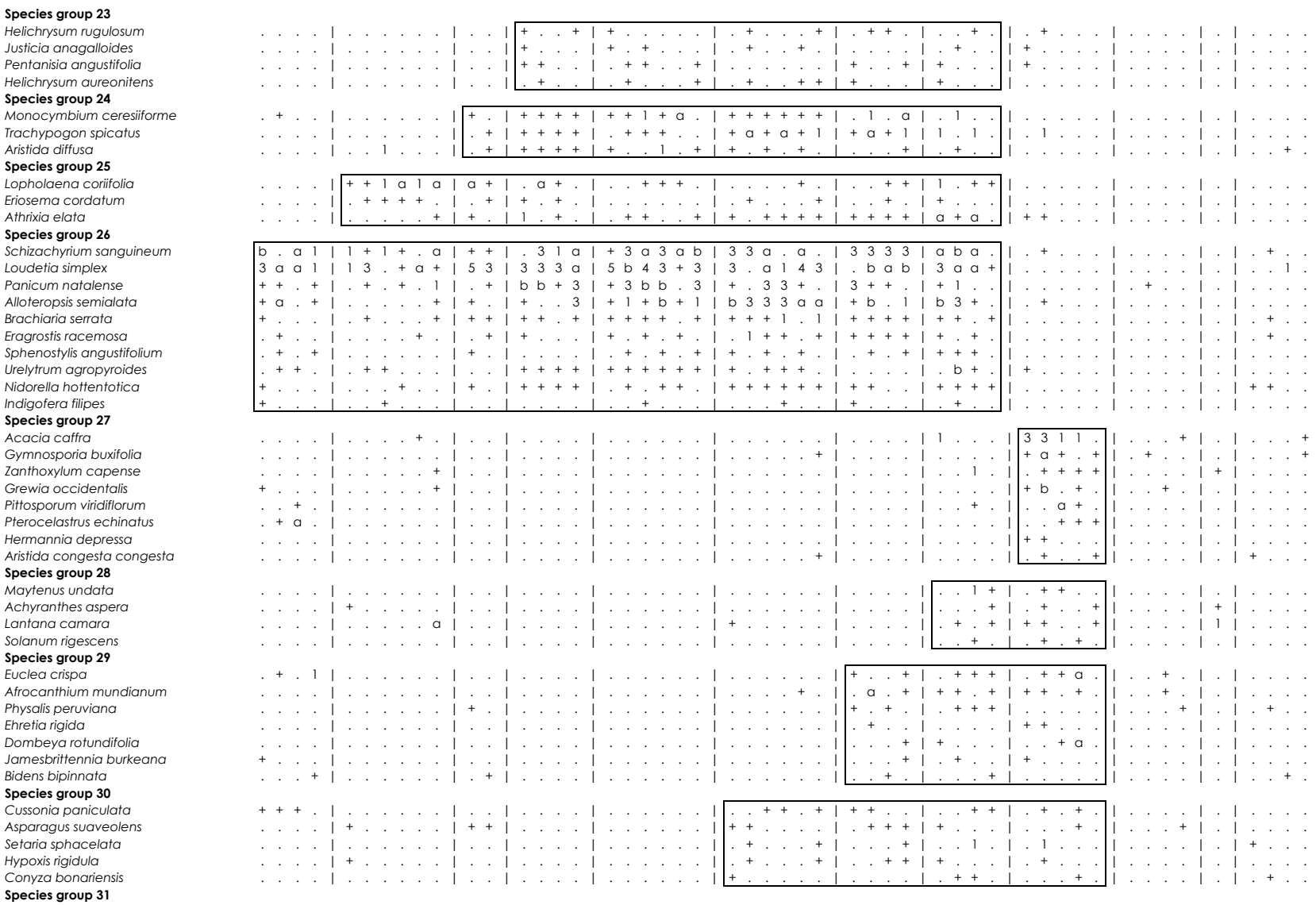
APPENDIX G

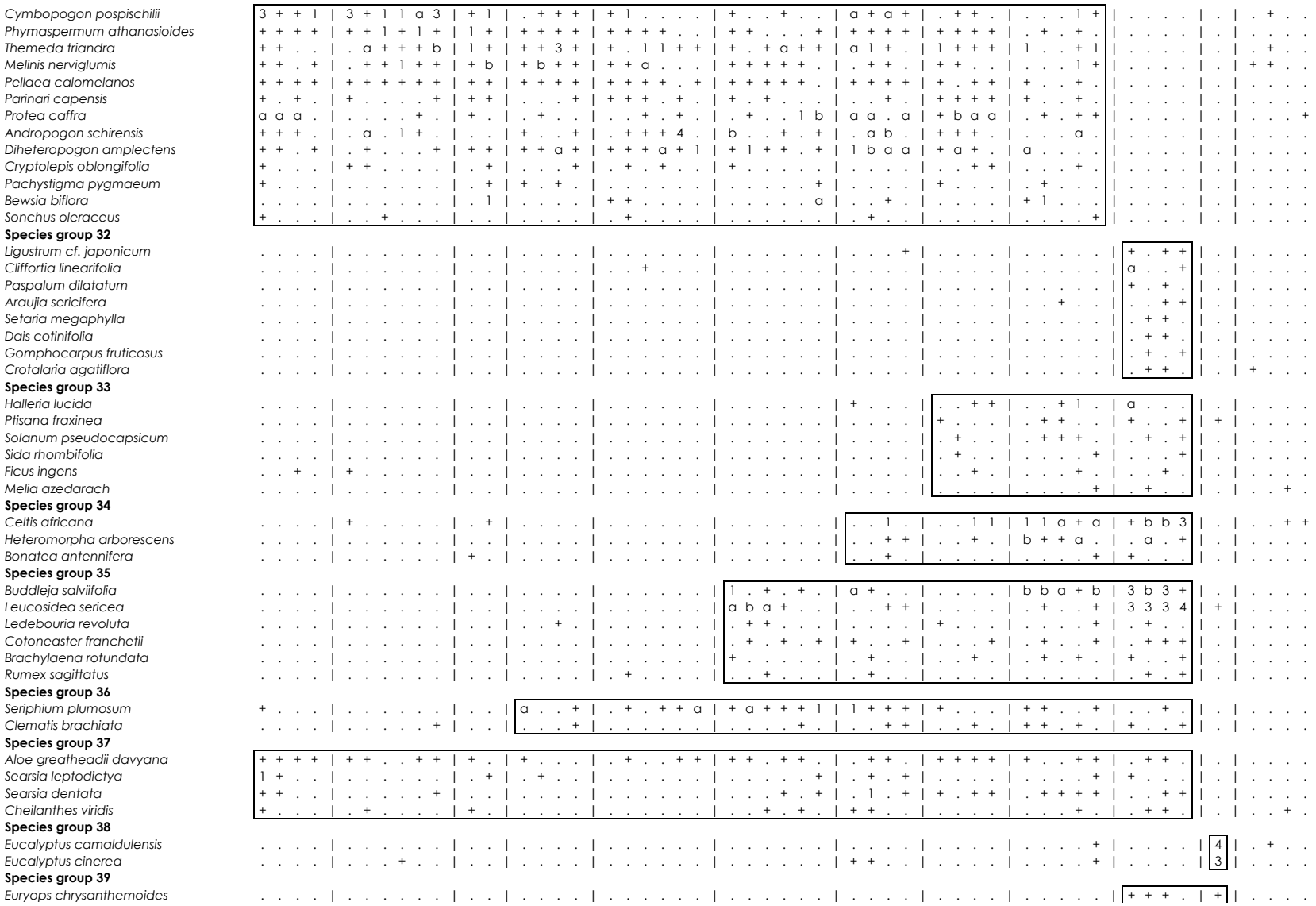
TABLE 6: DIFFERENTIAL TABLE OF THE VEGETATION OF KLOOFENDAL NATURE RESERVE

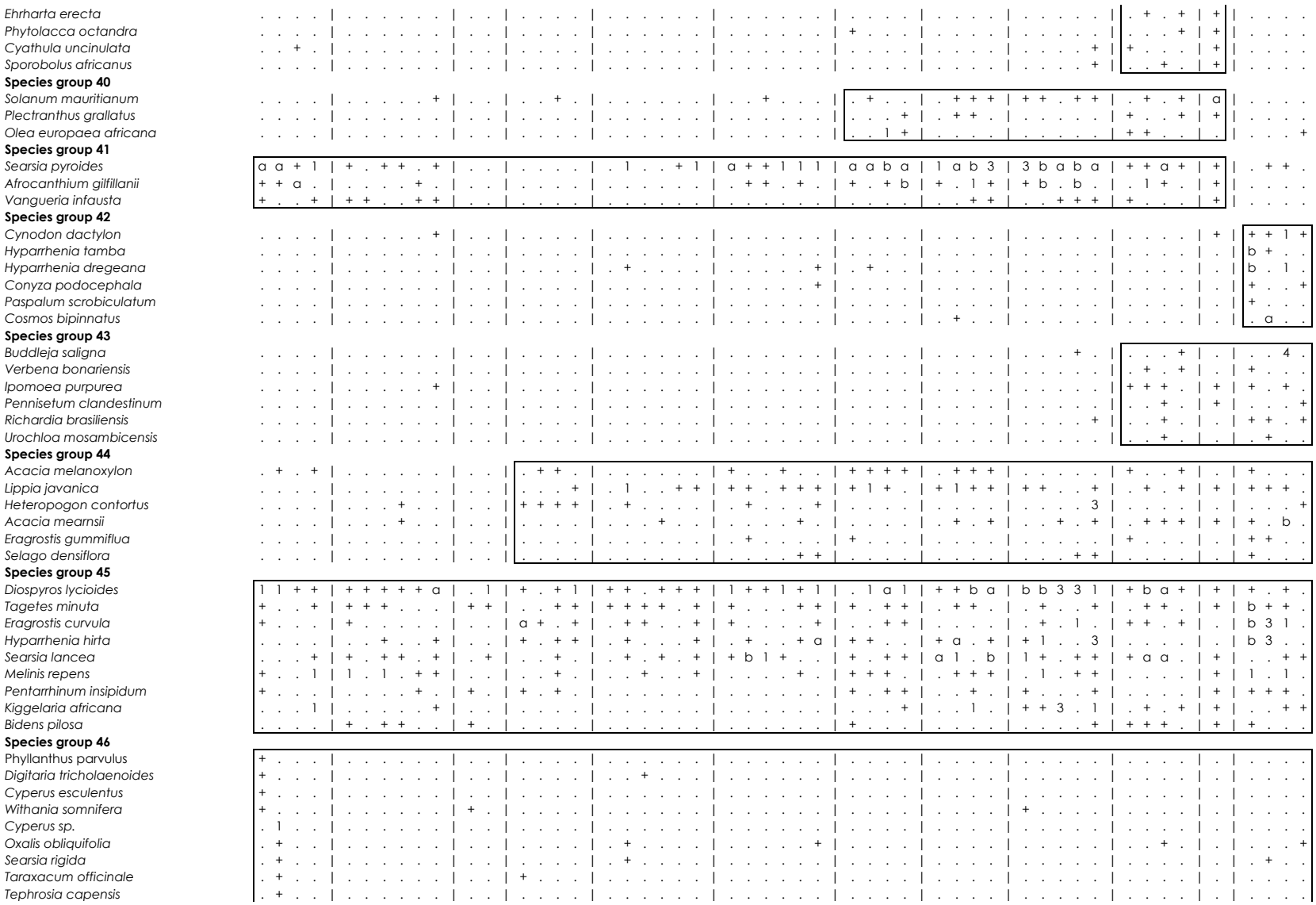
Community number	1				2							3		4		5						6						7			8			9				10				11	12			
Sample plot number	1	1	2	4	1		1	1	2	2					1		1	2	4	4	4	3	3	4	4	4	2		1	3	4	3	4	3		2	3	3	3	2	2	3	3	4	2	1	2	1	5
	8	9	8	3	5	4	1	2	7	4		3	7	5	8	9	3	6	6	6	2	7	5	3	8	0	1	4	0	1	7	4	8	7	6	1	2	9	0	2	5	2	5	6	9	9	3	0	1	4	0
Species group 1																																																	
Helichrysum lepidissimum	+	+	.	+	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypoxis galpinii	.	+	+	+	.	.	.	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalanchoe thyrsiflora	+	+	.	.	.	.	.	.	.	+		.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group 2																																																	
Adromischus umbraticola	.	.	.	.	+	+	+	+	+	+		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Selaginella dregei	.	.	.	.	+	+	.	+	+	1		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Coleochloa setifera	.	.	.	.	.	.	a	1	b	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Microchloa caffra	.	.	.	.	.	+	+	+	+	+		.	+	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aloe verecunda	.	.	.	.	.	+	+	+	.	.		.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wahlenbergia oxyphylla	.	.	+	.	.	+	+	.	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Abildgaardia ovata	.	.	.	.	+	.	.	+	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium sp.	.	.	.	.	+	.	+	+	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cineraria austrotransvaalensis	.	.	.	.	+	.	+	+	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalanchoe paniculata	.	.	.	.	+	+	+	.	.	.		.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group 3																																																	
Vangueria parvifolium	1	+	1	1	1	+	+	+	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.
Ancylobotrys capensis	.	1	+	.	.	.	+	.	+	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Haemanthus humilis	.	1	+	.	+	.	+	.	.	.		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group 4																																																	
Cleome angustifolia	.	.	.	.	.	.	.	.	.	.		+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leucas martinicensis	.	.	.	.	.	.	.	.	.	.		+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Aloe marlothii	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Psammotropha myriantha	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula sarcocaulis	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ornithogalum saundersii	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trichoneura grandiglumis	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhynchosia totta	.	.	.	.	.	.	.	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group 5																																																	
Gerbera viridifolia	.	.	.	.	.	.	+	.	.	+		+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Jacaranda mimosifolia	.	.	.	.	.	.	+	.	.	+		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group 6																																																	
Englerophytum magalismontanum	+	+	a	.	a	+	1	+	+	+		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Searsia magalismontana	1	+	+	1	+	+	+	+	+	+		+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Cyanotis speciosa	+	+	+	+	.	+	+	+	+	+		+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Crassula swaziensis	+	.	+	.	+	+	+	.	+	+		+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Boophane disticha	+	.	+	.	+	.	.	.	+	+		+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Berkheya seminivea	+	.	+	.	.	+	+	.	.	.		.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

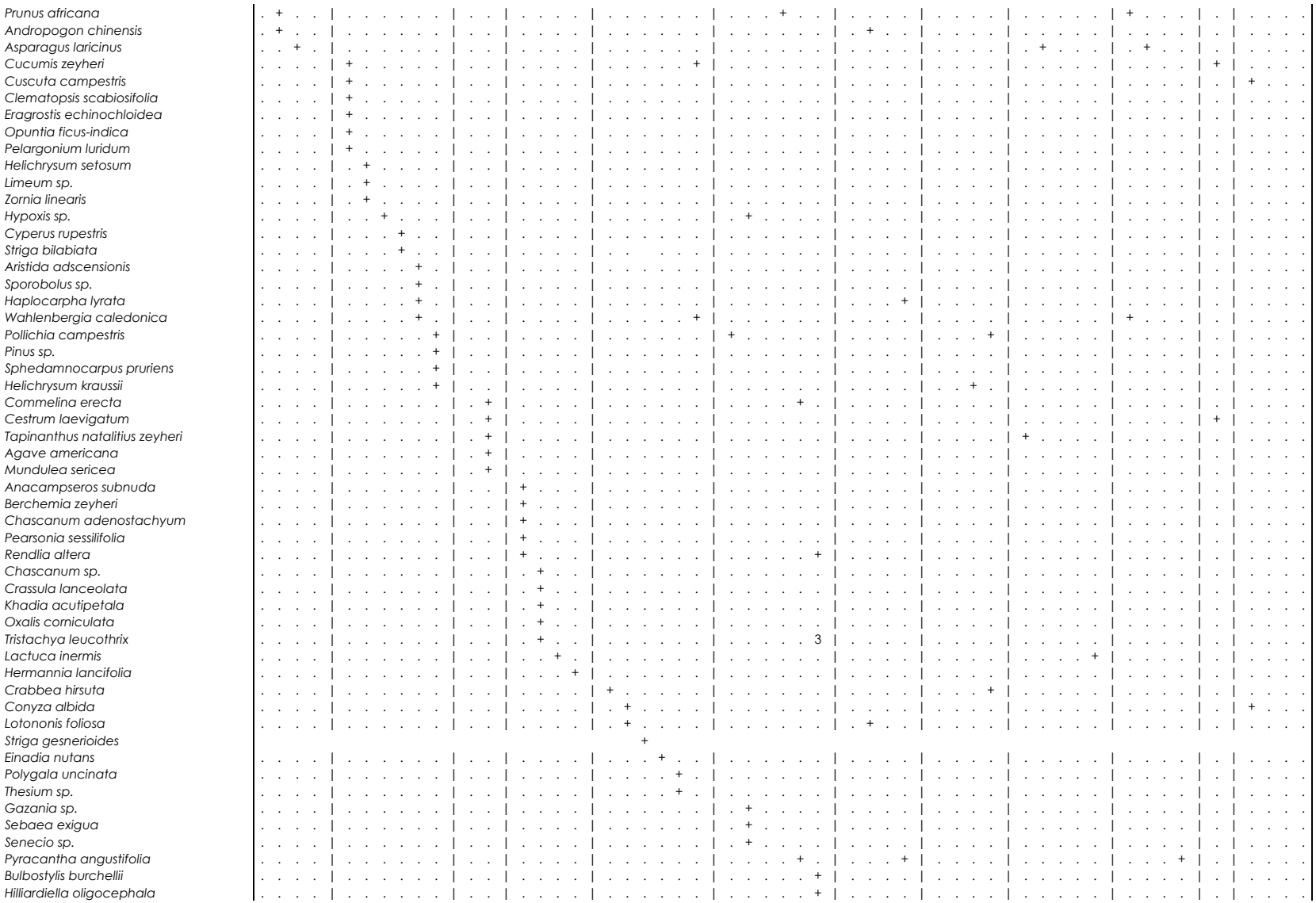

Anthospermum hispidulum
Aeollanthus buchnerianus
Leonotis ocymifolia
Sporobolus pectinatus
Species group 7
Senecio coronatus
Panicum maximum
Eragrostis sp.
Syncolostemon pretoriae
Lantana rugosa
Tephrosia longipes
Species group 8
Senecio oxyriifolius
Wahlenbergia undulata
Chlorophytum fasciculatum
Lotononis sp.
Species group 9
Cheilanthes hirta
Crassula setulosa
Helichrysum cerastioides
Species group 10
Campuloclinium macrocephalum
Chascanum hederaceum
Raphionacme galpinii
Dicoma anomala
Polygala hottentotta
Dianthus mooiensis
Aristida junciformis
Species group 11
Polydora poskeana
Indigofera comosa
Oldenlandia herbacea
Xerophyta retinervis
Gisekia africana
Cleome monophylla
Chaetacanthus costatus
Species group 12
Helichrysum acutatum
Crabbea angustifolia
Hypericum lalandii
Helichrysum aureum
Elionurus muticus
Eriosema salignum
Gazania krebsiana
Species group 13
Protea roupelliae
Tristachya rehmannii
Species group 14
Senecio inornatus
Eragrostis chloromelas
Scabiosa columbaria
Acalypha angustata
Hilliardiella aristata


Monsonia angustifolia
Felicia muricata
Ledebouria marginata
Species group 15
Ipomoea ommaneyi
Ledebouria ovatifolia
Dimorphotheca spectabilis
Digitaria monodactyla
Species group 16
Senecio venosus
Chaenostoma leve
Ursinia nana
Bulbostylis hispidula
Elephantorrhiza elephantina
Commelina africana
Helichrysum nudifolium
Eragrostis sclerantha
Species group 17
Searsia discolor
Digitaria diagonalis
Nuxia congesta
Sida dregei
Cynoglossum hispidum
Gladiolus crassifolius
Ipomoea crassipes
Acacia karroo
Species group 18
Gerbera piloselloides
Cymbopogon caesius
Crassula capitella
Species group 19
Chamaecrista comosa
Hypoestes forskaolii
Helichrysum ruderale
Helichrysum acutatum
Species group 20
Aristida transvaalensis
Digitaria brazzae
Species group 21
Tarchonanthus camphoratus
Cotyledon orbiculata
Tapinanthus rubromarginatus
Macledium zeyheri
Crabbea acaulis
Schkuhria pinnata
Zinnia peruviana
Polygala myrtifolia
Ozoroa paniculosa
Rhynchosia minima
Species group 22
Anthospermum rigidum
Helichrysum coriaceum
Striga asiatica


Species group 23
Helichrysum rugulosum
Justicia anagalloides
Pentanisia angustifolia
Helichrysum aureonitens
Species group 24
Monocymbium ceresiiforme
Trachypogon spicatus
Aristida diffusa
Species group 25
Lopholaena coriifolia
Eriosema cordatum
Athrixia elata
Species group 26
Schizachyrium sanguineum
Loudetia simplex
Panicum natalense
Alloteropsis semialata
Brachiaria serrata
Eragrostis racemosa
Sphenostylis angustifolium
Urelytrum agropyroides
Nidorella hottentotica
Indigofera filipes
Species group 27
Acacia caffra
Gymnosporia buxifolia
Zanthoxylum capense
Grewia occidentalis
Pittosporum viridiflorum
Pterocelastrus echinatus
Hermannia depressa
Aristida congesta congesta
Species group 28
Maytenus undata
Achyranthes aspera
Lantana camara
Solanum rigescens
Species group 29
Euclea crispa
Afrocanthium mundianum
Physalis peruviana
Ehretia rigida
Dombeya rotundifolia
Jamesbrittennia burkeana
Bidens bipinnata
Species group 30
Cussonia paniculata
Asparagus suaveolens
Setaria sphacelata
Hypoxis rigidula
Conyza bonariensis
Species group 31


Cymbopogon pospischilii
Phymaspermum athanasioides
Themeda triandra
Melinis nerviglumis
Pellaea calomelanos
Parinari capensis
Protea caffra
Andropogon schirensis
Diheteropogon amplectens
Cryptolepis oblongifolia
Pachystigma pygmaeum
Bewsia biflora
Sonchus oleraceus
Species group 32
Ligustrum cf. japonicum
Cliffortia linearifolia
Paspalum dilatatum
Araujia sericifera
Setaria megaphylla
Dais cotinifolia
Gomphocarpus fruticosus
Crotalaria agatiflora
Species group 33
Halleria lucida
Ptisana fraxinea
Solanum pseudocapsicum
Sida rhombifolia
Ficus ingens
Melia azedarach
Species group 34
Celtis africana
Heteromorpha arborescens
Bonatea antennifera
Species group 35
Buddleja salviifolia
Leucosidea sericea
Ledebouria revoluta
Cotoneaster franchetii
Brachylaena rotundata
Rumex sagittatus
Species group 36
Seriphium plumosum
Clematis brachiata
Species group 37
Aloe greatheadii davyana
Searsia leptodictya
Searsia dentata
Cheilanthes viridis
Species group 38
Eucalyptus camaldulensis
Eucalyptus cinerea
Species group 39
Euryops chrysanthemoides


Ehrharta erecta
Phytolacca octandra
Cyathula uncinulata
Sporobolus africanus
Species group 40
Solanum mauritianum
Plectranthus grallatus
Olea europaea africana
Species group 41
Searsia pyroides
Afrocanthium gilfillanii
Vangueria infausta
Species group 42
Cynodon dactylon
Hyparrhenia tamba
Hyparrhenia dregeana
Conyza podocephala
Paspalum scrobiculatum
Cosmos bipinnatus
Species group 43
Buddleja saligna
Verbena bonariensis
Ipomoea purpurea
Pennisetum clandestinum
Richardia brasiliensis
Urochloa mosambicensis
Species group 44
Acacia melanoxylon
Lippia javanica
Heteropogon contortus
Acacia mearnsii
Eragrostis gummiflua
Selago densiflora
Species group 45
Diospyros lycioides
Tagetes minuta
Eragrostis curvula
Hyparrhenia hirta
Searsia lancea
Melinis repens
Pentarrhinum insipidum
Kiggelaria africana
Bidens pilosa
Species group 46
Phyllanthus parvulus
Digitaria tricholaenoides
Cyperus esculentus
Withania somnifera
Cyperus sp.
Oxalis obliquifolia
Searsia rigida
Taraxacum officinale
Tephrosia capensis


Prunus africana
Andropogon chinensis
Asparagus laricinus
Cucumis zeyheri
Cuscuta campestris
Clematopsis scabiosifolia
Eragrostis echinochloidea
Opuntia ficus-indica
Pelargonium luridum
Helichrysum setosum
Limeum sp.
Zornia linearis
Hypoxis sp.
Cyperus rupestris
Striga bilabiata
Aristida adscensionis
Sporobolus sp.
Haplocarpha lyrata
Wahlenbergia caledonica
Pollichia campestris
Pinus sp.
Sphedamnocarpus pruriens
Helichrysum kraussii
Commelina erecta
Cestrum laevigatum
Tapinanthus natalitius zeyheri
Agave americana
Mundulea sericea
Anacampseros subnuda
Berchemia zeyheri
Chascanum adenostachyum
Pearsonia sessilifolia
Rendlia altera
Chascanum sp.
Crassula lanceolata
Khadia acutipetala
Oxalis corniculata
Tristachya leucothrix
Lactuca inermis
Hermannia lancifolia
Crabbea hirsuta
Conyza albida
Lotononis foliosa
Striga gesnerioides
Einadia nutans
Polygala uncinata
Thesium sp.
Gazania sp.
Sebaea exigua
Senecio sp.
Pyracantha angustifolia
Bulbostylis burchellii
Hilliardiella oligocephala

Lannea edulis	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	+	. . . .	.	. . . .
Acokanthera oppositifolia	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . + . .	. . . .	.	. . . .
Pavetta gardeniifolia	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . + . .	. . . .	.	. . . .
Pteridium aquilinum	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . + . .	. . . .	.	. . . .
Dovyalis zeyheri	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . + .	. . . .	.	. . . .
Myrsine africana	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . + .	. . . .	.	. . . .
Plectranthus hereroensis	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . + .	. . . .	.	. . . .
Scolopia zeyheri	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . + .	. . . .	.	. . . .
Setaria lindenbergiana	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . + .	. . . .	.	. . . .
Agapanthus sp.	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	+ . . .	.	. . . .
Rhus succedanea	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	+ . . .	.	. . . .
Virgilia oroboides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. + . .	.	. . . .
Bryophyllum delagoense	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Cyphia stenopetala	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Dietes cf. iridioides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Persicaria capitata	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Tagetes erecta	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Ziziphus mucronata	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . + .	.	. . . .
Aspalathus asparagoides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Asparagus virgatus	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Cyperus sphaerospermus	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Rhamnus prinoides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . +
Robinia pseudoacacia	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Setaria incrassata	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Setaria nigrirostris	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Vigna sp.	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Ziziphus zeyheriana	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Cissus sp.	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Hibiscus lunarifolius	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . +	.	. . . .
Amaranthus hybridus	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	+	. . . .
Mirabilis jalapa	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	+	. . . .
Celtis australis	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	+	. . . +
Indigofera sp.	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	+ . . .
Chenopodium album	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. + . .
Aloe arborescens	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Combretum erythrophyllum	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Paspalum notatum	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Plantago lanceolata	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Plumbago zeylanica	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Tecoma capensis	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Gomphrena celosioides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Trifolium repens	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Urochloa panicoides	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Cotula species	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Zea mays	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +
Euphorbia inaequilatera	. . . .	. . . . . .	. .	. . . .	. . . . . .	. . . . . .	. . . .	. . . .	. . . . .	. . . .	.	. . . +