

**The vegetation ecology of the Witteberg and Dwyka Groups south
of Worcester, Western Cape Province, South Africa.**

by

ANSO LE ROUX

submitted in accordance with the requirements
for the degree of

DOCTOR OF PHILOSOPHY

in the subject

ENVIRONMENTAL SCIENCE

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF L R BROWN

CO-SUPERVISOR: PROF P J DU PREEZ

JANUARY 2018

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Volume I

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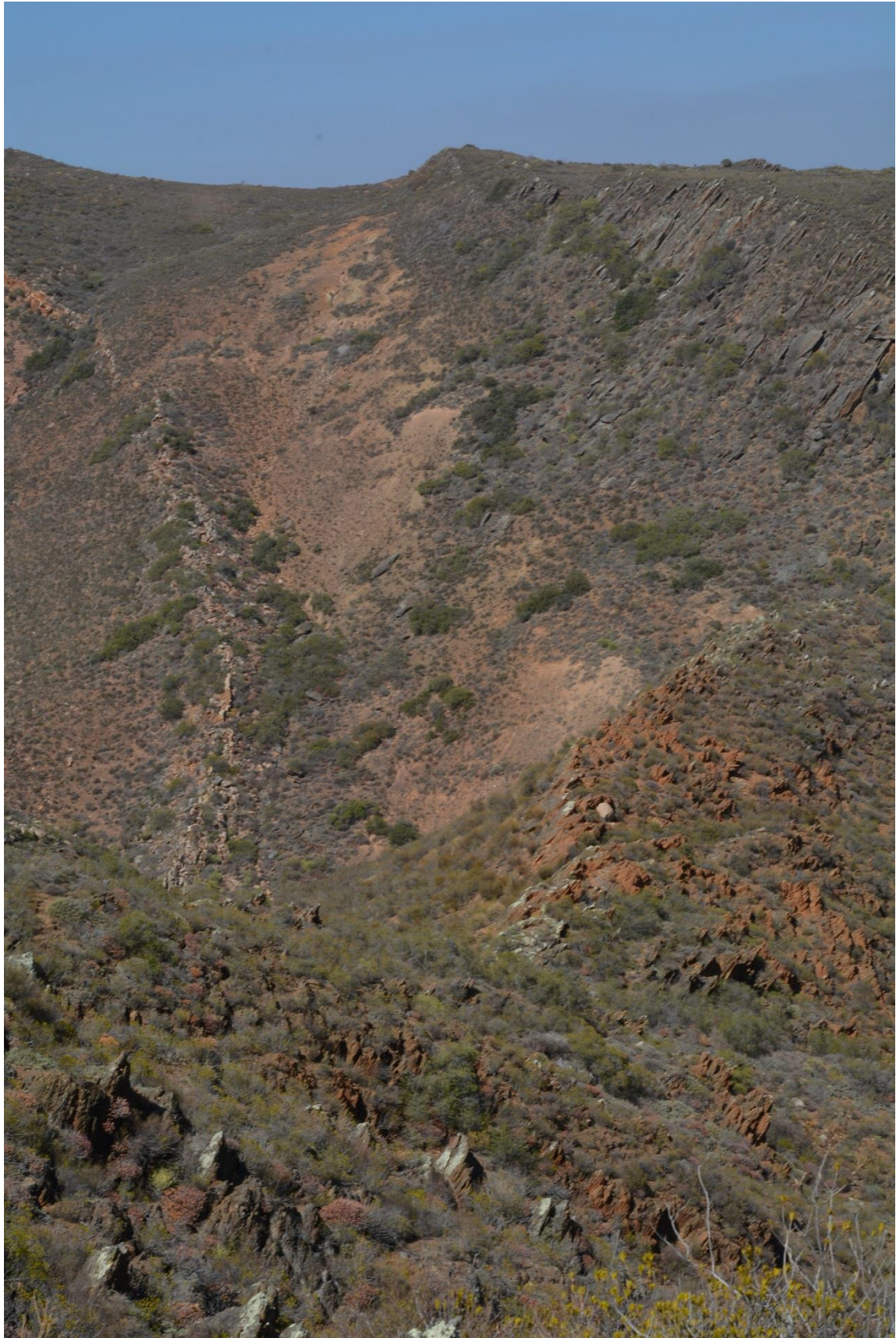
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January 2018



An interesting contact of Dwyka tillite overlying the Waaipoort – and Floriskraal Formations (Witteberg Group) on Droogeriviersberg in the study area.

Student number: 8773548

I, Anso le Roux, declare that The Vegetation Ecology of the Witteberg and Dwyka Groups South of Worcester, Western Cape Province, South Africa (Volume 1) is my own work. Apart from where mentioned otherwise, all photographs were taken by me. The copyright for the photographs in this theses remains with the owners.

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Date: 19 January 2018

VOLUME I

TABLE OF CONTENTS

ABSTRACT.....	viii
CHAPTER 1: INTRODUCTION.....	1
INTRODUCTION.....	3
1.1 Objectives and hypotheses.....	7
1.2 Thesis exposition.....	11
CHAPTER 2: LITERATURE REVIEW.....	13
2.1 THE FLORA OF THE SOUTHERN AFRICAN WINTER RAINFALL AREA	15
2.2 THE HISTORY OF PLANT COLLECTION AT THE CAPE AND VEGETATION MAPPING IN SOUTHERN AFRICA.....	19
2.2.1 A historical overview of plant collection at the Cape, with special reference to early expeditions into the interior of the southern Western Cape.....	19
2.2.2 A short overview of the history of Vegetation Sampling and Mapping in southern Africa.....	37
2.3 CONCLUSION.....	42
CHAPTER 3: STUDY AREA AND METHODS.....	43
3.1 STUDY AREA.....	50
3.1.1 Location.....	50
3.2 CLIMATE.....	51
3.3 GEOLOGY.....	55
3.3.1 Fossils.....	57
3.4 TOPOGRAPHY.....	60

3.5 LAND TYPES AND SOILS.....	61
3.6 VEGETATION.....	68
3.6.1 Heuweltjies.....	69
3.6.2 Animals in the study area.....	71
3.6.2 Mosses, liverworts and lichens.....	90
3.2 METHODS.....	95
3.2.1 Survey methods.....	96
3.2.1.1 Floristic data.....	97
3.2.1.2 Habitat data.....	98
3.2.1.3 Plant identification and taxon names.....	99
3.2.1.4 Controlled burning.....	99
3.2.1.5 Sample preparation for scanning electron microscope (SEM).....	100
3.2.2 Data analysis.....	101
3.2.2.1 Vegetation classification.....	101
3.2.2 Ordination.....	103
3.2.3 Plant community descriptions and names.....	103
3.2.4 Plant community diversity.....	104
CHAPTER 4: A CLASSIFICATION AND DESCRIPTION OF THE PLANT COMMUNITIES SUPPORTED BY THE WITTEBERG- AND DWYKA GEOLOGICAL GROUPS SOUTH OF WORCESTER IN THE WESTERN CAPE	106
4.1 INTRODUCTION.....	117
4.2 ECOLOGICAL DESCRIPTION OF PLANT COMMUNITIES.....	122
SECTION 4.2.1: MAJOR COMMUNITY 1.....	122
Major Plant Community 1: <i>Elytropappus rhinocerotis</i> shrubland.....	123
1. <i>Tylecodon ventricosus</i> – <i>Elytropappus rhinocerotis</i> community.....	132
2. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> community.....	137

2.1. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Limonium amoenum</i> sub-community.....	139
2.2. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia mucronata</i> sub-community.....	144
3. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> community.....	148
3.1. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia tenuifolia</i> sub-community.....	151
3.2. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Pelargonium pillansii</i> sub-community.....	161
3.3. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Crassula saxifraga</i> sub-community.....	164
4. <i>Lichtensteinia interrupta</i> – <i>Elytropappus rhinocerotis</i> community.....	175
5. <i>Erica boucheri</i> – <i>Elytropappus rhinocerotis</i> community.....	179
6. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> community.....	183
6.1. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> Typicum Sub-community.....	185
6.2. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> – <i>Senecio anthemifolius</i> sub-community.....	188
Heuweltjies.....	193
Conclusion.....	195
SECTION 4.2.2: MAJOR COMMUNITIES 2-5.....	197
Major Plant Community 2: <i>Passerina truncata</i> shrubland.....	199
7. <i>Pentameris eriostoma</i> – <i>Passerina truncata</i> community.....	203
8. <i>Drosanthemum hallii</i> – <i>Passerina truncata</i> community.....	207
9. <i>Protea laurifolia</i> – <i>Passerina truncata</i> community.....	210
9.1. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community....	212
9.2. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Secamone alpini</i> sub-community..	224
9.3. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Ruschia diversifolia</i> sub-community.....	227
Heuweltjies.....	231

Major Plant Community 3: <i>Capeochloa arundinacea</i> shrubland.....	232
10. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> community.....	238
10.1. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erica anguliger</i> sub- community.....	239
10.2. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erepsia anceps</i> sub- community.....	248
11. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> community.....	252
11.1. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Tritonia flabellifolia</i> sub- community	253
11.2. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Othonna arbuscula</i> sub- community.....	256
11.3. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Scopelogena verruculata</i> sub- community.....	259
11.4. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Curio crassulifolius</i> sub- community.....	266
Heuweltjies.....	269
Major Plant Community 4: <i>Hirpicium integrifolium</i> shrubland.....	270
12. <i>Euphorbia hamata</i> – <i>Hirpicium integrifolium</i> community.....	274
13. <i>Pelargonium karooicum</i> – <i>Hirpicium integrifolium</i> community.....	277
Heuweltjies.....	282
Major Plant Community 5: <i>Thamnochortus bachmannii</i> sandveld.....	284
14 <i>Leucospermum rodolentum</i> – <i>Thamnochortus bachmannii</i> community.....	288
15. <i>Willdenowia incurvata</i> – <i>Thamnochortus bachmannii</i> community.....	293
4.3 ORDINATION.....	297
4.4 CONCLUSION.....	301

ABSTRACT

The vegetation supported by the Witteberg and Dwyka Groups south of Worcester is a diverse mosaic of fynbos-, renosterveld- and succulent karoo vegetation units sustained by a winter-rainfall pattern. *Elytropappus rhinocerotis* (renosterbos) dominated plant communities are found on finer grained soils derived from the various mudrock-dominated formations of the Witteberg Group, a *Passerina truncata* (gonnabos) dominated shrubland with large Protea shrubs and / or small Protea trees where the substrate is largely influenced by the sandstone-dominated formations of the Witteberg Group, a grass dominated *Capeochloa arundinacea* (Olifantgras) shrubland where both mudrock-dominated and sandstone-dominated formations influence the substrate as a result of folding, a karoo *Hirpicium integrifolium* (Haarbossie) dominated shrubland where succulents are in abundance on the Dwyka tillite, and a distinct *Thamnochortus bachmannii* restio-dominated sandveld in areas where deep aeolian sand had accumulated.

The differences in vegetation communities are mainly based on geology with consequent soil characters and degree of rockiness, as well as topography, moisture availability and the water holding capacity of the soil. Although slope, aspect and elevation can sometimes be associated with specific plant communities, geology, soil pH and rock cover are the principal elements responsible for shaping the vegetation mosaic. Rather than a broad ecotone, the vegetation of the study area is understood as a complex mosaic mountain vegetation entity.

Keywords: Witteberg Group, Dwyka Group, geology, soil characters, rockiness, topography, soil water holding capacity, winter-rainfall, mosaic mountain vegetation.

CHAPTER 1

INTRODUCTION

“And some rin up hill and down dale
knapping the chunky stanes to pieces wi’ hammers, like sae many
road makers run daft. They say it is to see how the world was made.”

From: *St. Ronan's Well* by Sir Walter Scott, 1824



Conophytum ficiforme flowers opening at night-time, on Dwyka tillite in the study area.

TABLE OF CONTENTS

LIST OF FIGURES	2
1. INTRODUCTION.....	3
1.1 Objectives and hypotheses	7
1.2 Thesis exposition.....	11

LIST OF FIGURES

Figure 1.1: Because different plant communities are associated with different soils, an understanding of the geology of a study area is important.....	8
Figure 1.2: Views from the slopes of Trappieskraalkloof illustrate the diverse and complex mosaic of geological formations that occur in the study area. These strata are folded to a great extent creating different microhabitats.....	8
Figure 1.3: A view from the mountains north of Worcester towards the south in the direction of Villiersdorp, indicating the former lake Marais and the extent of the former floodplain (Lake Marais and to the south of it) now inundated by the Greater Brandvlei Dam (in the upper and upper left-hand corner of the picture, picture used with courtesy of E. du Plessis)..	9

1. INTRODUCTION

Whether due to pure inquisitiveness or part of one's profession, the urge to collect is inherent in human nature (Glen and Germishuizen 2010; Gunn and Codd 1981). For centuries people have been collecting, classifying and cultivating plants all over the world. Crowson (2017) states "classifying things is perhaps the most fundamental and characteristic activity of the human mind and underlies all forms of science." Plants are not only the physical representatives of ecosystems, but humans and animals depend on them for fuel, shelter as well as life sustaining food and medicines. Plants also uplift and inspire us (Beerling 2007; Kent and Coker 1992).

Vegetation science is inherently linked to other scientific fields such as palaeontology, geology, soil science, zoology, entomology, meteorology, landscape ecology and limnology (Brown *et al.* 2013).

Vegetation scientists work to discover an underlying order to vegetation patterns. Barbour *et al.* (1987) agree that "there seems to be a human need to know the complete story, to explain the past, and to predict the future." An understanding of the threads that link plants to each other and to their environment, knowledge of plant dispersal, competition, vigour, abundance and the ability to withstand unfavourable times can provide valuable information regarding ecosystem functioning (Barbour *et al.* 1987).

Kent and Coker (1992) recognise the threefold importance of vegetation within ecology:

- Vegetation is the most obvious physical representation of most terrestrial ecosystems.
- Most vegetation is the result of primary production and represents the base of the trophic pyramid – all other organisms depend on that base for food supply.
- Vegetation acts as the habitat within which organisms live, grow, reproduce and die.

Kent and Coker (1992) furthermore distinguish between “academic” vegetation studies, where vegetation may be described and analysed in service of science, and “applied” vegetation studies, where the aim is providing relevant information to an ecological problem regarding environmental conservation and/or ecosystem management. Information on vegetation may also be used to monitor management practices or to predict possible future changes (Kent and Coker 1992).

According to Pienkowski *et al.* (1996) it is important to have direct information on the distributions of species and their habitats in order to conserve biological diversity and to allow comparisons within similar vegetation types. Such information is invaluable to maintain and restore regional features of natural systems. Wessels *et al.* (2003) state that natural vegetation provides critical ecological services to humans and that ecosystem functioning is essential for sustainable agriculture as natural habitats may contain species and genes that can serve agriculture in future.

Data collected from vegetation ecological surveys are vital in determining the conservation status and biodiversity of different ecosystems. This is important especially with the ongoing and unchecked destruction of the Earth’s biological diversity by humans as a result of development and agricultural needs. Vegetation studies allow for the identification and quantification of biological diversity on various scales of study (Huntley 1989; Linder 2003).

Brown *et al.* (2013) describe the modern scientific uses of phytosociology (phyto = plant, sociology = groupings of species) in the following fields:

Vegetation classification and description

Data collected according to accepted quantitative methods, can be used:

- To give detailed information about the vegetation structure as well as plant species abundance;
- for gradient analyses;
- for measuring plant species diversity;
- for studying successional changes and

- for studying the differences between ecosystems.

Conservation

- Phytosociological data provide baseline data from where ornithological, herpetological, entomological, mammalogical etc. studies are planned and conducted.
- Defining plant communities could indicate the possible existence as well as conservation of rare or endangered plant species.
- When the expansion of conservation areas is considered, the results of phytosociological studies are used to assist authorities to make scientifically sound conservation decisions about important, scarce or rare plant communities.

Ecosystem monitoring and management

Plant communities and their associated vegetation maps are regarded as reliable in the demarcation of macro-ecosystems.

- By describing, monitoring and managing plant communities, the entire ecosystem can effectively be monitored and managed, without an attempt to in detail understand the different components and interactions of the ecosystem.
- Phytosociology forms part of the planning for monitoring plant species, communities and rare or endangered ecosystems.
- Phytosociology is important in the making of informed decisions on a fire policy of a specific ecosystem.
- Phytosociology is important in alien plant species clearing programmes.

Wildlife studies and management

Phytosociological studies provide the background for scientific studies on other organisms as well as in making informed decisions on the habitat that is available for wildlife.

Predictions regarding climate change

Phytosociological studies are important concerning climate change because, in most cases, only vegetation data are available to use for comparisons.

Impact assessment for development purposes

- With the current pressure on the natural environment, detailed vegetation classification, mapping and description should form the basis from which informed and scientifically defensible decisions can be taken when the permitting of infrastructure and other development such as mining, agricultural activities, urban and rural development are considered.
- Impact assessments regarding the effect of development on the natural environment are currently compulsory in South Africa in terms of the *National Environmental Management: Biodiversity Act* (Act No. 10 of 2004) (South African Government 2004). In cases where the need for development supersedes conservation importance, vegetation classification and description is important to identify ecologically sensitive areas so that development plans may be adapted in order to minimise those effects which can be detrimental to the natural environment.

South Africa is well-known for its rich flora with an estimated 21 000 different plant species. It contains approximately 8% of the world's vascular plants, while three global biodiversity hotspots are present within the country (Huntley 1994). Even though many vegetation studies have been undertaken in the country, the discovery of new plant species are still being made and many vegetation studies are still needed to assist in classifying plant communities and providing data on species composition and description (Brand 2007).

One of the best-known biodiversity hotspot areas where new species are still being identified, is the Cape Floristic Region (CFR). This study focuses

on the “renosterveld” (*Elytropappus rhinocerotis*) vegetation within the Worcester region of the CFR where no vegetation studies have been previously undertaken.

1.1 Objectives and hypotheses

Typical of Mediterranean-type climate regions, the Cape Floristic Region is recognised to be exceptional in terms of species abundance, biodiversity and the occurrence of a high number of endemic plant species (Bond 1983; Cody 1986; Cowling 1983; Cowling *et al.* 1992; Goldblatt 1978; Myers 1990; Rebelo 1994; Taylor 1978; Trinder-Smith *et al.* 1996).

According to Goldblatt and Manning (2002) the Cape region is characterised by rugged topography, a diversity of climates as well as steep ecological gradients as a result of differences in soil, altitude, aspect, and precipitation, which combine to form an unusually large number of local habitats for plants.

Geology, together with micro-climate environments as a result of the diverse topographical character of the area (Figures 1.1 and 1.2), give rise to the high biodiversity of the region between the Brandvlei Dam, south of Worcester and the Rooiberg, west of the town of Robertson. The study area includes a diverse and complex mosaic of geological strata of the Cape Supergroup, which in the study area comprises three different geological Groups, namely the Table Mountain Group, the Bokkeveld Group and the Witteberg Group. Dwyka tillite in the study area marks the geological boundary between the Cape Supergroup and the Karoo Supergroup (Figures 1.1 & 1.2; Gresse and Theron 1992).



Figure 1.1: Because different plant communities are associated with different soils, an understanding of the geology of a study area is important.

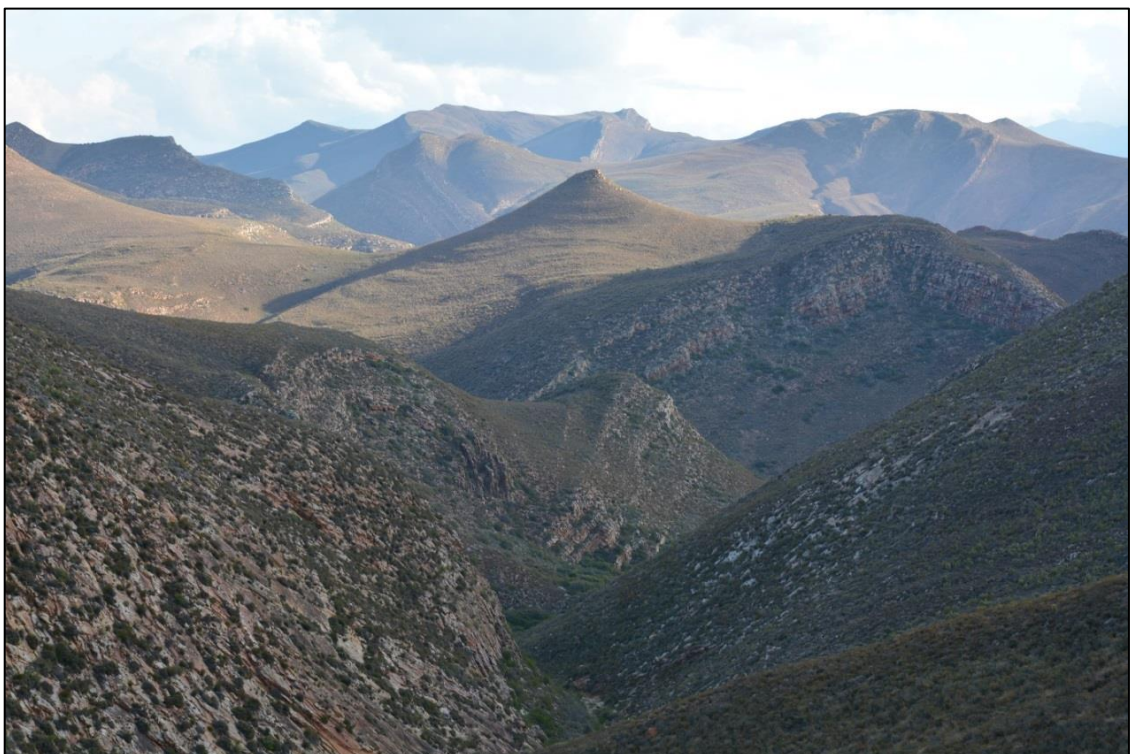


Figure 1.2: Views from the slopes of Trappieskraalkloof illustrate the diverse and complex mosaic of geological formations that occur in the study area. These strata are folded to a great extent creating different microhabitats.

This study serves both science and applied ecological purposes and focuses on the vegetation predominantly underlain by the Witteberg geological Group in the region of the Brandvlei Dam, as well as the mountains extending south-eastwards between Worcester and Robertson. The vegetation supported by the mudrock-rich contact zone between the Witteberg- and Bokkeveld geological Groups, as well as the vegetation supported by soil derived from Dwyka tillite, is furthermore examined regionally. The vast area currently covered by the Brandvlei Dam near Worcester was formerly part of an ancient floodplain to the south of the Breede River. This floodplain is characterized by thick layers of alluvial deposits and extends from south of the town of Worcester in the direction of Villiersdorp (Figure 1.3; Gresse and Theron 1992). Farming in the area south of Worcester is known from as early as 1709 when European settlers first occupied land in the area (DWAF 1995; Le Roux 2013). The first dam in the area, Lake Marais (now part of the Greater Brandvlei Dam), was constructed in 1922 to meet the increased demand for irrigation water in the dry summer months (Figure 1.3; DWAF 1995; Le Roux 2013).



Figure 1.3: A view from the mountains north of Worcester towards the south in the direction of Villiersdorp, indicating the former lake Marais and the extent of the former floodplain (Lake Marais and to the south of it) now inundated by the Greater Brandvlei Dam (in the upper and upper left-hand corner of the picture, picture used with courtesy of E. du Plessis).

The study area forms part of the Mountain Renosterveld (Acocks 1988), or, according to Rebelo *et al.* (2006) the “inland renosterveld of the Mountain Centre” that tends to be more xeric and generally has a lower vegetation cover (determined by moisture) in comparison with the coastal renosterveld types. Mountain Renosterveld is marked by a higher proportion of succulents and is dominated by renosterbos (*Elytropappus rhinocerotis*) and *Oedera* spp., while C₄ genera grasses may be prominent (Moll *et al.* 1984, Rebelo *et al.* 2006). Moll and Jarman (1984) state that though the Mountain Renosterveld is similar to some communities in the Fynbos Biome, Taylor (1978) considered this vegetation to be “...more akin to Karoo in habitat and floristics...”. According to Rebelo *et al.* (2006), very little is known about renosterveld ecology.

In the face of unpredictable environmental changes such as climate change (Turpie 2003), Wright *et al.* (2001) state that site specific ecological research is required to identify areas of conservation importance and to ensure that different variations of vegetation types are protected. Up to now, no detailed vegetation classification and description have been done for the specific area round the Greater Brandvlei Dam. This study will provide the Department of water Affairs and Sanitation (DWS), to which part of the property north and east of the Greater Brandvlei Dam belongs, with information regarding sensitive areas and ecotourism management planning around the Greater Brandvlei Dam as the Brandvlei Dam Yacht Club and the Quaggaskloof Ski Club are situated on the northern, and on the southern perimeter of the dam respectively. Populated farming communities with human structures such as power lines, roads, buildings and crops surround the remaining natural areas around the Brandvlei Dam. Because natural fires (started by lightning) and human induced fires are extinguished as soon as possible due to their threat to the various agricultural activities, the excluding of fire, especially in the moister renosterveld component of the vegetation in the area raises concern regarding the maintenance of biodiversity in this part of the ecosystem.

The purpose of this study is to:

- a. Identify, classify and describe the vegetation of the study area.

- b. Examine how the vegetation in the region of the Brandvlei Dam relates to similar geological areas between the Brandvlei Dam and the Rooiberg near Robertson.
- c. Investigate post-fire regeneration of two plant communities within the study area by comparing the vegetation structure and species composition with pre-fire data.

Research aims are:

1. Identify, classify and describe the vegetation of the study area.
2. Examine how the vegetation in the region of the Brandvlei Dam relate to similar geological areas between the Brandvlei Dam and the Rooiberg near Robertson.
3. To determine the influence of soil and environmental factors on the vegetation.
4. Investigate post-fire regeneration of two plant communities within the study area by comparing the vegetation structure and species composition with pre-fire data.

1.2 Thesis exposition

The thesis is presented in nine (9) Chapters, which describe the study, and provide a detailed set of phytosociological descriptions, analysis of the various plant communities and accompanying vegetation tables.

Chapter one provides a brief introduction and lists the aims and objectives of this study. This is followed by a literature review section (Chapter 2) on the vegetation of the larger area as well as an overview of the history of plant collection at the Cape (with special reference to early expeditions into the interior of the southern Western Cape) and vegetation mapping in southern Africa. Chapter 3 describes the location, climate, geology, land-types and soils, broad vegetation as well as a short overview of the vertebrates and invertebrates

occurring in the study area. The methods used for data collection- and analyses are also included in Chapter 3. Chapter 4 comprises the classification and description of the plant communities in the study area. Chapter 5 includes species new to science found during the years of data collection as well as taxonomic difficulties that were examined with the help of taxonomic specialists, as well as questions that need further investigation. Chapter 6 comprises a floristic analysis of the vegetation studied which includes floristic composition, endemism, plant physiognomy, species utilised for their specific attributes, rare and endangered species as well as species richness and plant community diversity. Chapter 7 describes the effects of a controlled fire in Breede Shale Renosterveld and Breede Quartzite Fynbos vegetation in part of the study area. Chapter 8 comprises conclusions, lessons learnt from this study as well as recommendations for further study. Acknowledgements and a reference list follow thereafter.

The Appendices at the end of the thesis includes a full species list, alphabetically arranged for the study area, complete phytosociological- and synoptic tables, and research publications emanating from this study.

CHAPTER 2

LITERATURE REVIEW

"...the only thing that can be predicted is the probability of different events".

From: Six Easy Pieces by Richard Feynman, 1998



Disa triloba

TABLE OF CONTENTS

LIST OF FIGURES	14
2.1 THE FLORA OF THE SOUTHERN AFRICAN WINTER-RAINFALL AREA.....	15
2.2 THE HISTORY OF PLANT COLLECTION AT THE CAPE AND VEGETATION MAPPING IN SOUTHERN AFRICA	19
2.2.1 A historical overview of plant collection at the Western Cape, with special reference to early expeditions into the interior of the southern Western Cape.	19
2.2.2 A short overview of the history of Vegetation Sampling and Mapping in southern Africa	37
2.3 CONCLUSION	42

LIST OF FIGURES

Figure 2.1: One of the earliest photographs of the hot spring in the western perimeter of the Greater Brandvlei Dam. The valley now inundated by the dam is visible in the background.	27
Figure 2.2: A photograph of the thermal spring around 1899, long after Burchell's visit in 1810, but long before construction of the Greater Brandvlei Dam which now inundates the valley visible in the picture (picture used with courtesy of E. du Plessis).....	29

2.1 THE FLORA OF THE SOUTHERN AFRICAN WINTER-RAINFALL AREA

In a popular reconstruction of the evolutionary history of the Cape flora, Linder and Hardy (2004) state that the Mid-Miocene (about ten million years ago) vegetation of the area was tropical, or sub-tropical with no dry season. As the oligotrophic sandstone-derived soils of the mountains could have sustained a sclerophyllous heath-like type of vegetation, the ancestral lineages of the modern Cape flora were possibly restricted to the mountains (Linder and Hardy 2004). The authors state that the steepening of global pole-to-equator climatic gradients and the complete glaciation of Antarctica caused for upwelling of cold bottom waters along the Atlantic coastline of southern Africa. Goldblatt and Manning (2002) point out that “the establishment of the cold Benguella Current along the west coast of southern Africa in the Miocene, with its cooling and drying effects, was probably the single most important influence affecting vegetation change in the subcontinent.” According to Siesser (1980), this upwelling started about eight to ten million years ago and resulted in conditions that caused summer rainfall to come to an end. As this current strengthened due to of the spread of the Antarctic ice sheet, summer drought became increasingly severe (Goldblatt and Manning 2002). The seasonal Mediterranean-type climate with winter-rainfall and summer drought that ensued, led to the extinction of the tropical flora and opened habitat for sclerophyllous heath-like plants from the mountains to radiate and generate the nearly thirty most successful clades of Cape plants (Linder and Hardy 2004). Although the evidence is sparse and Linder and Hardy (2004) quote literature indicating a broader Miocene start of the radiation of the Cape flora, it is believed that the massive diversification process occurred less than five million years ago during the late Pliocene, and may have been facilitated by recurring fires during the hot summer periods (Cowling and Pressey 2001; Goldblatt 1978; Linder and Hardy 2004). Goldblatt and Manning (2002) is of the view that the species richness of the Cape flora is the result of parapatric radiation in an area where a mosaic of different habitats caused by differences in climate, topography and soil yield steep ecological gradients. The authors furthermore note that a relatively stable geological history since the end of the Miocene contributed to this diversity (Goldblatt and Manning 2002).

The flora of the south-western Cape is dominated by small-leaved, sclerophyllous shrubs and is very distinct from that of the surrounding areas (Born *et al.* 2007; Manning and Goldblatt 2012; Moll 1991). The area is characterised by a low number of tree species, a low proportion of annuals, but a very high proportion of geophytic species (which are defined as “seasonal herbaceous perennials with subterranean innovation buds on bulbs, corms, or perennial rhizomes”) (Manning and Goldblatt 2012). Manning and Goldblatt (2012) state that it was for several decades treated as one of the six floral kingdoms of the world regarding levels of endemism (Takhtajan 1986). However, Cox (2001) is of the view that the Cape flora, being one of five areas in the world with Mediterranean-type climates (California, central Chile, south-western Australia and the Mediterranean Basin), should be recognised as a floristic Region rather than a Kingdom.

Where the Cape Floristic Region was formerly delimited to include only the Cape Fold Mountains, adjacent intermontane valleys and coastal plains, Born *et al.* (2007) recommended the delimitation to include the whole winter-rainfall area. Because a winter-rainfall flora is evident of a greater area, Mr M.B. Bayer¹ already in 1984 suggested that two of southern African biodiversity hotspots, the Cape Floristic Region and the Succulent Karoo Region (Myers *et al.* 2000) cannot essentially be separated (Bayer 1984; Moll 1991). Among others, Myers *et al.* (2000) define ‘hotspots’ as “areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat.” Born *et al.* (2007) note that although the CFR is considered a valid floristic region regarding endemism and the distinctive composition of the flora, the total endemism is higher for the whole winter-rainfall area and the authors therefore support the recognition of the larger unit, namely the Greater Cape Floristic Region (GCFR) (Born *et al.* 2007).

In the recent revision of *Cape Plants* (Goldblatt and Manning 2000), the flora of the Greater Cape Floristic Region (GCFR) (Manning and Goldblatt 2012) is

¹ Entomologist formerly with the South African Department of Agriculture as well as with other research institutions, former curator of the Karoo Botanic Garden in Worcester (1969-1987) and later at the Worcester Veld Reserve. Retired at Fisherhaven, Hermanus.

treated in two volumes, i.e. the flora of the Cape Core Subregion (CCR) which was formerly called Cape Floristic Region (CFR) (Goldblatt and Manning 2000), and a companion volume, the Extra Cape Subregion (ECR), which covers the flora of Namaqualand to southern Namibia and the western Karoo (Manning and Goldblatt 2012).

The Core Cape Subregion (formerly recognised as the Cape Floristic Kingdom or the Cape Floristic Region) is situated at the south-western tip of the African continent between latitudes 31° and 34°30' South (Manning and Goldblatt 2012). The CCR encompasses an area of approximately 90 760 km² and support close to 9 383 species of vascular plants of which over 68% are endemic (Manning and Goldblatt 2012). The Cape flora is remarkably rich for a temperate flora and comprises almost half (just over 46%) of all the vascular plants species recorded to occur in southern Africa as well as approximately 20% of the entire flora of sub-Saharan Africa (Manning and Goldblatt 2012). Compared to global floras, the diversity of the Cape flora is lower than Neotropical areas such as Costa Rica, Ecuador or Guatemala, but compares favourably with several regions in the moist tropics which are known for having the highest number of species on Earth. Within an African perspective the Cape flora is remarkably rich and more conspicuous than the tropical flora of Africa that lacks both high numbers as well as variety of species (Manning and Goldblatt 2012).

Although limestone and granite contribute to the edaphic diversity of the CCR, the geology primarily comprises a mosaic of alternating sandstone and shale substrates that weathers to various types of soils (Moll 1991; Manning and Goldblatt 2012). Climates across the region are variable. Seasonal winter-rainfall is typical for the western part of the region, but changes in seasonality is evident from the west to east of the region. The southern coast receives rainfall throughout the year. Depending on the direction of the moisture-bearing winds, elevation and aspect affect precipitation and because of the mountainous landscape, extremely sharp climatic gradients are attributes of the area. The unusual diversity of local habitats and consequential available ecological niches are related to the combination of climatic and edaphic diversity (Manning and Goldblatt 2012).

Fire is an important ecological driver in the CCR. In areas where the rainfall is high and fairly evenly spread throughout the year, fire-protected sites with deeper soils support forest vegetation. Where rainfall is lower and more seasonal, forest is replaced by varieties of Fynbos heathland, a sclerophyllous shrub dominated vegetation type, in areas with nutrient poor, sandy soils. Succulent shrublands become the dominant vegetation type in areas that receive a minimum of 250 – 300 mm rain per year. Renosterveld, a “distinctive shrubland dominated by shrubby, microphyllous Asteraceae” is found on richer clay soils (Manning and Goldblatt 2012) where precipitation is high. Renosterveld is replaced by vegetation that is progressively dominated by succulent perennials (mainly leaf-succulents) in areas where less than 100 mm rain per year is received (Manning and Goldblatt 2012).

Extending over four biomes i.e. Fynbos, Succulent Karoo, Albany Thicket and Afrotemperate Forest, several vegetation types are distinctive in the CCR (Manning and Goldblatt 2012; Mucina and Rutherford 2006). The three major vegetation types of the CCR are described in Manning and Goldblatt (2012) and in Mucina and Rutherford (2006):

- Fynbos, a sclerophyllous heathland characterised by shrubs with ericoid (short and narrow) leaves is typically found on the oligotrophic soils derived from sandstone and is the most common vegetation type, covering around half of the CC (Manning and Goldblatt 2012).
- Renosterveld is an evergreen, fire-prone shrubland which is dominated by Asteraceae and is mostly restricted to richer, fine grained soils (Manning and Goldblatt 2012).
- Strandveld, which is often dominated by the Restionaceae as well as sclerophyllous, broad-leaved shrubs, differs remarkably from Fynbos and is found along the southern and western coasts (Manning and Goldblatt 2012).

2.2 THE HISTORY OF PLANT COLLECTION AT THE WESTERN CAPE AND VEGETATION MAPPING IN SOUTHERN AFRICA

2.2.1 A historical overview of plant collection at the Cape, with special reference to early expeditions into the interior of the southern Western Cape.

In an extraordinary reference work to the collectors of the flora on the southern African subcontinent, Miss Mary Davidson Gunn (1899-1989), a Librarian at the Botanical Research Institute in Pretoria from 1916 to 1954 and in a temporal capacity until 1973, and the botanist Dr Leslie Edward Wostall Codd (1908-1999), who was a director of the Botanical Research Institute from 1963 to 1973, compiled an invaluable reference work concerning collectors of southern African plants. Published in 1981 in Cape Town as the introductory volume to the *Flora of Southern Africa*, their book, *Botanical exploration of southern Africa: an illustrated history of early botanical literature on the Cape flora - Biographical accounts of the leading plant collectors and their activities in southern Africa from the days of the East India Company until modern times*, is dedicated to biographical sketches of plant hunters dead and alive (Glen and Germishuizen 2010).

This exceptional volume, revised by Glen and Germishuizen (2010), describes how the early collectors were inspired by the love of adventure and by the instinct for collecting interesting flora which was never encountered before. Much of the initial botanical exploration in southern Africa was carried out by pioneering farmers, missionaries and traders, but many of the first recorded accounts of the plant and animal life of the country were provided by naturalists such as Thunberg, Sparrman, Paterson, Le Vaillant, and Burchell. There were also anonymous people who contributed to our current knowledge of the flora and fauna, but because they did not publish accounts of their travels we do not know the extent of their personal contributions. Such people only sent collections back to Europe where descriptions were published by botanists and zoologists of various nationalities (Gunn and Codd 1981). Living plants and seeds were sent to Europe long before herbarium collections of southern African plants were gathered. Goldblatt (1978) states that at the time when

Linnaeus was formulating his principles of plant classification and nomenclature during the late seventeenth and early eighteenth century, the first major collections of plants from southern Africa began to arrive in Europe. Because these specimens, such as examples of the Proteaceae, Restionaceae, Cunoniaceae and Bruniaceae families, were remarkably different from anything known at the time, they caused great excitement in the scientific community. Just as popular as they were then, South African succulents and geophytes are still sought after in the horticultural world today (Goldblatt 1978). Keeping this in mind, it is not surprising that one of the two first illustrations of South African land plants (made by two Flemish artists) was indeed of Cape bulbs that had already found their way to European gardens. Published as early as 1605, these first illustrations can be seen in Gunn and Codd (1981) – a sketch of a dried inflorescence of *Protea neriifolia* (by Charles de l'Ecluse), as well as a drawing of two Cape bulbs (by Mathias de L'Obel), which may with some certainty be identified as *Haemanthus coccineus* and *H. rotundifolius* (Glen and Germishuizen 2010; Gunn and Codd 1981).

The works of Gunn and Codd (1981) and Glen and Germishuizen (2010) provides a valuable record of the work and dedication which form the foundation of modern vegetation studies such as this one. These historical collections deserve to be acknowledged in this thesis as they are not only invaluable references in all fields of botanical science, but a respected representation of courage and persistence as well as an enormous source of inspiration to modern vegetation enthusiasts.

Gunn and Codd (1981) collected most of the earliest records concerning foreign visitors at the Cape from the 1967 Cape Town published work of R. Raven-Hart, *Before van Riebeeck* (Glen and Germishuizen 2010). Pioneer voyagers from Portugal began exploring routes to Africa and the Far East from end of the fifteenth century (Ravenstein 1900; Gunn and Codd 1981). Early in 1486, Diogo Cão set up the first *padrão* (a stone pillar bearing the King's coat of arms together with an inscription and surmounted by a cross as a symbol of Christianity) at Cape Cross on the Namibian shoreline, just north of the 22 degrees south latitude. These *padrão*'s were the first landmarks to indicate the

range of voyage and Portuguese sovereignty. Although Arabs may have known about a sea route linking the Indian and Atlantic oceans before the Portuguese, during the first 100 years since the rounding of the Cape by Bartolomeu Dias in 1488, no information on the plant and animal life of the southern tip off Africa was made known to Europe as the Portuguese seem to have been reluctant to make their first discoveries known. The first record was of a South African seaweed, *Ecklonia maxima*, growing along the coast at the southern tip of the African continent, was reported from Vasco da Gama's historic voyage to India in 1497. Today known as sea bamboo, the Portuguese originally named the species *trombas* "because the soft hollow stems with inflated ends could be fashioned into effective trumpets." This was also the first illustrated southern African plant as an illustration of a few stems of the 'trombás' floating in the sea off the cape coast was found in a published account (1598) of the voyage of four Dutch ships under Cornelius de Houtman that sailed from Holland in April 1595 (Glen and Germishuizen 2010; Gunn and Codd 1981).

Antonio de Saldanha was the first Portuguese explorer recorded to have landed in Table Bay in 1503. To make sure if he had indeed rounded the Cape, he climbed the "flat-topped mountain" which he called "The Table of the Cape of Good Hope" from where he saw the end of the Cape to the south (Gunn and Codd 1981). As he replenished his water supplies there, the bay became known as the "Watering-place of Saldanha" (*Aguada de Saldanha*). The first documented conflict between Portuguese voyagers and the original local inhabitants at the Cape took place in 1510 when the Portuguese Viceroy, Francisco d'Almeida called at the *Aguada de Saldanha* for fresh water (Glen and Germishuizen 2010).

At least since the late Stone Age, the original inhabitants of the southern Western Cape were Khoi-San hunter-gatherers and pastoralists whose knowledge of ethno-medicinal botany was extensive. (Boonzaier *et al.* 1996; Scott and Hewett 2008; Donaldson and Scott 1994; Shapera 1930). Southern African plants were collected and used by these local inhabitants long before the first European explorers visited the Cape (Deacon 1995; Masson 1776; Musselman 2003; Steele and Klein 2013; Van Wyk and Gericke 2000). The

subsistence lifestyle of the original inhabitants depended on biodiversity, the sustainable use of the natural resources, and familiarity with the species in their environment (Donaldson and Scott 1994). Numerous references provide examples of indigenous plants used by local people for various purposes such as food, shelter, timber, firewood, various utility items, thatching, mats, brooms, basketry, ropes, hunting, fishing, dyes, tans, perfumes, repellents, soaps, cosmetics and medicine (Musselman 2003; Van Wyk and Gericke 2000). Interestingly, the first geobotanical observation recorded in southern Africa was made as early as 1514 when the Portuguese explorer Antonio Fernandes set out to discover the source of the gold trade in southern Africa. Near the headwaters of the Pungwe River, which originates in eastern highlands of modern Zimbabwe, it is known that Fernandes was told that “gold-bearing ground could always be recognised since over it grew a distinctive plant something like a clover.” (Glen and Germishuizen 2010; Gunn and Codd 1981).

Despite the exceptionally rich botanical diversity and high levels of endemism in the Cape region, the ethnobotany of the Khoi-San people is poorly recorded (Donaldson and Scott 1994; Van Wyk 2008). However archaeological records of plants in the form of rock paintings and engravings are rare, eight species of medicinal plants have been recorded before 1650. Amongst these were *Searsia lancea* (L.f.) L.A.Barkley and *Boophone disticha* (L.f.) Herb (Van Wyk 2008). As the European colonists came in contact with the local Khoi groups after 1652, knowledge of the indigenous medicinal plants was acquired from the local people (Donaldson and Scott 1994; Musselman 2003; Van Wyk 2008). Van Wyk (2008) lists a total of about 170 medicinal plant species which were documented up to 1932. Amongst these Cape-endemics are species such as *Agathosma betulina* (P.J. Bergius) Pillans (boegoe, buchu), *Arctopus echinatus* L. (platdoring), *Carpobrotus edulis* L.Bolus (suurvy), *Chironia baccifera* L. (bitterbos, aambeibos), *Cissampelos capensis* L.f. (dawidjies), *Elytropappus rhinocerotis* (L.f.) Less. (renosterbos), *Eriocephalus africanus* L. (kapokbos, wilderoosmaryn), *Galenia africana* L. (kraalbos), *Gethyllis* species (kukumakranka, koekemakranka), *Lobostemon fruticosus* (L.) H.Buek (agdaegeneesbos), *Oncosiphon suffruticosum* (L.) Källersjö (stinkkruid), *Pelargonium triste* (L.) L'Hér. (rooirabas), *Protea repens* (L.) L. (suikerbos),

Salvia africana-caerulea L. (bloublomsalie), *Sutherlandia frutescens* (L.) R.Br. (kankerbossie) and *Viscum capense* L.f. (voëlent), all of which are presently still being used by rural communities in the Cape region.

Although English written records of Khoi-San traditional medicine are mainly from 1800 and onward, references to the use of medicinal plants by the traditional inhabitants of the Cape between 1650 and 1800 can be found in journals of exploratory expeditions, herbarium specimens, published academic works and other historical records of the former Dutch East India Company (Vereenigde Oost-Indische Compagnie, or VOC) at the Cape (Scott and Hewett 2008). Scott and Hewett (2008) state that almost all of the relevant historical ethnobotanical records were associated in some way with the activities of the former VOC when the Cape of Good Hope was identified as a possible station for the supply of fresh produce and water to ships sailing between Europe and the East.

In later years, ships of other nationalities, particularly the French, English and Dutch followed the Portuguese in sailing to the southern tip of Africa. Although numerous ships sailed around the Cape or called at 'Saldanha's Watering-place', early records show little mention regarding the vegetation observed. On their way to India, Thomas Stevens lead the first recorded English ship that passed the Cape in 1579. The well-known observation "This Cape is a most stately thing, and the fairest Cape we saw in the whole circumference of the earth" was recorded when Sir Francis Drake, near the end of his voyage around the world, sailed within sight of the Cape of Good Hope in 1580 (Glen and Germishuizen 2010; Gunn and Codd 1981). While the first English ships landed at the Cape in 1591, John Davis who reached the 'Bay of Saldania' in November 1598 mentions that "This land is a good soile, and an wholesome Aire, full of good herbes as Mints, Calamint, Plantine, Ribwort, Trifolium, Scabious and such like." Saldanha's Watering-place was renamed Table Bay in 1601 by Joris van Spilbergen, the commander of a Dutch fleet (Glen and Germishuizen 2010; Gunn and Codd 1981).

According to Gunn and Codd (1981) an enthusiastic field botanist, Mathias de L'Obel (1535–1616) from the country of Flanders, mentioned the first plant collector at the Cape by name. L'Obel published illustrations of two species of *Haemanthus* from the Cape (grown in Europe) and mentions the collector being Gouarus de Keyser who visited the Cape and in 1603 dug out bulbs for his brother, Jacobus de Keyser who was a wealthy merchant and plant lover of Wiesbaden in Germany (Gunn and Codd 1981). A particular expedition, undertaken in 1685–1686 by Simon van der Stel to the Copper Mountains in Namaqualand gave rise to a set of watercolour paintings by Hendrik Claudius (known as the first resident at the Cape to make illustrations of Cape plants) depicting the fauna and flora seen on the journey. Together with the place and date of the specimen, the journal provided a short description of the plant habitat, traditional use and vernacular names of the plants (Gunn and Codd 1981, Scott and Hewett 2008).

In addition to journals associated with VOC expeditions, several visitors to Cape contributed to early plant collection records. Although casual visitors were usually not allowed to travel far inland, as the VOC ensured that only their employees could collect natural history material which was forwarded to the Dutch authorities, interested travellers made use of opportunities to buy curios which were for sale at the seaports. Occasionally a book in which dried plant specimens were pasted would be offered as such. Such a souvenir was obtained at the Cape in 1764 by the Swedish merchant, mineralogist, banker and director of the Swedish East India Company, Michael Grubb (1728 –1808). Regarding the collection of plant specimens, the Dutch were not co-operative towards their new competitors and the newcomers when the Swedish E.I. Company. was found in 1731 (Glen and Germishuizen 2010; Gunn and Codd 1981).

The following includes notes on the collectors who explored the interior of the Western Cape which also encompasses the area of this study.

Gunn and Codd (1981) discuss the Cape voyages of the former Swedish ship doctor and later expert navigator, Carl Gustaf Ekeberg (1716-1784) who called

in at the Cape several times between 1742 and 1778 on journeys to India and China (Forbes 1986). Ekeberg was considered one of the most capable seamen of that time. He made magnetical and meteorological observations on his travels and described the sea route round the Cape in detail through excellent black and white, as well as colour sketches. While at the Cape, he collected plants mostly around False Bay and is known to have taken specimens to the Swedish botanist Carl Linnaeus (1707–1778) whose *Species plantarum* (published in Stockholm in 1753) is, for most groups of plants, accepted as the starting point of nomenclature (Gunn and Codd 1981). Gunn and Codd (1981) also discuss expeditions of the Swedish physician and naturalist, Anders Sparrman (1748-1820) who first passed the Cape on a voyage accompanying Captain C.G. Ekeberg as the ship's doctor in 1765, was later sent to South Africa by Linnaeus in 1772 to make natural-history collections (Svedelius 1944). Sparrman spent a few days botanizing around Cape Town with C.P. Thunberg, who arrived just four days after Sparrman. Together they compiled a large collection with many duplicates. Sparrman later made excursions to Paarl but left Cape Town in July 1775 on an extensive expedition to the Eastern Cape. This journey took him across the Cape Flats to the Hottentots Holland Mountains, farther to the Outeniqua Mountains, towards the Eastern Cape through the Langkloof and farther eastwards to the Fish River. His party returned by much the same route, but from Swellendam deviated from their outward journey and followed the northern bank of the Breede River to the Hex River and Tulbagh, returning to Cape Town across the Swartland in April 1776. Sparrman's travels are described in two volumes which are considered the first personal account of extensive travels into the interior of the Cape Province and therefore have considerable historical significance (Hutchinson 1946; Hansen and Wagner 1998; Glen and Germishuizen 2010).

Scottish-born Francis Masson (1741–1805) was a gardener at the royal gardens at Kew when he was on two occasions (1772–1775 and 1786–1795) sent to the Cape by the king to collect seeds and plants for the Kew garden. Masson spent twelve years at the Cape of Good Hope during which he had travelled extensively (Saltmarsh 2003). As his personal journal has been lost, little is known of Masson's first couple of months at the Cape (Saltmarsh 2003).

His short account of the three journeys made into the interior of the Cape was published in the *Philosophical Transactions of the Royal Society* in 1776 as 'Three Journeys at the Cape of Good Hope, 1772-1775' and was the first narrative in English of extensive travels in South Africa (Glen and Germishuizen 2010; Gunn and Codd 1981; Saltmarsh 2003). In 1781, Linnaeus named a new genus *Massonia* which was firstly collected by Masson, for him (Saltmarsh 2003).

Because of the botanical interest inspired by the southern African plants, South Africa became one of the first areas outside the European sphere to be explored botanically (Goldblatt 1978). Also, a former ship's surgeon and appropriately called 'the father of Cape botany', Swedish botanist and physician Carl Peter (Pehr) Thunberg (1743–1828), Linnaeus's favourite and most famous pupil, arrived at the Cape on 16 April 1772. Thunberg is recognised as the most prominent botanical explorer of his time whose scientific work opened up the two great countries, South Africa and Japan, to botanical research. According to Svedelius (1944), C. A. Agardh remarked that "no naturalist had at his time detected, examined and described so many natural objects as he." The number of new plant species that Thunberg had collected and described is estimated to be near 1 900 (Svedelius 1944). The same author notes that Thunberg did not only collect while he was in South Africa but also used the opportunity to revise his collections. In the three years spent at the Cape (1772 to 1775) Thunberg embarked on three main collecting expeditions to the interior. His Cape plant collection, comprising of 3100 specimens, was enumerated with brief descriptions in two parts in his *Prodromus plantarum capensium* (1794 and 1800) which, enlarged with localities and vernacular names, appeared in his *Flora Capensis* between 1807 and 1820.

The existence of a thermal spring (from which the name 'Brandvlei' originates) in the vicinity of the Greater Brandvlei Dam (Figure 2.1), attracted the attention of travellers such as botanists and other naturalists in the past, resulting in at least four new species being described from 'Brandvlei' in the early years (Le Roux *et al.* 2010). In his *Travels at the Cape of Good Hope 1772–1775*, Thunberg described a visit to the hot spring in October 1772 on his first journey into the interior which was guided by Johann Andreas Auge (1711 – 1805?).

The German born Andreas Auge arrived at the Cape of Good Hope in 1747 to work as assistant in the Company's Garden. He was later appointed a superintendent of the Garden and as botanist and collector, accompanied, as well as guided many explorations to the interior of the Cape. Thunberg commemorated his name in the genus *Augea* (Forbes 1986; Glen and Germishuizen 2010.)



Figure 2.1: One of the earliest photographs of the hot spring in the western perimeter of the Greater Brandvlei Dam. The valley now inundated by the dam is visible in the background.

Edited by J.A Schultes in 1823, this work is considered the first comprehensive treatment of the Cape Flora (Glen and Germishuizen 2010; Svedelius 1944). While at the Cape, Thunberg and Masson accompanied each other on various collecting trips into the interior of the colony (Saltmarsh 2003). Svedelius (1944) reiterated the following appreciation that the South African botanist Verduyn den Boe gave to Thunberg's works: "Nevertheless, as long as in our paradise of flowers there wanders a single botanist, so long will the name of Thunberg be held in honoured remembrance."

The main interest of the French traveller, naturalist and painter, François Le Vaillant (1753-1824), who made several travels to the Cape, was ornithology.

He arrived in the Cape for the first time in 1784. Le Vaillant admitted to being ignorant of botany and preferred painting plants to the “tedious, minute and useless cares” required to press and dry herbarium specimens. Although he collected numerous plant specimens, he did not appreciate the importance of such specimens for documentation and description (Forbes 1965; Glen and Germishuizen 2010).

The Scot William Paterson (1755-1810), a naturalist and traveller, was sent to the Cape as a plant collector in 1777. A record of the four journeys that he undertook into the interior between 1777 and 1780 was given in his book, *A narrative of four journeys into the country of the Hottentots and Caffraria*, which was published in London in 1789. Paterson describes an expedition through the study area in December 1777 (Paterson 1789; Glen and Germishuizen 2010).

Amongst the early collectors who documented their excursions into the Western Cape interior, and by that means had contributed largely to early records of the environment and flora, is also the English naturalist, traveller, artist and author, William John Burchell (1781–1863) who landed in Table Bay in November 1810. He embarked on a journey covering more than 7000 km, much of it never explored before, to the Cape interior in June 1810, returning to Cape Town almost five years later in April 1815. Burchell described an expedition through the study area in his book *Travels in the Interior of Southern Africa*, published in 1822 (Burchell 1822; Glen and Germishuizen 2010). William Burchell described his visit to the spring (Figure 2.2) on 14 April 1810 and wrote: “At five o’clock we reached Brand (or Brandt) Valley, and took up our lodging at the farm-house of De Wet. I immediately went to examine the Hot Spring, which is at a very short distance from the house, and found it much larger, and more remarkable, than the spring at Zwartberg. It formed a shallow pond of about fifty feet across, of the most transparent water; in the middle of which several strong springs bubble up through a bottom of loose white sand, and afterwards, flowing in a very copious stream, become a rivulet, which for at least a mile and a half continues so hot along the valley may, at any time of day, but more particularly in the morning, be traced by the steam which perpetually rises from it. The pond is sheltered by a small clump of white

poplars, which thrive perfectly well, although growing at the very edge of the water, and bedewed with the hot steam, which ascends to their highest branches. No plant, it seems, can grow in the water itself, but the margins of the bank are thickly covered with sedge. *Royena glabra*, a *Rhus* and a variety of other plants stood within the influence of its heat” (Burchell 1822; Burchell 1953; Le Roux et al. 2010).



Figure 2.2: A photograph of the thermal spring around 1899, long after Burchell’s visit in 1810, but long before construction of the Greater Brandvlei Dam which now inundates the valley visible in the picture (picture used with courtesy of E. du Plessis²).

Appointed as a missionary to Calcutta in 1812, another Scot, George Thom (1789-1842) abandoned his plans of going to India when he arrived at the Cape where he remained to work among the Europeans, coloured people and the slaves. He was later appointed as minister of the Dutch Reformed Church at Caledon and went to Britain in 1820 to recruit Scottish ministers and teachers at the request of Lord Charles Somerset. Gunn and Codd (1981) note that some of Thom’s students later were to play an important role in the religious and educational history of South Africa. He was interested in geology and botany and sent plant as well as geological specimens to the Department of

² Mr Du Plessis grew up and lived in Worcester, now in Port Elizabeth, South Africa.

Botany at the University of Glasgow as well as to the Hunerian Museum at the same university. He was transferred to Tulbagh in 1925 where his collections continued (Du Plessis 1965; Glen and Germishuizen 2010).

Christian, Frederick Ecklon (1795–1886) who was born in Denmark and trained as an apothecary, became interested in botany and wanted to extend his knowledge beyond that of the European flora. He was appointed a post as assistant at an apothecary firm in Cape Town in 1823 and started to collect around Cape Town and on Table Mountain in his spare time. In 1827 he started to collect natural history specimens on a full time basis. In order to cover larger areas and also pool their collections, Ecklon joined forces with the botanical collector Carl Zeyher around 1829. Together they made several productive joint expeditions not only into the Cape interior, but also to other parts of South Africa where they collected between 7 000 and 8 000 specimens (Nordenstam 2003; Glen and Germishuizen 2010).

Carl, Ludwig, Philip Zeyher (1799–1858) was born in Germany. Zeyher travelled to Mauritius in 1822 to collect specimens as part of a group of young men, mostly trained gardeners, who were appointed by F.W. Sieber of Prague. Sieber planned a commercial enterprise in the retailing of natural history specimens and left Zeyher at the Cape to collect material while he went on to Mauritius and Australia. On his return to the Cape in 1824, Sieber took the material that Zeyher had collected and promised him a share of the incomes. When no payments were coming after a reasonable time, Zeyher considered himself free to collect on his own and made a journey to the east of South Africa in 1825. Other collecting expeditions took him to the Karoo, the Northern Cape as well as the Eastern Cape, the Orange Free State, the former Transvaal and the present KwaZulu Natal (Nordenstam 2003; Glen and Germishuizen 2010).

The German horticulturist, plant collector and traveller, Johann, Fran(t)z Drège (1794-1881), joined his brother, Carl F. Drège, who was an apothecary at the Cape, in March 1826. As professional collectors, the two brothers made several excursions to the Cape interior where Franz concentrated on plants while Carl collected zoological and ethnological specimens. It is documented that Franz

Drège collected more than 9 500 plant specimens which included a great number of undescribed species, over 100 of which were named after him (Glen and Germishuizen 2010). Another German born physician, Carl, Wilhelm, Ludwig Pappé (1803-1862) settled in South Africa in 1831 and although he immediately started a medical practice in Cape Town, plants (medicinal plants at first) were his main interest. Although he did not venture far from the area around Cape Town (as far as Caledon at first) he did make collecting expeditions to Tulbagh, Namaqualand and also to Knysna. In 1858 Pappé was appointed as the first Colonial Botanist at the Cape and when a Chair of Botany was created at the South African College later that year, Pappé became the first Professor in botany in South Africa (Bruyns and Klak 2006; Carruthers 2011; Glen and Germishuizen 2010; Gunn and Codd 1981).

Harry Bolus (1834-1911) was born in England and arrived in the Cape in 1850 as assistant to William Kensit, a trader of Grahamstown, whose sister Sophia, he later married. Gunn and Codd (1981) note that after Harry Bolus lost his eldest son in 1864, his close friend Prof Francis Guthrie of Graaff Reinet advised him to take up the study of botany to take his mind off his bereavement. The knowledge of South African flora was greatly increased through Bolus' dedication and extensive knowledge gained on journeys throughout South Africa (Gunn and Codd 1981). Bolus furthermore did much to encourage the study of botany in providing bursaries and helping young botanists such as R. Schlechter, C.L. Leipoldt and N.S. Pillans. However a keen observer of plants in the field, his interest was in orchids as well as the Ericaceae. He bequeathed his herbarium and library, as well as funds for the maintenance thereof, to the University of Cape Town (Glen and Germishuizen 2010). In 1903 Harry Bolus appointed his niece (who later became his daughter in law), Harriet Margaret Louisa Bolus (1877-1970) as the Curator of his private herbarium. Louisa Bolus kept this post when the herbarium was bequeathed to the University of Cape Town in 1911 and held it until her retirement in 1955. She was an internationally recognised botanist who had been secretary, companion as well as herbarium- and library assistant to Harry Bolus before his death in 1911. She was particularly interested in the Orchidaceae and Ericaceae but also specialized in the Iridaceae and

Mesembryanthemaceae. Apart from her scientific work, she also tried to make botany attractive to the layman by publishing in a popular gardening magazine and authoring *A book of South African flowers*, meant for the layman and school children (Glen and Germishuizen 2010). Frank Bolus (1870-1945), the youngest son of Harry Bolus and husband of Louisa Bolus, took care of his father's herbarium while it was still at Harry Bolus's home. It is known that he accompanied his father on a collecting expedition to the Swartberg Mountains in 1904 (Carruthers 2011; Glen and Germishuizen 2010).

The Austrian botanist and geographer, Anton Rehmman (1840–1917) collected more than 9000 specimens (probably over 3000 species) during his two visits to South Africa in 1875–1877 and in 1879–1880 (Glen and Germishuizen 2010). The same authors provide a summary of Rehmman's numbers and collecting localities which extends through the Cape to Pretoria in the former Transvaal and also through the Orange Free State and the present KwaZulu Natal (Codd and Gunn 1982; Glen and Germishuizen 2010).

The German botanist and traveller, Friedrich, Richard, Rudolf Schlechter (1872-1925) came to the Cape in 1891 where he worked under Harry Bolus as a herbarium and library assistant. Schlechter was known as a hardworking man with a remarkable memory. Making use of the available rail network and collecting at nearly every station, he collected a vast number of specimens on expeditions to the Cape interior as well as in other areas all over South Africa (Glen and Germishuizen 2010; Klopper *et al.* 2013).

The English born mathematician, Alfred Arthur Bodkin (1847–1930) taught Mathematics and Natural Science in Cape Town when he became friends with Harry Bolus and occasionally accompanied him on collecting expeditions in various parts of the Cape and often at high altitudes (Glen and Germishuizen 2010; Gunn and Codd 1981).

The botanist Illtyd, Buller Pole Evans (1879–1968) was born in Wales, but was in 1905 appointed to the post of Mycologist and Plant Pathologist in the former Transvaal Department of Agriculture. He travelled widely through South Africa and South West Africa recording and photographing the major vegetation types

and classified the country into 19 botanical regions. The regions, together with a short ecological characterisation of each region were published in the paper 'The Veld, its Resources and Dangers' which was published in 1920 in the *South African Journal of Science*. In 1992, Pole Evans also contributed a chapter 'Vegetation of South Africa' with accompanying map to a handbook entitled *Science in South Africa*. The well-known 1: 3 000 000 vegetation map which was published as Memoirs of the Botanical Survey of South Africa No. 15 of 1936, originated from the before mentioned map compiled by Pole Evans (Glen and Germishuizen 2010; Klopper *et al.* 2013).

Gunn and Codd (1981) state that Augusta Vera Duthie (1881-1963) was probably the first South African trained botanist to be appointed as lecturer in the country. Born in Knysna, she studied at the Huguenot College in Wellington, later at Cape Town and also at the University of South Africa before she was in 1902 appointed as lecturer in Botany at the Victoria College (later the University of Stellenbosch), specialising in the flora of the sand-flats in the Stellenbosch area (Glen and Germishuizen 2010; Jordaan 1967).

Terence Maclean Salter (1883-1969) was born in England and came to South Africa in 1927 where he was stationed in Simonstown as a paymaster officer in the Royal Navy. Captain Salter, known for his thorough fieldwork kept close contact with the Bolus Herbarium and after his retirement in 1931 devoted most of his time to botany where his main interest was in the genus *Oxalis* (Du Plessis and Rourke 1971; Gunn and Codd 1981).

The Cape Town born botanist, Neville, Stuart Pillans (1884–1964) joined the Bolus Herbarium in 1918 where he spent the rest of his life. While still at school, he started growing indigenous plants, especially succulents. His collection was noticed by the leading botanists of the time and N.E. Brown referred to Pillans as "the most eminent collector of Stapeliads in the eventful history of the tribe." In an article published in the *Agricultural Journal* in 1910, he advocated the establishment of a garden for the indigenous flora and later assisted Professor H.H.W. Pearson in choosing the site for the future Kirstenbosch Botanic garden (Glen and Germishuizen 2010; Gunn and Codd 1981). The English botanist Robert Steven Adamson (1855-1965) occupied the

Harry Bolus Chair of Botany at the University of Cape Town from 1923 to 1950. His interests were mainly ecological at first and apart from his major contributions to the knowledge of South African plant geography, he also specialised in taxonomy and published revisions of a number of genera. He returned to Britain after his retirement in 1955 (Glen and Germishuizen 2010; Klopper *et al.* 2013).

The Compton Herbarium at Kirstenbosch was named in honour of Robert Harold Compton (1886-1979) an English botanist who came to South Africa in March 1919 to become the Director of the National Botanic Gardens of South Africa at Kirstenbosch. Compton, one of the most prolific collectors in South Africa, collected more than 35 000 specimens of which about 8000 were collected in Swaziland (Glen and Germishuizen 2010; Gunn and Codd 1981). When Professor Compton in 1921 started the Karoo Garden at Whitehill, adjacent to the Matjiesfontein Railway Station, Joseph Archer (1871-1954) the stationmaster at Matjiesfontein (who came to the Cape from England around 1890), was appointed the first curator of the garden. His successor, Jacques Thudichum (born in Switzerland in 1893) came to South Africa in July 1924 where he initially managed a private property near Tulbagh. He was the second curator of the Karoo Garden (1945-1958) where after the Cape Roads Department employed him in 1959 to beautify the national roads of the Cape Province. He collected a great number of succulents to stock the garden, but most of the records regarding these collections are unfortunately lost (Glen and Germishuizen 2010; Gunn and Codd 1981). During his time as curator, the Karoo Garden was in 1946 moved to a more appropriate site near Worcester. The English horticulturist Roy Charles Littlewood (1924-1967) came to the Cape in 1957 and was the first horticulturist appointed to the Karoo Garden in Worcester. The South African horticulturist Frank James Stayner (1907-1981) succeeded Thudichum as curator from 1959 to 1973. His plant collection mostly comprised of succulent plants for the garden (Gunn and Codd 1981). Martin Bruce Bayer, an entomologist and botanist who was born in Zululand in 1935, succeeded Stayner as curator of the garden in 1969. After the Karoo Garden, Bruce was in charge of the Worcester Veld Reserve (Department of Agriculture) from 1987. Although his main interest is the genus *Haworthia*,

Bruce and his wife Daphne are still ardent botanists with admirable fieldwork experience in the Cape flora of the winter-rainfall area. The Karoo Garden is today known as the Karoo Desert National Botanical Garden (Carruthers 2011; Glen and Germishuizen 2010; Rourke and Voget 2013).

The studies of Cape Town born Margaret Rutherford Bryan Levyns (1890-1975) at first concentrated on mathematics, but encouraged by Professor Harold Pearson to change to botany, she became an outstanding botanist and phytogeographer (Glen and Germishuizen 2010; Gunn and Codd 1981). Her interests included taxonomy and phytography where her contributions include revisions of genera of South African plants such as *Muraltia*. Her collection, mainly include plants from the Western Cape and comprise of nearly 12 000 specimens (Glen and Germishuizen 2010; Ogilvie *et al.* 2000.).

The German horticulturist and succulent plant specialist, Adolar, Gottlieb, Julius (Hans) Herre (1895 –1979) was a former curator of the Stellenbosch University Botanic Garden (1925-1963). He made several expeditions, especially to the arid ecosystems of the Karoo, Namaqualand, Richtersveld and South West Africa and successfully grew the many succulent plants which he collected on these expeditions. Of his most noteworthy achievements were the growing of *Welwitschia mirabilis* from seeds as well as authoring *The genera of the Mesembryanthemaceae*, an illustrated book which was published in 1971. Herre collected more than 300 species new to science of which over thirty was named after him (Glen and Germishuizen 2010; Tijmens 1970).

Most of the early years of the well-known South African poet, author, journalist, medical practitioner and plant collector, Christian Frederick Louis Leipoldt (1880-1947) was spent in Clanwilliam where his interest in nature was encouraged by his father, a minister in the Dutch Reformed Church. In 1897, Leipoldt accompanied Rudolph Schlechter on a collecting expedition in Namaqualand by ox-wagon. This led to correspondence with Harry Bolus in Cape Town who later provided Leipoldt with a grant to study medicine in London. His Cape plant collection comprise of 1000 specimens (Glen and Germishuizen 2010; Sandler 1979).

Amongst plant collectors of southern African plants, Glen and Germishuizen (2010) discuss the following explorers (born in the twentieth century) who collected in the interior of the Cape, including the Upper Breede River Valley, in more recent years: Harry Hall (1906-1986), Frank James Stayner (1907-1981), Gwendoline, Joyce Lewis (1909-1967), John Philips Harison Acocks (1911-1979), Miriam Phoebe de Vos (1912-unknown), Elsie Elizabeth Esterhuysen (1912-2006), Ion James Muirhead Williams (1912-2001), Ian Basil Walters (1917–1983), Bo Hagart Peterson (1918-1990), Phillip Albert Brand van Breda (1922-1995), Roy Charles Littlewood (1924-1967), Pauline Lesley Perry (1927-current), Maria Catherina Olivier (1927-current), Rolf Martin Theodor Dahlgren (1932-1987), Martin Bruce Bayer (1935-current), Edward George Hudson Oliver (1938-current), Heidrun Elsbeth Klara Hartmann (1942-2017), Peter Goldblatt (1943-current), Josephine Bertha Pauline Beyers (1944-2003), Charles Boucher (1944-current), Elizabeth Maria Marais (1945- current), Jacobus Petrus Roux (1954-2013), Charles Howard Stirton (1946-current), Deirdre Ann Snijman (1949-current), Ernst Jacobus Van Jaarsveld (1953-current), Hans Peter Linder (1954-current), Ben-Erik Van Wyk (1956-current), Peter Vincent Bruyns (1957-current), Johannes Hendrik Jacobus Vlok (1957-current), John Charles Manning (1962-current), Anne Lise Schutte-Vlok (1962-current) and Cornelia Klak (1968-current).

Gunn and Codd (1981) and Glen and Germishuizen (2010) provide an extensive chronological list of collectors between 1600 and 1850. The authors note that the pace of collecting started to accelerate from 1850 onwards to a point where keeping record thereof would become unmanageable. From about 1850 one starts to see resident collectors born in southern Africa. Exploration was easier after the coming of good roads and affordable motor transport between 1920 and 1925 (Glen and Germishuizen 2010). Although, a high percentage of the flowering plants of southern Africa have been collected and described today, Glen and Germishuizen (2010) state that because much information regarding accounts of the diversity of many areas remains incomplete, the tendency indicated by the steep decline in plant collecting since 1975 is indeed disturbing.

2.2.2 A short overview of the history of Vegetation Sampling and Mapping in southern Africa

To give something a name conveys definite attachment and responsibility. Ancient peoples believed that to name something is to know and/or to possess it. Between people, using the same names for things provide common ground and shared experience (Glen 2004). In the foreword of a comprehensive account on the vegetation of southern Africa, Professor B J Huntley, former Chief Director of the National Botanical Institute, underlines that from the earliest botanical explorations in the late 18th century until today, a strong tradition of fieldwork lies behind the study of southern African flora (Cowling *et al.* 1997). While type specimens of much of the early botanical explorations are housed in herbaria in Kew, Paris, Berlin and other European institutions, southern African herbaria were established during the mid-nineteenth century in Cape Town, Pretoria, Durban, Grahamstown, Windhoek and other centres. The collections in these herbaria provided the foundation for the first plant ecologists and pioneers of vegetation science such as H.W.R. Marloth, R.S. Adamson, J.F.V. Phillips, J.W. Bews, I.B. Pole Evans, J.A. Pentz, M.R.B. Levyns and C.L. Wicht to describe and map the southern African vegetation (Cowling *et al.* 1997).

Early accounts of the different vegetation types in southern Africa include that by H. Bolus as early as 1905 and J.W. Bews in 1916 (Bews 1916; Bolus 1905), but it was largely due to the initiative of Dr I.B. Pole Evans, the then Chief of the Division of Botany in the Department of Agriculture in Pretoria, that the first official vegetation survey was initiated in 1918. An article titled 'The Botanical Survey of the Union of South Africa', in 1919 announced the "appointment by the Government of the Union of South Africa of an Advisory Committee to carry out and supervise a Botanical Survey of the territories included in the Union." This article appeared in the *Bulletin of Miscellaneous Information* (Royal Gardens, Kew). The Committee was appointed in the autumn of 1918.

According to the same reference source, the following aims and scope of the Survey were stated at a meeting of botanists of the Department held in Pretoria in February 1918:

- 1. *To continue and extend the Survey and systematic work already carried out by the Division of Botany on the Vegetation of the country.*
- 2. *To continue and extend the survey work already carried out by the Division of Veterinary Research on the relation of such vegetation to the unsolved stock diseases of South Africa.*
- 3. *To continue and extend the collections of the plant parasites of the indigenous vegetation already made by the Division of Botany, and proceed with its examination as a possible reservoir of diseases of cultivated plants and of domesticated animals, and in particular map their distribution.*
- 4. *To continue and extend the work already accomplished by the Forest Department in further ascertaining the composition of the indigenous forests, the value of their products and their industrial possibilities.*
- 5. *To study the vegetation from an industrial point of view.*
- 6. *To study the vegetation in its relation to agricultural and pastoral developments.*
- 7. *To study the plant succession under natural and artificial conditions.*
- 8. *To study the vegetation of the veld in connection with its feeding value and carrying capacity and to distinguish botanically between "sour" and "sweet" velds, good and bad pastures.*
- 9. *To study the disturbing influence of burning, manuring, cultivation, drainage, irrigation, overstocking, insect and plant pests on the natural vegetation.*
- 10. *To study plant distribution according to geological, oro-graphical and climatological conditions and the conditions which influence the different plant formations.*
- 11. *To extend their knowledge of the medicinal and poisonous plants of the country.*

- 12. *To study the influence of South African conditions on the structure and physiology of the plants of the country and in particular the causes which give rise to non-parasitic diseases.*
- 13. *To compare and correlate our flora and its associated animal and plant diseases with those existing in other parts of the world under somewhat similar telluric and climatic conditions.*
- 14. *To devote more attention to the soil and its micro-organisms.*

Today, almost a century later, the aims of the first vegetation survey in South Africa as stated above, include the main objectives why vegetation surveys are still important. Various reference works agree that as a result of the official survey, the first mapping of the vegetation of southern Africa (describing 12 vegetation types) was done by Pole Evans in 1935 (Acocks 1988; Adamson 1938; Cole 1956; Glen and Germishuizen 2010; Low and Rebelo 1996; Mucina and Rutherford 2006; Pentz 1945; Pole Evans 1936). This was followed by a map published by Adamson in 1938 which illustrated 14 vegetation types (Acocks 1988; Adamson 1938; Cole 1956; Glen and Germishuizen 2010; Low and Rebelo 1996; Mucina and Rutherford 2006). Acocks (1988) mentions another map compiled by Pentz in 1945 which focused on the vegetation of Natal, recognising 21 vegetation types.

Although the English botanist Robert Steven Adamson in 1938 contributed to the knowledge of plant geography in South Africa with his 'Vegetation of South Africa' published in *Monographs of British Empire vegetation*, the map of Pole Evans remained to be recognised as the standard vegetation map of South Africa until it was replaced by the one compiled by Acocks in 1953 (Brown and Bredenkamp 2017; Glen and Germishuizen 2010).

The South African botanist and pasture ecologist, John Philips Harison Acocks (1911-1979), is known as one of the most prolific collectors of South African plants. He discovered many undescribed species and collected more than 28 000 specimens, excellently prepared and usually with several duplicates, from all over the country. (Glen and Germishuizen 2010; Gunn and Codd 1981;

Mucina and Rutherford 2006). His interest in detailed studies of vegetation types lead to his 'Veld Types of Southern Africa', in which he mapped 70 veld types in South Africa, Lesotho and Swaziland (Acocks 1953; Brown and Bredenkamp 2017). In agreement with many other of resources, Professor Huntley rightly regards Acocks' *Veld Types* as a major milestone in southern African vegetation studies and states that "Acocks' interpretation of vegetation relationships and long-term dynamics has provided the platform for many subsequent studies." Over a period of more than five decades Acocks' work became known as the most widely used publication on South African ecology. (Cowling *et al.* 1997; Mucina and Rutherford 2006). Compiled by Frank White, The United Nations Educational, Scientific and Cultural Organization (UNESCO) published a map of the vegetation of Africa in 1983. Mucina and Rutherford (2006) note that though White relied heavily on the work of Acocks for the southern African section of his map, the result was less detailed as that of Acocks (Mucina and Rutherford 2006; White 1983).

Despite these maps being produced there were no plot-based vegetation sampling conducted in South Africa until 1960. The Braun-Blanquet approach of vegetation sampling and classification was only initiated in South Africa in 1971. Van Zinderen Bakker (1971) was the first researcher to apply this approach in the country (Brown and Bredenkamp 2017). Since then there have been numerous phytosociological studies undertaken by researchers throughout southern Africa. The main aim of the phytosociological approach in South Africa is to classify, describe, map the vegetation and to describe and interpret the environmental gradients affecting the plants species distribution.

The South African Association of Botanists (SAAB) in 1992 decided that a new vegetation map in a use-friendly text intended for tutors and planners was needed (Low and Rebelo 1996). The map, which was planned to be available in electronic format for rapid distribution and study, aimed at incorporating new information on structure and floristics as well as providing an update of the conservation status of southern African vegetation types (Low and Rebelo 1996; Mucina and Rutherford 2006). Relative to the map of Acocks, the SAAB map consisted of less detailed as well as more detailed parts and where the

scale of the Acocks' map was 1: 1 500 000, the SAAB map was printed at three different smaller scales namely 1:1 850 000, 1:2 000 000 and 1:3 880 000 (Mucina and Rutherford 2006).

The National Vegetation Database (NVD) was established by Prof G.J. Bredenkamp from the University of Pretoria in 1996. The main aim of the NVD was to collate all plot based (phytosociological) data from the grassland and savanna biomes, but has since grown to include all plot-based vegetation data from southern Africa. The NVD was since 2009 managed by the South African National Botanical Institute (SANBI) and comprises more than 46 000 vegetation plots (Dengler *et al.* 2011)

Because vegetation is often used to stratify land into management units, vegetation mapping is frequently used in wildlife conservation in South Africa for the scientifically defensible management of conservation areas (Mucina and Rutherford 2006; Brown *et al.* 2013). The same authors note that even before the mentioned map of Low and Rebelo was published, it was clear that for management and planning on regional level, a much more detailed approach needed to be implemented. For this purpose, a large number of local vegetation maps of small areas have been constructed. However, such maps have been published in local journals such as *South African Journal of Botany*, *Bothalia*, *Koedoe* and *Bontebok*, or in series of reports, more maps remain unpublished in postgraduate theses, reports and management planning documents of provincial nature conservation organisations (Mucina and Rutherford 2006). These studies are mostly following the plot-based Braun-Blanquet approach, which has proved a very successful and efficient method in South Africa (Brown and Bredenkamp 2017). The data obtained from these studies have been used in various biodiversity projects, in making scientifically defensible management decisions and has greatly contributed towards the national biodiversity initiatives of the country. These mentioned studies and maps were mostly used in the most recent work regarding mapping of the vegetation of South Africa, Lesotho and Swaziland (Mucina and Rutherford 2006). *VEGMAP* was initiated by Professor B.J. Huntley, former Chief Executive Officer of the then National Botanical Institute (NBI) during a national

workshop of vegetation scientists at Kirstenbosch in August 1995. The map and book that accompany it, mapping 435 vegetation units in South Africa, Lesotho and Swaziland, was a great cooperative project with over a hundred people from numerous organisations contributing to it (Mucina *et al.* 2005; Mucina and Rutherford 2006). The results of the VEGMAP project represent a current account of the knowledge of the variability of South African vegetation. The map is described by the authors thereof as a process where users are invited to make the authors aware of their work so that new accumulated data could shape new editions of the map (Mucina and Rutherford 2006).

2.3 CONCLUSION

As mentioned in Chapter 1.1, spatial and temporal changes in the environment are first of all observed in the vegetation. Brown *et al.* (2013) underline the important role that mapping and description of vegetation play as a tool to classify and interpret different ecosystems. Synecology (the classification, description and mapping of vegetation, succession and dynamics) (Barbour *et al.* 1987), stems from observations of the great variety of form as well as structure of plants that repeat themselves in similar environmental conditions and is an important field of vegetation science (plant ecology) (Brown *et al.* 2013).

Because vegetation is a highly visible and measurable biological manifestation of all the other environmental factors shaping and driving a specific ecosystem (Barbour *et al.* 1987, Kent 2012), Brown *et al.* (2013) point out that “by identifying different plant communities, we are essentially identifying different ecosystems at a particular hierarchical level.”

CHAPTER 3

STUDY AREA AND METHODS

"We shall not cease from exploration

And the end of all our exploring

Will be to arrive where we started

And know the place for the first time"

From: *Little Gidding* by T. S. Eliot, 1942



A view over the mountains of the study area from Kweekraalberg in the west.

TABLE OF CONTENTS

3.1 STUDY AREA.....	50
3.1.1 Location.....	50
3.2 CLIMATE	51
3.3 GEOLOGY	55
3.3.1 Fossils	57
3.4 TOPOGRAPHY	60
3.5 LAND TYPES AND SOILS	61
3.6 VEGETATION.....	68
3.6.1 Heuweltjies.....	69
3.6.2 Animals in the study area	71
3.6.3 Mosses, liverworts and lichens.....	90
3.7 METHODS.....	94
3.7.1 Survey methods	96
3.7.1.1 Floristic data	97
3.7.1.2 Habitat data	98
3.7.1.3 Plant identification and taxon names	99
3.7.1.4 Controlled burning	99
3.7.1.5 Sample preparation for scanning electron microscope (SEM)	100
3.7.2 Data analysis.....	101
3.7.2.1 Vegetation classification	101
3.7.2 Ordination.....	103
3.7.3 Plant community descriptions and names	103
3.7.4 Plant community diversity.....	104

LIST OF TABLES

Table 3.1: Stratigraphy and lithology of the Cape Supergroup in the study area (from Le Roux <i>et al.</i> in prep.).	55
Table 3.2: Land type Bb41a, eastern perimeter of the Greater Brandvlei Dam (Land Type Survey Staff 2002 a and b).	62
Table 3.3: Land type Fa198a, northern perimeter of the Greater Brandvlei Dam (Land Type Survey Staff 2002 a and b).	63
Table 3.4: Land type Fb122a, Hammansberg (Land Type Survey Staff 2002 a and b).	64
Table 3.5: Land Type Fb123 a, hills bordering the Greater Brandvlei Dam to the east, and Land Type Fb123 b for the hills southeast of the dam (Land Type Survey Staff 2002 a and b).	65
Table 3.6: Land Type Ic116a, Droëriviersberg, Ouhangsberg, Gannaberg, Gembokkop and Rooiberg (Land Type Survey Staff 2002 a and b).	66
Table 3.7: Modified Braun-Blanquet cover abundance scale (Mueller-Dombois and Ellenberg, 1974).	97
Table 3.8: pH values are interpreted according to Hossner (2008).	99
Table 3.9: Relevé numbers of post fire samples matching the numbers of pre-fire sample plots.	100

LIST OF FIGURES

Figure 3.1: The general location of the study area south of Worcester in the Western Cape (adapted from 1:250 000 Topographical sheet 3319 Worcester).	50
Figure 3.2: The study area around the Greater Brandvlei Dam extending South-eastwards and Eastwards towards Rooiberg near Robertson, indicated on the Google Earth satellite image (DigitalGlobe 2017).	51
Figure 3.3: Precipitation in the study area includes rain (a) and snow on the highest mountain peaks (b) mainly in the winter months and fog mostly in spring (c). Prevailing southeasterly- and northwesterly winds can often be rather strong (d).	52

Figure 3.4: The location of the weather stations, of which long term climate data were available (AgroMet-ISCW) on the Google Earth satellite image (DigitalGlobe 2017).	53
Figure 3.5: A climate diagram for Meulplaas to the northwest of the study area with data for 14 years. Frost may occur from early June to mid-August (Agromet-ISCW).	54
Figure 3.6: A climate diagram for Aan-de-Doorns Wine Cellar, east of the Greater Brandvlei Dam, with data for 43 years. Frost may occur from end of June to early August (Agromet-ISCW).	54
Figure 3.7: A climate diagram for Meerlust within the study area with data for 14 years.	54
Figure 3.8: A climate diagram for Robertson Rabiesdal to the southeast of the study area with data for 7.3 years. Frost may occur from end of June to July (Agromet-ISCW).	54
Figure 3.9: A climate diagram for Le Chasseur, to the southeast of the study area, data for 16 years. Frost may occur from end of May to mid-September (Agromet-ISCW).	54
Figure 3.10: A climate diagram for Vinkrivier, to the east of the study area, data for 16 years. Frost may occur from mid-June to the end of August (Agromet-ISCW).	54
Figure 3.11: The geology of the study area (Adapted from 1:250 000 GEOLOGICAL SERIES 3319 WORCESTER, Council For Geosciences, 1997) Legend: C-Pd Dwyka tillite (Dwyka Group), Cw Waaipoort Formation (Witteberg Group), Cf Floriskraal Formation (Witteberg Group), Ck Kweekvlei Formation (Witteberg Group), Dwi Witpoort Formation (Witteberg Group), Ds Swartruggens Formation (Witteberg Group), DBI Blinkberg Formation (Witteberg Group), Dwa Wagen Drift Formation (Witteberg Group), Dk Klipbokkop Formation (Bokkeveld Group).	56
Figure 3.12: The study area holds remarkable <i>Spirophyton</i> specimens that occur in sandstone- (a & b) and in mudrock dominated (c & d) formations of the Witteberg Group.	57

Figure 3.13: A fine example of the Witteberg-Dwyka contact zone in the study area (a) with trace fossils (b) and ripple marks (c) in the fine mudrock of the Waaipoort Formation.....	58
Figure 3.14: In the study area, Lycopod stem fossils (a, b & c) are occasionally found in sandstone layers of the Witpoort- and Floriskraal Formations of the Witteberg Group.....	59
Figure 3.15: Various drop-stones in glacial deposits Dwyka tillite (a, b & c)	60
Figure 3.16: The view of Gannaberg from the top of Ouhangsberg illustrates the typical topography of the study area with its weathering-resistant sandstone ridges and shale-dominated slopes and shoulders with intermontane valleys and drainage lines.....	61
Figure 3.17: Typical soil profiles of Mispah (a) and Glenrosa (b) as well as Fernwood soil forms (c) in the study area.....	67
Figure 3.18: The vegetation of the study area according to Mucina <i>et al.</i> (2005) and Rebelo <i>et al.</i> (2006) From: VEGMAP 2012 , scale 1:1 000 000 (SANBI, BGIS)	69
Figure 3.19: A high density of heuweltjies occurs in the Bokkeveld- Witteberg transitional area on the southern slopes of Hammansberg (in the background) and Ouhangsberg (foreground) in the southwest of the study area.	70
Figure 3.20: A Cape rock elephant shrew occupying a rock fissure on Hammansberg.	71
Figure 3.21: A pair of Klipspringer on a rocky ridge in the study area.....	73
Figure 3.22: A Fiery-necked Nightjar chick in the study area.....	74
Figure 3.23: A Cape Grassbird in renosterbos scrub near the Greater Brandvlei Dam.	76
Figure 3.24: A Karoo Scrub-robin near the Greater Brandvlei Dam.....	76
Figure 3.25: Orange-breasted Sunbirds are often seen on Ouhangsberg during the flowering time of <i>Protea</i> - and <i>Leucospermum</i> species.	77
Figure 3.26: A Spotted Harlequin Snake in the south of the study area.	78
Figure 3.27: This Spotted Skaapsteker was on several visits, observed in exactly the same spot on the range of hills bordering the Greater Brandvlei Dam to the north.	78

Figure 3.28: This Karoo Girdled Lizard was observed between Dwyka rocks in the study area.	79
Figure 3.29: A female Southern Rock Agama well camouflaged within its surroundings near the Greater Brandvlei Dam.	80
Figure 3.30: This mottled little Ocellated Thick-toed Gecko was unexpectedly found near the Greater Brandvlei Dam. It typically lives under rocks and emits a loud sound when threatened.	80
Figure 3.31: The burrow with turret of plant material, probably of a baboon spider (Theraphosidae), in Trappieskraalkloof.	81
Figure 3.32: <i>Pignus</i> cf. <i>simoni</i> (Salticidae) female near the Greater Brandvlei Dam.	81
Figure 3.33: A female orb-web spider <i>Argiope australis</i> (Araneidae).	82
Figure 3.34: Young spiders, probably of the family Araneidae or Theridiidae.	82
Figure 3.35: Young communal-nest spiders, <i>Stegodyphus dumicola</i> (Eresidae).	82
Figure 3.36: A roman spider (in all probability a <i>Solpugema</i> sp.) excavating its burrow in the study area.	83
Figure 3.37: A thin-tailed rock-scorpion (<i>Opistacanthus</i>) on Hammansberg.	83
Figure 3.38: A burrowing thick-tailed (<i>Parabuthus</i>) scorpion on the farm Droogeriviersberg.	83
Figure 3.39: Termite mounds are common in the study area.	84
Figure 3.40: Among the mantids occurring in the study area, these (a & b) are representatives of the Empusidae (cone-headed mantids).	84
Figure 3.41: Different species of Toad Grasshoppers occur in the study area.	85
Figure 3.42: The Silver-spotted Bladder Grasshopper (<i>Physemacris variolosus</i>) (Pneumoridae) (a), known to feed on renosterbos, here observed in major community 1. Rain locusts, possibly <i>Lamarckiana</i> sp. (Pamphagidae) (b) and grasshoppers of the Pyrgomorphidae family (c) also occur in the study area.	85
Figure 3.43: Thunberg's Stick-insect (<i>Macynia labiata</i>) (Bacillidae).	85
Figure 3.44: Larval stages of the Order Lepidoptera (moths and butterflies) occurring in the study area (a-e). Picture a illustrates the larval bag of a bagworm (a moth in the Psychidae) constructed with sticks in a <i>Drosanthemum hallii</i> flower. A Cherry Spot moth caterpillar (<i>Diaphone eumela</i>) (Noctuidae) is illustrated in picture d.	86

Figure 3.45: One of the 'geranium bronze' butterflies in the genus <i>Cacyreus</i> , sub-family Polyommatainae (Lycaenidae).....	87
Figure 3.46: One of the 'browns' in the sub-family Satyrinae (Nymphalidae) of butterflies in the study area.....	87
Figure 3.47: The small Fynbos blue (<i>Tarucus thespis</i>) on <i>Elytropappus gnaphaloides</i> in the study area.....	87
Figure 3.48: The Painted lady (<i>Cynthia cardui</i>) on Bergmelkbos (<i>Gomphocarpus cancellatus</i>) in the study area.....	87
Figure 3.49: Balls of spittle found on renosterbos in summer months (a), housing the nymphs of a spittle bug (b) species in the study area.....	87
Figure 3.50: Representatives of the Coleoptera (beetles) include dung beetles (Scarabaeidae) (a), monkey beetles (Scarabaeidae) such as this oval hairy monkey beetle (probably <i>Peritrichia cinerea</i>) on an <i>Ixia</i> species (b), shiny green beetles (Chrysomelidae) feeding on <i>Elytropappus gnaphaloides</i> shrub near the Greater Brandvlei Dam (c & d). The Tenebrionidae (Darkling beetles) are represented with species such as the Striped toktokkie (<i>Psammodes striatus</i>) (e).....	88
Figure 3.51: Brush jewel beetles (Buprestidae) (a & b) are frequently observed on flowers in spring.....	89
Figure 3.52: A horse-fly (Order Diptera) species frequently visiting the flowers of <i>Pelargonium fergusoniae</i> in the study area.....	89
Figure 3.53: Mosses and liverworts occur in moist habitats in the study area.....	90
Figure 3.54: Lichens also occur on the ground in the study area. The light-grey coloured ground-lichens are often associated with localities of <i>Moraea vuvuzela</i> plants (b).....	91
Figure 3.55: Different kinds of, sometimes colourful, lichens grow in beautiful patterns on rocks in the study area. Pictures k, l and m were taken by Mr Eduard Haumann.....	93
Figure 3.56: Examples of lichens that occur on wood in the study area.....	94

3.1 STUDY AREA

3.1.1 Location

The study area is located in the southern Western Cape of South Africa (Figure 3.1; South Africa 1:250 000 Topographical Sheet 3319 Worcester) and includes areas on the 3319 CB, 3319 DA, 3319 CD and 3319 DC maps.

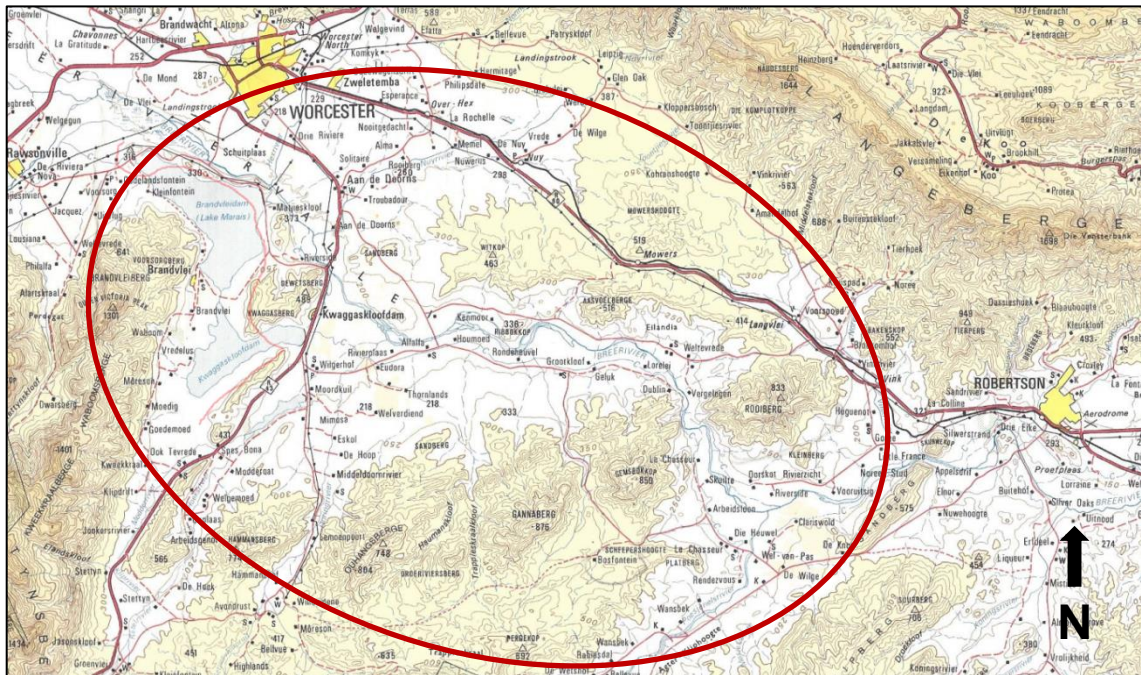


Figure 3.1: The general location of the study area south of Worcester in the Western Cape (adapted from 1:250 000 Topographical sheet 3319 Worcester).

The study follows the Witteberg Geological Group from the narrow range of hills bordering the Greater Brandvlei Dam on the northern side (between the dam and the Breede River), encompassing the hills east of the dam and south-eastwards around the dam towards Moddergat. From there the study area turns, almost at a right angle, eastwards at De Hoek and includes parts of Hammansberg, Ouhangsberg, Droëriviersberg, Haumanskloof (Between Ouhangsberg and Droëriviersberg), Trappieskraalkloof (Between Droëriviersberg and Gannaberg), Gannaberg, Gembokkop towards Rooiberg east of Robertson (Figure 3.2).



Figure 3.2: The study area around the Greater Brandvlei Dam extending South-eastwards and Eastwards towards Rooiberg near Robertson, indicated on the Google Earth satellite image (DigitalGlobe 2017).

3.2 CLIMATE

The climate of the area is predominantly Mediterranean, receiving rainfall (usually associated with frontal systems) and snow on the highest mountain peaks (Figure 3.3) mainly in the winter months (May to August). Fog often occurs during autumn and spring (Figure 3.3). The prevailing south-easterly- and north-westerly winds are often fairly strong (Figure 3.3). The dry season generally stretches from the middle of November to the middle of March (driest in February), where May, June, July and August usually are the wettest months. A steep moisture gradient is evident from west to east where the western part of the study area generally receives a higher amount of winter-rainfall (Le Roux *et al.* in prep.).



Figure 3.3: Precipitation in the study area includes rain (a) and snow on the highest mountain peaks (b) mainly in the winter months and fog mostly in spring (c). Prevailing southeasterly- and northwesterly winds can often be rather strong (d).

Apart from Meerlust, which is a private weather station (Mr J. le Roux¹ pers. com.), long term weather data from weather stations within, and on the perimeter of the study area was obtained from the Agrometeorological programme at the Agricultural Research Council's Institute for Soil, Climate and Water – Agromet-ISCW) (Figure 3.4).

¹ Meerlust Farm, Doornrivier, Worcester.



Figure 3.4: The location of the weather stations, of which long term climate data were available (AgroMet-ISCW) on the Google Earth satellite image (DigitalGlobe 2017).

The north-western part of the study area has a shorter dry period. The area usually receives more rain, predominantly in the autumn, winter and spring months (April to September), but summer thundershowers often occur (Figure 3.5). The dry season lasts longer in the northern part of the study area where the wet season usually lasts from May to mid-August (Figure 3.6). The core part of the study area typically receives rain from May to mid-August, but the prevalence of summer showers is higher (Figure 3.7). The southern part of the study area gets somewhat more rain during winter with the increased incidence of summer rains (Figures 3.8, 3.9 and 3.10).

Although the locality of the Vinkrivier at the southern foot of the Langeberge is not part of the study area, data from this weather station provide insight on more moist conditions to the east of Rooiberg (Figure 3.10).

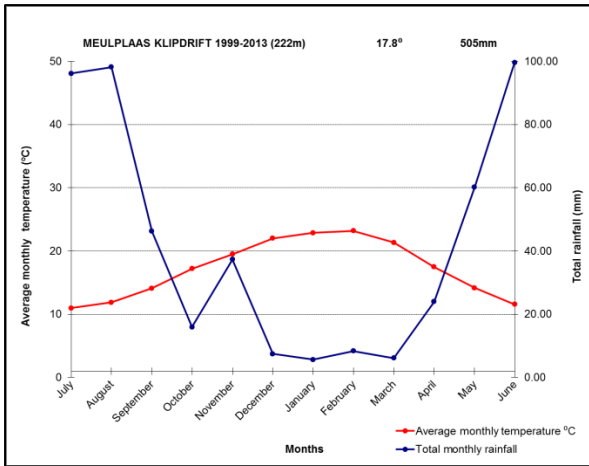


Figure 3.5: A climate diagram for Meulplaas to the northwest of the study area with data for 14 years. Frost may occur from early June to mid-August (Agromet-ISCW).

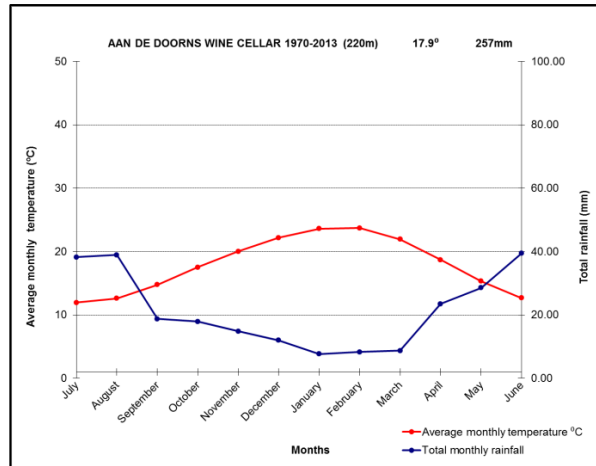


Figure 3.6: A climate diagram for Aan-de-Doorns Wine Cellar, east of the Greater Brandvlei Dam, with data for 43 years. Frost may occur from end of June to early August (Agromet-ISCW).

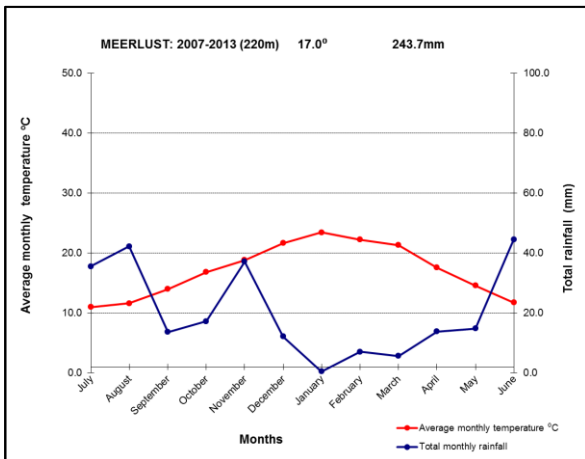


Figure 3.7: A climate diagram for Meerlust within the study area with data for 14 years.

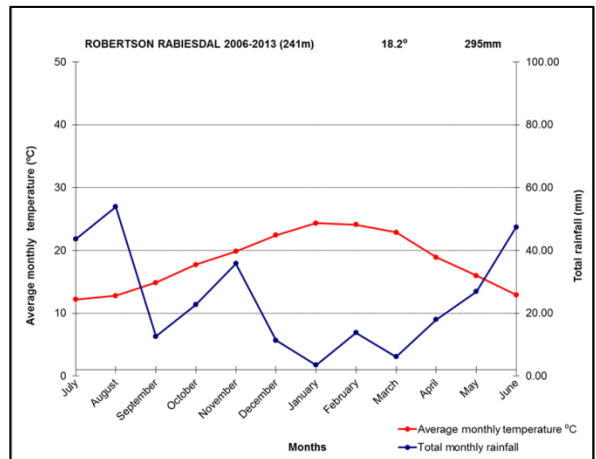


Figure 3.8: A climate diagram for Robertson Rabiesdal to the southeast of the study area with data for 7.3 years. Frost may occur from end of June to July (Agromet-ISCW).

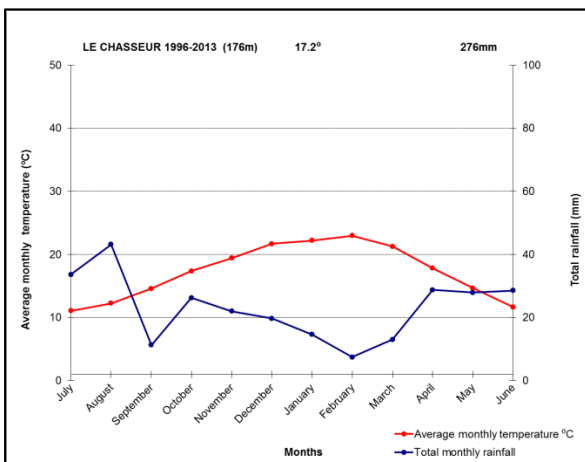


Figure 3.9: A climate diagram for Le Chasseur, to the southeast of the study area, data for 16 years. Frost may occur from end of May to mid-September (Agromet-ISCW).

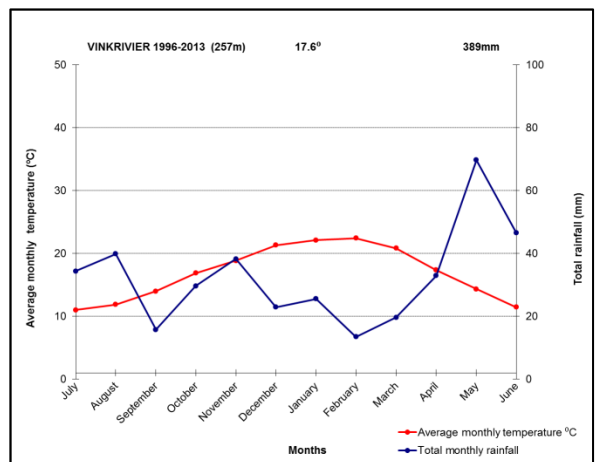


Figure 3.10: A climate diagram for Vinkrivier, to the east of the study area, data for 16 years. Frost may occur from mid-June to the end of August (Agromet-ISCW).

3.3 GEOLOGY

The study follows the Witteberg Geological Group between the towns of Worcester and Robertson (coloured green and turquoise-blue on the map) (Figure 3.11).

Fossil evidence dates the base of the Witteberg Group to Middle- to Late Devonian to Early Carboniferous age (Table 3.1; Thamm and Johnson 2006).

Table 3.1: Stratigraphy and lithology of the Cape Supergroup in the study area (from Le Roux *et al.* in prep.).

Age	Supergroup	Group	Subgroup	Formation	Dominant Lithology (in type area)
Permian	Karoo	Ecca			Mudrock
Carboniferous		Dwyka			Elandsfontein	Diamictite
	Cape	Witteberg	Lake Mentz	Waaipoort	Mudrock
				Floriskraal	Mudrock/Sandstone
				Kweekvlei	Mudrock
Witpoort			Sandstone		
Weltevrede		Swartruggens	Mudrock/Sandstone		
		Blinkberg	Sandstone		
Wagen Drift		Mudrock/Sandstone			
Devonian		Bokkeveld	Bidouw	Karooport	Mudrock
				Osberg	Sandstone
				Klipbokkop	Mudrock
	Wuppertal			Sandstone	
	Waboomborg			Mudrock	
	Ceres	Boplaas	Sandstone		
		Tra-Tra	Mudrock		
		Hex River	Sandstone		
		Voorstehoek	Mudrock		
		Gamka	Sandstone		
Silurian	Table Mountain	Nardouw	Gydo	Mudrock	
			Rietvlei	Sandstone	
			Skurweberg	Sandstone	
Ordovician	Table Mountain	Nardouw	Goudini	Sandstone	
			Cedarberg	Mudrock	
			Pakhuis	Diamictite	
				Peninsula	Sandstone

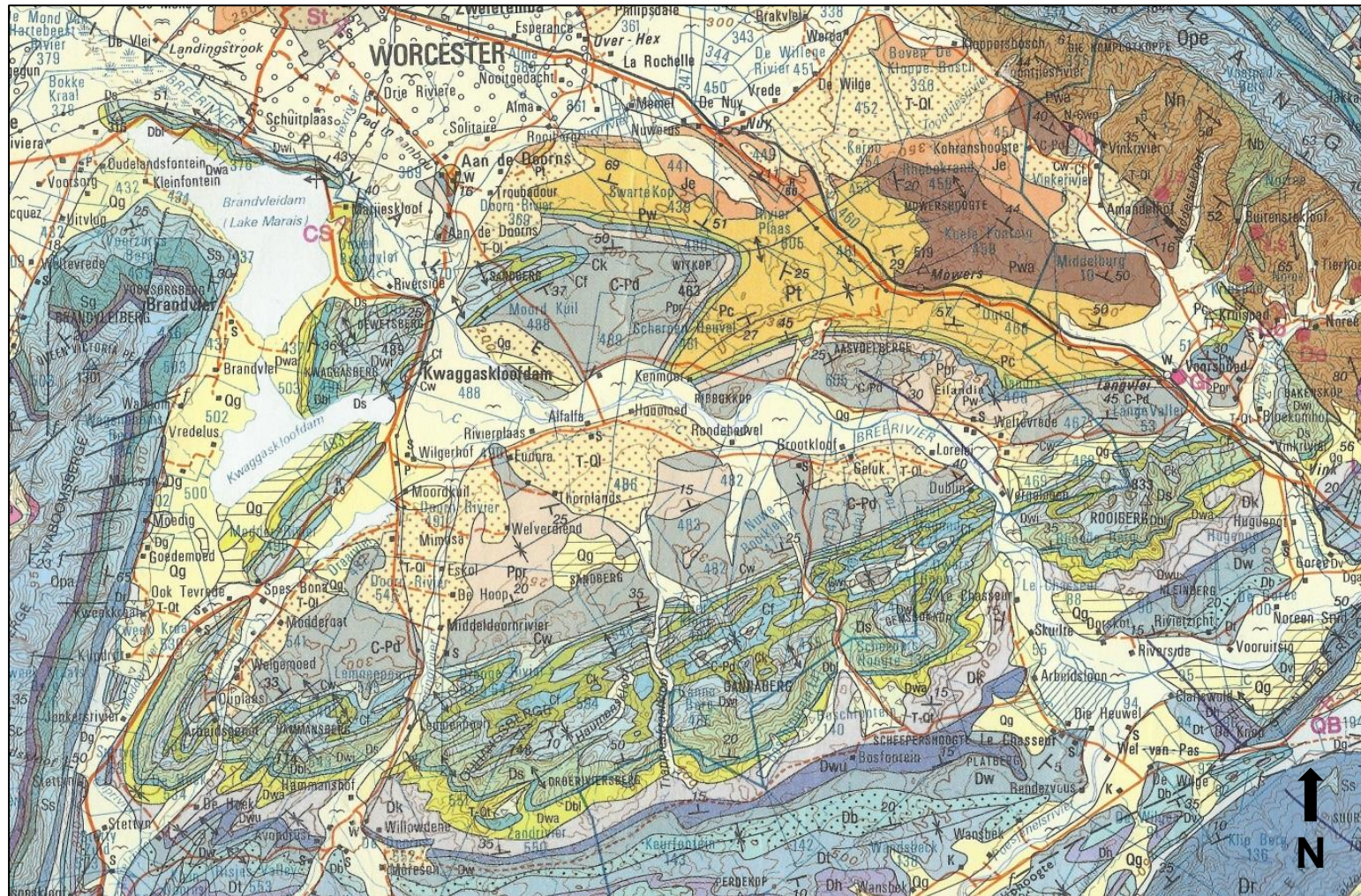


Figure 3.11: The geology of the study area (Adapted from 1:250 000 GEOLOGICAL SERIES 3319 WORCESTER, Council For Geosciences, 1997) Legend: C-Pd Dwyka tillite (Dwyka Group), Cw Waaipoort Formation (Witteberg Group), Cf Floriskraal Formation (Witteberg Group), Ck Kweekvlei Formation (Witteberg Group), Dwi Witpoort Formation (Witteberg Group), Ds Swartruggens Formation (Witteberg Group), DBI Blinkberg Formation (Witteberg Group), Dwa Wagen Drift Formation (Witteberg Group), Dk Klipbökkop Formation (Bokkeveld Group).

The Bokkeveld and Witteberg Groups were deposited in a sea (the Agulhas sea) of which the most northerly position of its coastline, which was moving respectively south- and northwards during periods of lower and higher sea-level stands, extends approximately in a line from south of the town of Calvina eastwards towards the city of East London (Le Roux et al. in prep). The quartzitic sandstone and generally micaceous mudrock sediments of the Witteberg Group (that are present in nearly equal proportions) were deposited in shallow near-shore marine environment that includes month-bar, deltaic, fluvial, lagoonal and tidal flat areas (Thamm and Johnson 2006; McCarthy and Rubidge 2005).

3.3.1 Fossils

Trace fossils present in the formations of the Witteberg Group of the study area include *Zoophycos* (*Spirophyton*) (Figure 13.12) and *Skolithos* (Figure 3.13 e). Fossils of plant fragments in the study area include psilophyte and lycopod stems (Figure 13.14) (Miller 1991; MacRae 1999; Thamm and Johnson 2006).

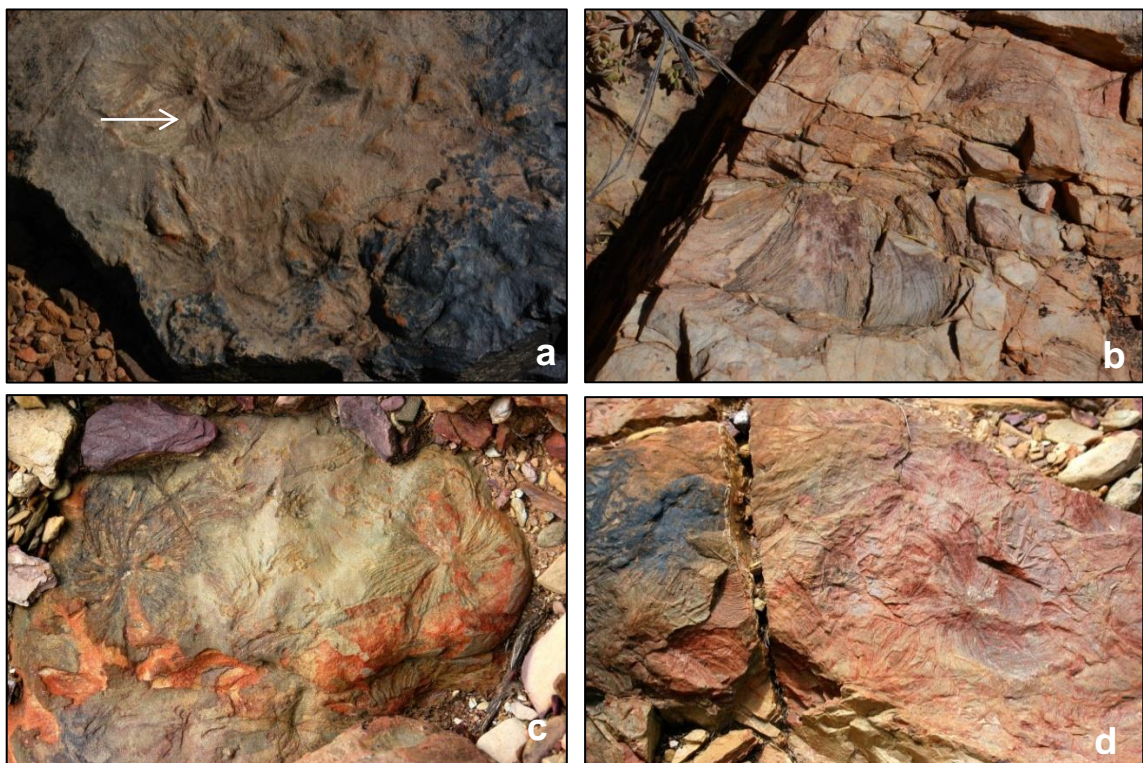


Figure 3.12: The study area holds remarkable *Spirophyton* specimens that occur in sandstone- (a & b) and in mudrock dominated (c & d) formations of the Witteberg Group.

The contact between the Bokkeveld- and Witteberg Groups are transitional and not easily recognised. Well exposed areas of the contact between the Witteberg- and Dwyka Groups occur in the study area (Figure 3.13).

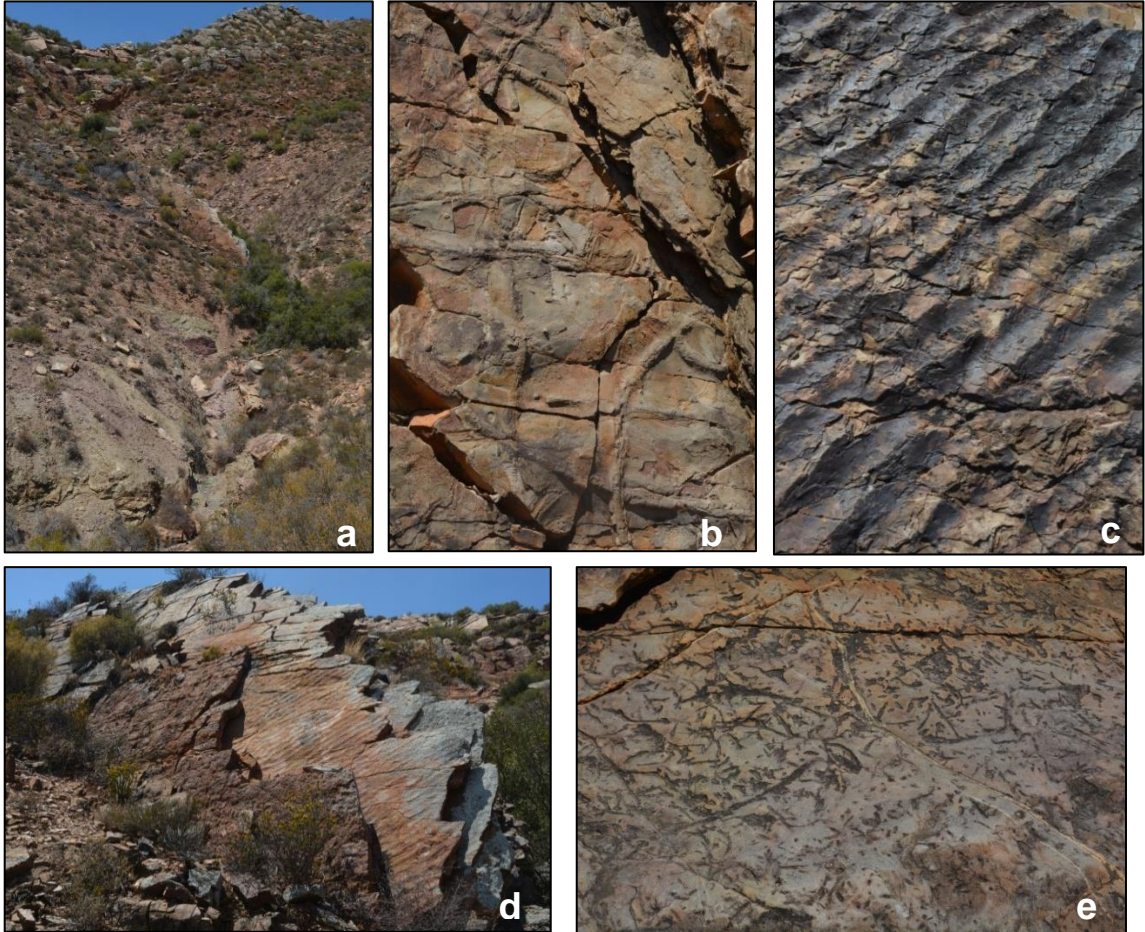


Figure 3.13: A fine example of the Witteberg-Dwyka contact zone in the study area (a) with trace fossils (b) and ripple marks (c) in the fine mudrock of the Waaipoort Formation (d & e).



Figure 3.14: In the study area, Lycopod stem fossils (a, b & c) are occasionally found in sandstone layers of the Witpoort- and Floriskraal Formations of the Witteberg Group.

The youngest sediments of the Witteberg Group mark the end of sedimentation of the Agulhas Sea (McCarthy and Rubidge 2005). Glacial deposits, Dwyka tillite with various drop-stones (Figure 3.15) of the Dwyka Group (Late Carboniferous to Early Permian) overlie the Cape Supergroup (Thamm and Johnson 2006).

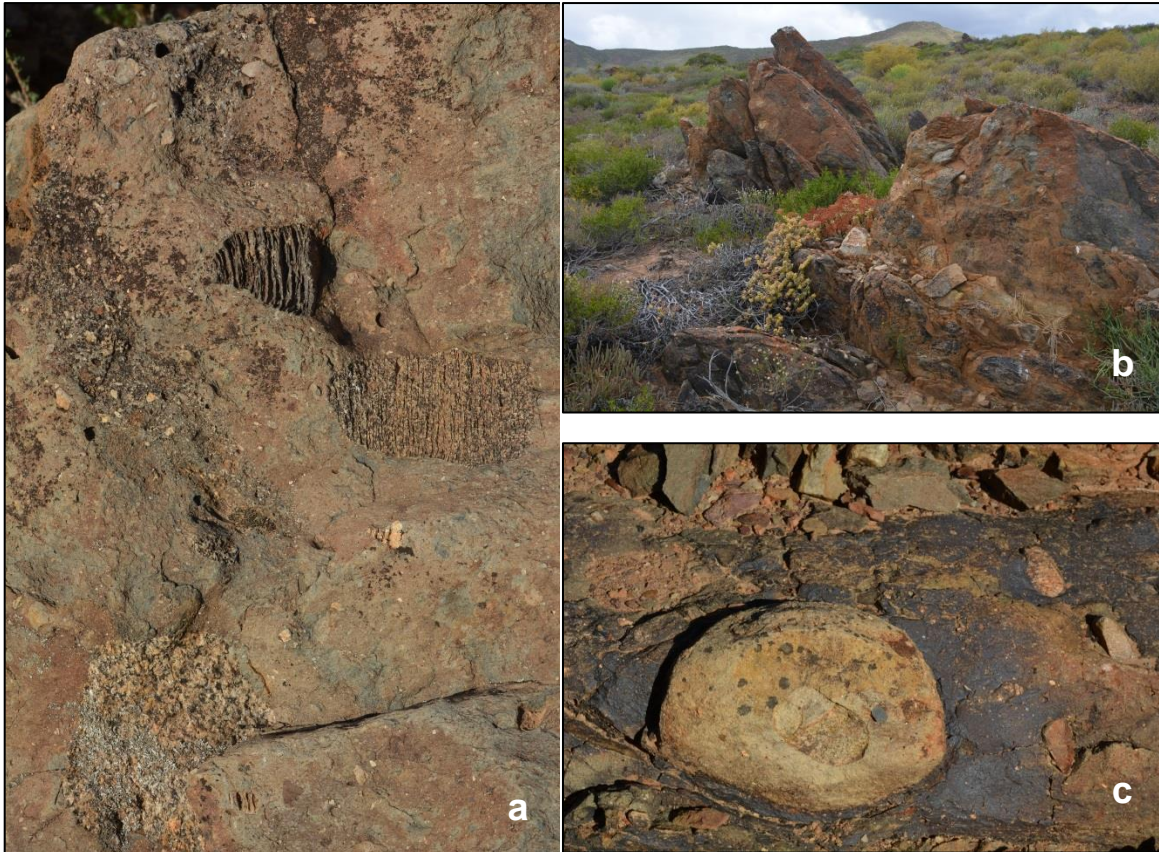


Figure 3.15: Various drop-stones in glacial deposits Dwyka tillite (a, b & c).

3.4 TOPOGRAPHY

The study area comprises of mountainous terrain with intermontane valleys and drainage lines such as the fast-flowing streams and ephemeral rivers draining Trappieskraalkloof and Haumanskloof in a northerly direction. The Doring Rivier (a tributary of the Breede River) runs between Hammansberg and Ouhangsberg. The study area is dominated by folded ridges, shoulders and slopes with a smaller degree of flat areas (Figure 3.16).



Figure 3.16: The view of Gannaberg from the top of Ouhangsberg illustrates the typical topography of the study area with its weathering-resistant sandstone ridges and shale-dominated slopes and shoulders with intermontane valleys and drainage lines.

3.5 LAND TYPES AND SOILS

A summary of each of the five different land types that occur in the study area is given in Table 3.2 to Table 3.6 (Land Type Survey Staff, 2002a; Land Type Survey Staff, 2002b).

Terrain Units: 1 = crest, 2 = scarp, 3 = midslope, 4 = footslope, 5 = valley bottom.

Range in percentage slope is measured by using a slope wedge.

Slope shape: X = concave, Y = convex, Z = straight.

The mechanical limitations due to stoniness and/or shallowness with regard to the soil being ploughable or not, is given in the following classes: MB0 = no mechanical limitations, MB1 = many stones, MB2 = large stones and boulders, MB3 = very shallow soils on rock, MB4 – lack of soil

Table 3.2: Land type Bb41a, eastern perimeter of the Greater Brandvlei Dam (Land Type Survey Staff 2002 a and b).

LAND TYPE Bb41a 3319 WORCESTER MAP Surface area: 2 430 ha					
Geology: Alluvial sand on shale of the Bokkeveld Group.					
Terrain unit		3	4	5	
% of land type		5	60	35	
Slope (%)		8-15	3-5	0-3	
Slope length (m)		300-500	300-700	50-200	
Slope shape		Y	X-Z	Z	
Soil series or land classes	Stoniness	Depth (mm)	% of Land Type		
% Rock	MB 4		12		
Dundee Du10	MB 0	>1200	20		
Mispah Ms10	MB 3	150-400	20		
Terrain type: A2 Percentage level land: more than 80% of the area has slopes less than 8% Local relief: 30 – 90 m					
Terrain unit sketch					
<p>The sketch shows a cross-section of the terrain. A dashed horizontal line on the left is labeled '215m'. The terrain profile is shown as a solid line. Vertical dashed lines divide the profile into sections labeled '3', '4', '5', and '4'. The label 'Bb41' is centered above the profile.</p>					

Table 3.3: Land type Fa198a, northern perimeter of the Greater Brandvlei Dam (Land Type Survey Staff 2002 a and b).

LAND TYPE Fa198a						
3319 WORCESTER MAP						
Surface area of the 3319 Worcester map: 702 ha						
Geology: Quartzitic sandstone and shale of the Witteberg Group.						
Terrain unit		1	3	4	5	
% of land type		10	73	15	2	
Slope (%)		0-15	15-65	5-15	0-5	
Slope length (m)		10-75	100-500	50-100	10-50	
Slope shape		Y	Z-Y	X	X	
Soil series or land classes	Stoniness	Depth (mm)	% of Land Type			
Soil-rock complex						
Rock %	MB 4		50	30		
Mispah Ms10	MB 3	10-100	20	20		
Mispah Ms10	MB 3	10-100	20	25	50	30
Williamson Gs16, Saintfaiths Gs19	MB 3	50-400	10	25	50	70
Terrain type: D3						
Percentage level land: Less than 20% of the area has slopes less than 8%						
Local relief: 90–150 m						
Terrain	unit					sketch

Table 3.4: Land type Fb122a, Hammansberg (Land Type Survey Staff 2002 a and b).

LAND TYPE Fb122a							
3319 WORCESTER MAP							
Surface area: 2291 ha							
Geology: Quartzitic sandstone, siltstone, shale and mudrock of the Witteberg Group. The northern extensions consist of tillite of the Dwyka Group.							
Terrain unit	1	2	3	4	5		
% of land type	5	2	78	10	5		
Slope (%)	0-10	>100	10-60	5-10	0-5		
Slope length (m)	50-300	2-5	300-1000	10-600	5-20		
Slope shape	Y	Z	X-Y	X	Z		
Soil series or land classes	Stoniness	Depth (mm)	% of Land Type				
Rock %	MB4		80	100	50	30	70
Mispah Ms10	MB3	150-250	20		35	35	20
Platt Gs14, Trevanian Gs17	MB3	150-300			10	25	
Terrain type: D5							
Percentage level land: Less than 20% of the area has slopes less than 8%							
Local relief: 300 – 900 m							
Terrain unit sketch							

Table 3.5: Land Type Fb123 a, hills bordering the Greater Brandvlei Dam to the east, and Land Type Fb123 b for the hills southeast of the dam (Land Type Survey Staff 2002 a and b).

LAND TYPE Fb123 a and b							
3319 WORCESTER MAP							
Surface area: 3001 ha							
Geology: Quartzitic sandstone, siltstone, shale and mudrock of the Witteberg Group.							
Terrain unit	1	2	3	4	5		
% of land type	5	5	80	5	5		
Slope (%)	0-10	>100	10-60	5-10	0-5		
Slope length (m)	50-400	2-5	300-1800	10-50	5-20		
Slope shape	Y	Z	X-Y	X	Z		
Soil series or land classes	Stoniness	Depth (mm)	% of Land Type				
Soil-rock complex							
Rock %	MB 4		80		40	25	70
Mispah Ms10	MB 3	10-50	20		25	25	20
Rock %	MB 4			100	15	10	
Platt Gs14, Trevanian Gs17	MB 3	50-200			10	20	10
Mispah Ms10	MB 2	100-200			5	5	
Terrain type: D5 Percentage level land: Less than 20% of the area has slopes less than 8% Local relief: 300 – 900 m							
Terrain unit sketch							

Table 3.6: Land Type Ic116a, Droëriviersberg, Ouhangsberg, Gannaberg, Gemsbokkop and Rooiberg (Land Type Survey Staff 2002 a and b).

LAND TYPE Ic116a						
3319 WORCESTER MAP						
Surface area: 15856 ha						
Geology: Sandstone, shale, mudrock and siltstone of the Bokkeveld and Witteberg Groups.						
Terrain unit	1	2	3	4	5	
% of land type	5	1	80	10	4	
Slope (%)	0-20	>100	20-70	5-20	0-5	
Slope length (m)	50-300	20-100	500-1200	50-600	5-20	
Slope shape	Y	Z	X	Y-Z	Z	
Soil series or land classes	Stoniness	Depth (mm)	% of Land Type			
Soil-rock complex						
Rock %	MB 4		90	100	85	60
Mispah Ms10	MB 3	10-50	10		10	25
Terrain type: D5						
Percentage level land: Less than 20% of the area has slopes less than 8%						
Local relief: 300 – 900 m						
Terrain unit sketch						

The three major soil profiles that occur in the study area are Mispah, Glenrosa and Fernwood (Figure 3.17).

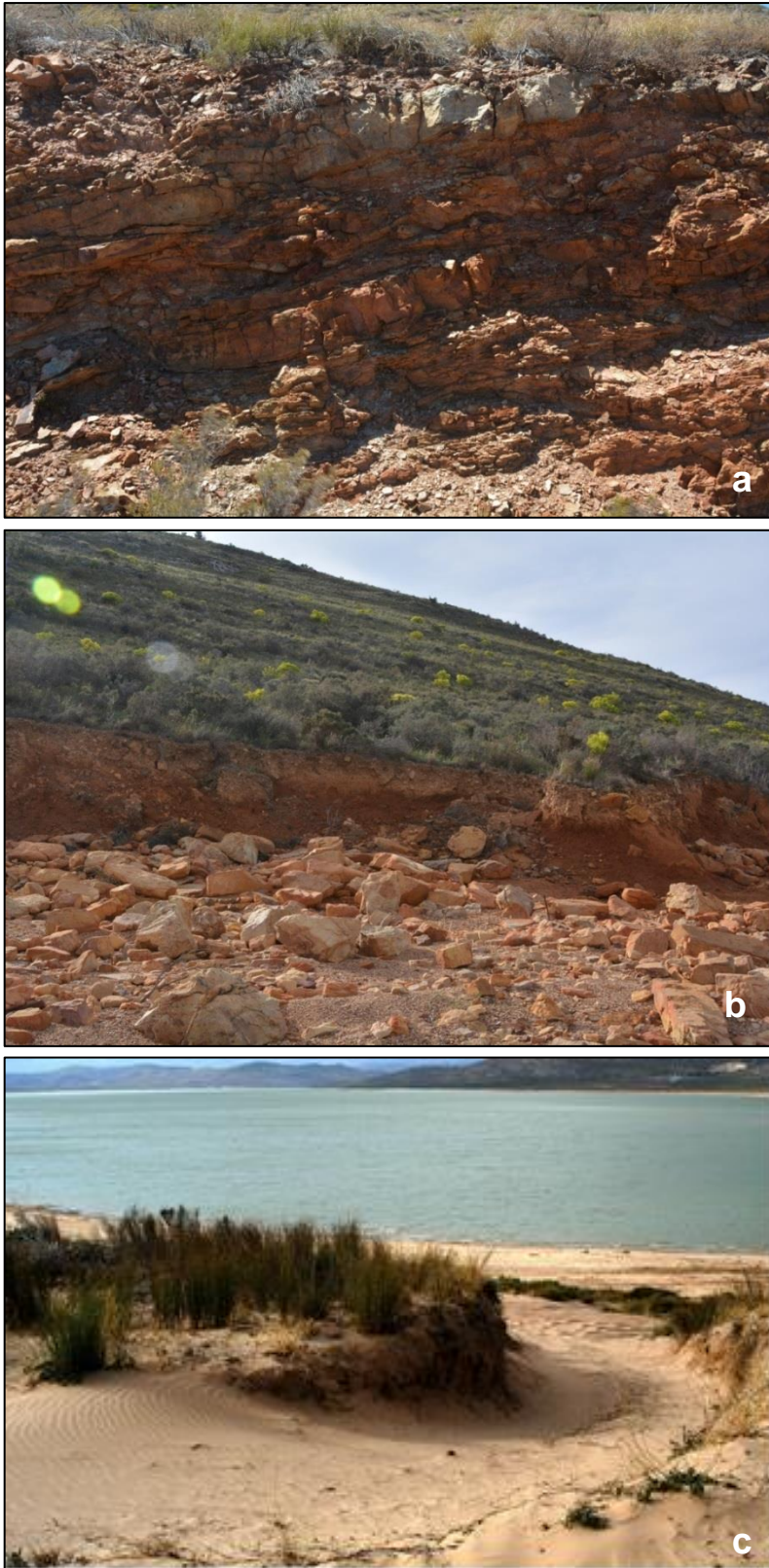


Figure 3.17: Typical soil profiles of Mispah (a) and Glenrosa (b) as well as Fernwood soil forms (c) in the study area.

The study area primarily comprises natural veld and private conservation areas, but the main land use in parts of the study area include agriculture crop production such as fruit, grapes for the wine industry, wheat, lucerne and to a lesser extent livestock- and game farming. Other human related infrastructure comprises towns and rural settlements, roads, reservoirs and irrigation canals.

3.6 VEGETATION

Mucina *et al.* (2005) and Rebelo *et al.* (2006) describe the following vegetation types to occur in the study area (the range of the respective vegetation types can be seen by following their respective codes in Figure 3.18):

Breede Shale Renosterveld – FRs 8

(A poorly studied vegetation type; conservation status: vulnerable)

Breede Quartzite Fynbos – FFq 4

(A poorly studied vegetation type; conservation status: least threatened),

Breede Sand Fynbos – FFd 8

(A poorly studied vegetation type; conservation status: vulnerable),

Breede Alluvium Renosterveld – FRa 1

(conservation status; endangered)

Breede Alluvium Fynbos – FFa 2

(A poorly studied vegetation type; conservation status; endangered),

Robertson Karoo – SKv 7

According to Mucina *et al.* (2005), Breede Shale Renosterveld (on predominantly clay soils) and Breede Quartzite Fynbos (on predominantly sandy soils) occur on the hills to the north and east of the dam. According to

Mucina *et al.* (2005) Breede Sand Fynbos is indicated as the vegetation type of alluvial areas around the dam. Breede Alluvium Renosterveld occurs in the low-lying areas to the east, and southeast of the dam. Breede Alluvium Fynbos is associated with the floodplains of the Breede River and its tributaries and Robertson Karoo is associated with the shale soils derived from the Karoo Group such as Dwyka tillite (Figure 3.18).

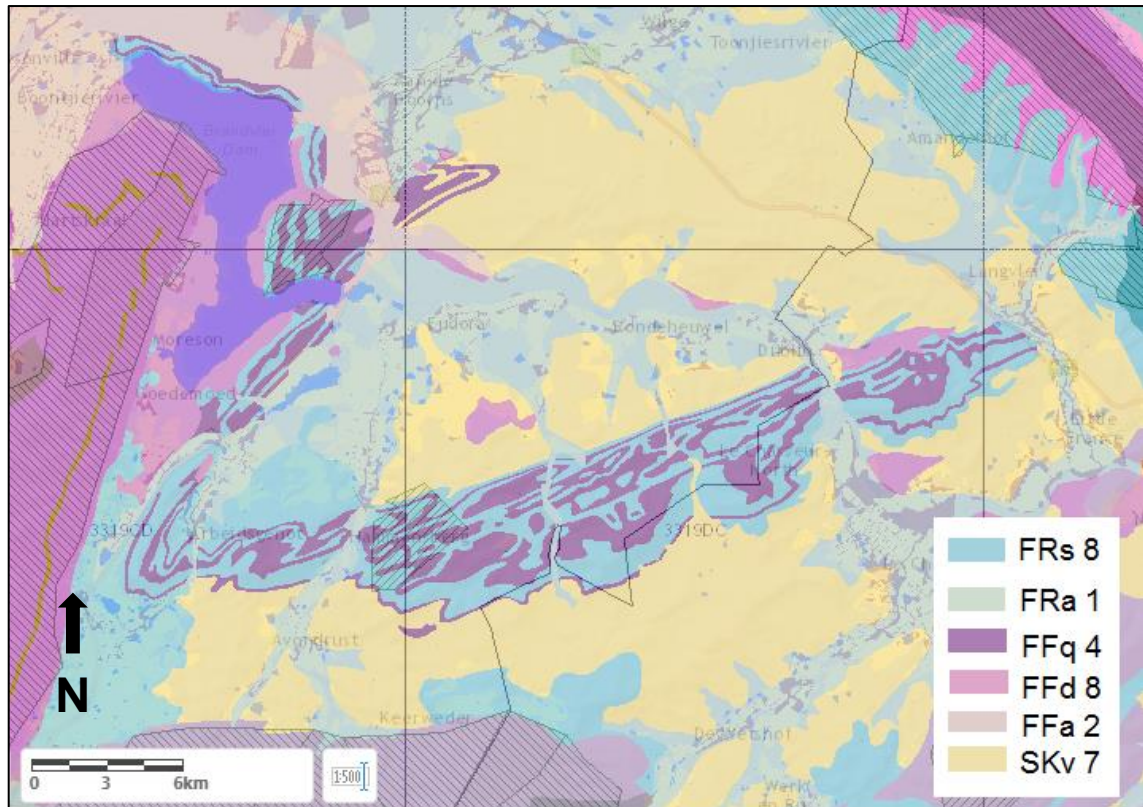


Figure 3.18: The vegetation of the study area according to Mucina *et al.* (2005) and Rebelo *et al.* (2006) From: VEGMAP 2012, scale 1:1 000 000 (SANBI, BGIS)

3.6.1 Heuweltjies

The origin and characteristics of heuweltjies (active termitaria of the harvester termite *Microhodotermes viator*) are described by Booij (2011) in a study which investigated and compared the topsoil properties, vegetation structure and the ecophysiology of plants growing on these mounds, to areas off these patches: “Heuweltjies are below ground termitaria found along the west coast and the south-western and -eastern Cape. They traverse different climates, soil and vegetation types within the Succulent Karoo and Fynbos biomes. From a bird’s eye view, *heuweltjies* appear as near-circular landscape features,

demonstrating clear difference in vegetation structure to their surroundings” (Booi 2011).

In a study of heuweltjies in the Clanwilliam district of the Cape Province, Moore and Picker (1991) found that presently occupied mounds can be older than 4000 years.

The stable existence of heuweltjies over a long time provided the development of distinctive vegetation and a habitat for animal species such as burrowing bees, ants and mole-rats to inhabit the mounds. Because of the presence and subsurface activity of these animals, the mounds play an essential role in the cycling of energy and nutrients (Knight *et al.* 1989; Midgley and Musil 1990; Moore and Picker 1991). Booi (2011) note that heuweltjies soils have more available nutrients, have a better water holding capacity and were found to be “hotspots” for nutrients and biogeochemical activity.

Although heuweltjies occur all over the study area, they especially occur in high densities on the finer grained soils predominantly derived from mudrock such as the youngest Wagen Drift layer of the Witteberg Geological Group, as well as the transitional area of the Bokkeveld- and Witteberg Groups (Figure 3.19).



Figure 3.19: A high density of heuweltjies occurs in the Bokkeveld- Witteberg transitional area on the southern slopes of Hammansberg (in the background) and Ouhangsberg (foreground) in the southwest of the study area.

3.6.2 Animals in the study area

A number of mammals occur in the study area. These include species such as: The Cape golden mole (*Chrysochloris asiatica*), Round-eared elephant-shrew (*Macroscelides proboscideus*), Cape rock elephant shrew (*Elephantulus edwardii*) (Figure 3.20), Aardvark (*Orycteropus afer*), Rock dassie (*Procavia capensis*), Cape hare (*Lepus capensis*), Scrub hare (*Lepus saxatilis*), Smith's red rock rabbit (*Pronolagus rupestris*), Cape dune mole-rat (*Bathyergus suillus*), African mole-rat (*Cryptomys hottentotus*), Cape mole-rat (*Georchus capensis*), Porcupine (*Hystrix africaeaustralis*), Spectacled dormouse (*Graphiurus ocellaris*), Cape spiny mouse (*Acomys subspinosus*), Four-striped grass mouse (*Rhabdomys pumilio*), Pygmy mouse (*Mus minutoides*), Verreaux's mouse (*Myomyscus verreauxi*), Namaqua rock mouse (*Aethomys namaquensis*), Brants's whistling rat (*Parotomys brantsii*), Bush vlei rat (*Otomys unisulcatus*), Cape short-tailed gerbil (*Desmodillus auricularis*), Hairy-footed gerbil (*Gerbillurus paeba*), Cape gerbil (*Tatera afra*), White-tailed mouse (*Mystromys albicaudatus*), Gerbil mouse (*Malacothrix typica*), Grey climbing mouse (*Dendromus melanotis*), Krebs's fat mouse (*Steatomys krebsii*), Chacma baboon (*Papio ursinus*), Forest shrew (*Myosorex varius*), Reddish-grey musk shrew (*Crocidura cyanea*) and the Greater red musk shrew (*Crocidura flavescens*) (Skinner and Chimimba 2005).



Figure 3.20: A Cape rock elephant shrew occupying a rock fissure on Hammansberg.

Bats that may occur in the study area are the Little free-tailed bat (*Chaerephon pumilua*), Egyptian free-tailed bat (*Tadarida aegyptiaca*), Schreiber's long-fingered bat (*Miniopterus schreibersii*), Cape serotine bat (*Neoromicia capensis*), Temminck's hairy bat (*Myotis tricolor*), Long-tailed Serotine Bat (*Eptesicus hottentotus*), Geoffroy's horseshoe bat (*Rhinolophus clivosus*) and the Cape horseshoe bat (*Rhinolophus capensis*) (Skinner and Chimimba 2005; Taylor 2000.). The Aardwolf (*Proteles cristatus*) and African wild cat (*Felis silvestris*) may still occur in the remote mountainous areas of the study area, while Caracal (*Caracal caracal*) are occasionally observed. Leopard (*Panthera pardus*), Small-spotted genet (*Genetta genetta*), South African large-spotted genet (*Genetta tigrina*) and mongoose species such as the Yellow mongoose (*Cynictis penicillata*), Cape Grey Mongoose (*Galerella pulverulenta*) and the Marsh mongoose (*Atilax paludinosus*) occur in the study area. The foxes and jackals are represented by the Bat-eared fox (*Otocyon megalotis*), Cape Fox (*Vulpes chama*) while Black-backed jackal (*Canis mesomelas*) can also occur. The African clawless otter (*Aonyx capensis*), Honey Badger (*Mellivora capensis*), African striped weasel (*Poecilogale albinucha*) and Striped polecat (*Ictonyx striatus*) occur in the study area.

Although Gemsbok (*Oryx gazella*), Eland (*Taurotragus oryx*), Kudu (*Tragelaphus strepsiceros*), Mountain zebra (*Equus zebra zebra*) as well as Burchell's zebra (*Equus quagga burchellii*), Black wildebeest (*Connochaetes gnou*), Red hartebeest (*Alcelaphus buselaphus caama*), Blesbok (*Damaliscus pygargus phillipsi*) and Springbok (*Antidorcas marsupialis*) are kept in fenced game camps by some of the farmers, small antelope such as the Common Duiker (*Sylvicapra grimmia*), Grey rhebuck (*Pelea capreolus*), Steenbok (*Raphicerus campestris*), Cape Grysbok (*Raphicerus melanotis*) and Klipspringer (*Oreotragus oreotragus*) (Figure 3.21) still occur naturally in the study area (Skinner and Chimimba 2005).

The activity of animals, birds and invertebrates is significant in the pollination of flowers as well as seed distribution. Rodents for example, are important pollinators of species such as *Protea humiflora* (Cowling *et al.* 1995; Rebelo 2001).



Figure 3.21: A pair of Klipspringer on a rocky ridge in the study area.

Ostriches (*Struthio camelus*) are kept in fenced game camps by some of the farmers, while the following birds occur naturally in the study area (Hockey *et al.* 2005): Grey-winged Francolin (*Scleroptila afra*), Cape Spurfowl (*Pternistis capensis*), Helmeted Guineafowl (*Numida meleagris*), White-faced duck (*Dendrocygna viduata*), Egyptian Goose (*Alopochen aegyptiaca*), Spur-winged Goose (*Plectropterus gambensis*), African Black Duck (*Anas sparsa*), Yellow-billed Duck (*Anas undulata*), Ground Woodpecker (*Geocolaptes olivaceus*), Acacia Pied Barbet (*Tricholaema leucomelas*), African Hoopoe (*Upupa epops*), Pied Kingfisher (*Ceryle rudis*), European Bee-eater (*Merops apiaster*),

Speckled Mousebird (*Colius striatus*), White-backed Mousebird (*Colius colius*), Red faced Mousebird (*Urocolius indicus*), Klaas's Cuckoo (*Chrysococcyx klaas*), Diederick Cuckoo (*Chrysococcyx caprius*), Alpine swift (*Tachymarptis melba*), African Black Swift (*Apus barbatus*), Little Swift (*Apus affinis*), White-rumped Swift (*Apus caffer*), Barn Owl (*Tyto alba*), Cape Eagle Owl (*Bubo capensis*), Spotted Eagle Owl (*Bubo africanus*), Fiery-necked Nightjar (*Caprimulgus pectoralis*) (Figure 3.22) and the Freckled Nightjar (*Caprimulgus tristigma*).



Figure 3.22: A Fiery-necked Nightjar chick in the study area.

The Rock Dove (*Columba livia*), Speckled Pigeon (*Columba guinea*), Laughing Dove (*Streptopelia senegalensis*), Cape turtle-dove (*Streptopelia capicola*), Red-eyed Dove (*Streptopelia semitorquata*), Namaqua Dove (*Oena capensis*), Southern Black Korhaan (*Afrotis afra*), Blue Crane (*Grus paradisea*), Red-knobbed Coot (*Fulica cristata*), Spotted Thick-knee (*Burhinus capensis*), Three-banded Plover (*Charadrius tricollaris*), Blacksmith Lapwing (*Vanellus armatus*), Crowned Lapwing (*Vanellus coronatus*), Black-shouldered Kite (*Elanus caeruleus*), African Fish Eagle (*Haliaeetus vocifer*), Black Harrier (*Circus maurus*), African Harrier-hawk (*Polyboroides typus*), Southern Pale Chanting

Goshawk (*Melierax canorus*), Steppe Buzzard (*Buteo buteo*), Jackal Buzzard (*Buteo rufofuscus*), Verreaux's Eagle (*Aquila verreauxii*), Secretary-bird (*Sagittarius serpentarius*), Rock Kestrel (*Falco rupicolus*), Lanner Falcon (*Falco biarmicus*), Little Grebe (*Tachybaptus ruficollis*), African Darter (*Anhinga rufa*), Reed Cormorant (*Phalacrocorax africanus*), White-breasted Cormorant (*Phalacrocorax lucidus*), Grey Heron (*Ardea cinerea*), Black-headed Heron (*Ardea melanocephala*), Purple Heron (*Ardea purpurea*), Cattle Egret (*Bubulcus ibis*), Hamerkop (*Scopus umbretta*), Hadeda Ibis (*Bostrychia hagedash*), African Sacred Ibis (*Threskiornis aethiopicus*), Black Stork (*Ciconia nigra*), African Spoonbill (*Platalea alba*), Bokmakierie (*Telophorus zeylonus*), Cape Batis (*Batis capensis*), Cape Crow (*Corvus capensis*), White-necked Raven (*Corvus albicollis*), Pied Crow (*Corvus albus*), Common Fiscal (*Lanius collaris*), Cape Penduline Tit (*Anthoscopus minutus*), Grey Tit (*Parus afer*), Brown-throated Martin (*Riparia paludicola*), Barn Swallow (*Hirundo rustica*), White-throated Swallow (*Hirundo albigularis*), Greater Striped Swallow (*Hirundo cucullata*), Rock Martin (*Hirundo fuligula*), Cape Bulbul (*Pycnonotus capensis*), Cape Grassbird (*Sphenoeacus afer*) (Figure 3.23), Long-billed Crombec (*Sylvietta rufescens*), Layard's Tit-warbler (*Parisoma layardi*), Cape White-eye (*Zosterops virens*), Grey-backed Cisticola (*Cisticola subruficapilla*), Karoo Prinia (*Prinia maculosa*), Bar-throated Apalis (*Apalis thoracica*), Clapper Lark (*Mirafra apiata*), Karoo Lark (*Calendulauda albescens*), Cape Grey-backed Sparrow Lark (*Eremopterix verticalis*), Red-capped Lark (*Calandrella cinerea*), Large-billed Lark (*Galerida magnirostris*), Cape Rock Thrush (*Monticola rupestris*), Fiscal Flycatcher (*Sigelus silens*), Cape Robin Chat (*Cossypha caffra*), Tractrac Chat (*Cercomela tractrac*), Karoo Scrub Robin (*Cercotrichas coryphoeus*) (Figure 3.24), African Stonechat (*Saxicola torquatus*), Capped Wheatear (*Oenanthe pileata*), Familiar Chat (*Cercomela familiaris*), Pale-winged Starling (*Onychognathus nabouroup*), Pied Starling (*Spreo bicolor*), Orange-breasted Sunbird (*Anthobaphes violacea*) (Figure 3.25), Cape Sugarbird (*Promerops cafer*), Malachite Sunbird (*Nectarinia famosa*), Southern Double-collared Sunbird (*Cinnyris chalybeus*), Cape Weaver (*Ploceus capensis*), Southern Masked Weaver (*Ploceus velatus*), Southern Red Bishop (*Euplectes orix*), Yellow Bishop (*Euplectes capensis*), Common Waxbill (*Estrilda astrild*), Pin-tailed Whydah (*Vidua macroura*), Cape Sparrow (*Passer*

melanurus), Cape Wagtail (*Motacilla capensis*), African Pipit (*Anthus cinnamomeus*), Cape Canary (*Serinus canicollis*), Black-headed Canary (*Serinus alario*), Yellow Canary (*Crithagra flaviventris*), White-throated Canary (*Crithagra albogularis*) and the Cape Bunting (*Emberiza capensis*) also inhabit the study area.



Figure 3.23: A Cape Grassbird in renoosterbos scrub near the Greater Brandvlei Dam.



Figure 3.24: A Karoo scrub-robin near the Greater Brandvlei Dam.



Figure 3.25: Orange-breasted Sunbirds are often seen on Ouhangsberg during the flowering time of *Protea*- and *Leucospermum* species.

Snakes occurring in the study area include the following species (Alexander and Marais 2007; Marais 2004): Berg Adder (*Bitis atropos*), Puff Adder (*Bitis arietans*), Cape Cobra (*Naja nivea*), Rinkhals (*Hemachatus haemachatus*), Spotted Harlequin Snake (*Homoroselaps lacteus*) (Figure 3.26), Boomslang (*Dispholidus typus*), Cape Whip Snake (*Psammophis leightoni*), Spotted Skaapsteker (*Psammophylax rhombatus*) (Figure 3.27), Herald Snake (*Crotaphopeltis hotamboeia*), Olive Snake (*Lycodonomorphus inornatus*), Brown House Snake (*Lamprophis capensis*), Spotted House Snake (*Lamprophis guttatus*), Mole Snake (*Pseudaspis cana*), Southern Shovel-snout Snake (*Prosymna sundevallii*), Common Egg Eater (*Dasypeltis scabra*),

Common Slugeater (*Duberria lutrix*), Delalande's Blind Snake (*Rhinotyphlops lalandei*), Black Thread Snake (*Leptotyphlops nigricans*) and the Slender Thread Snake (*Leptotyphlops gracilior*).



Figure 3.26: A Spotted Harlequin Snake in the south of the study area.

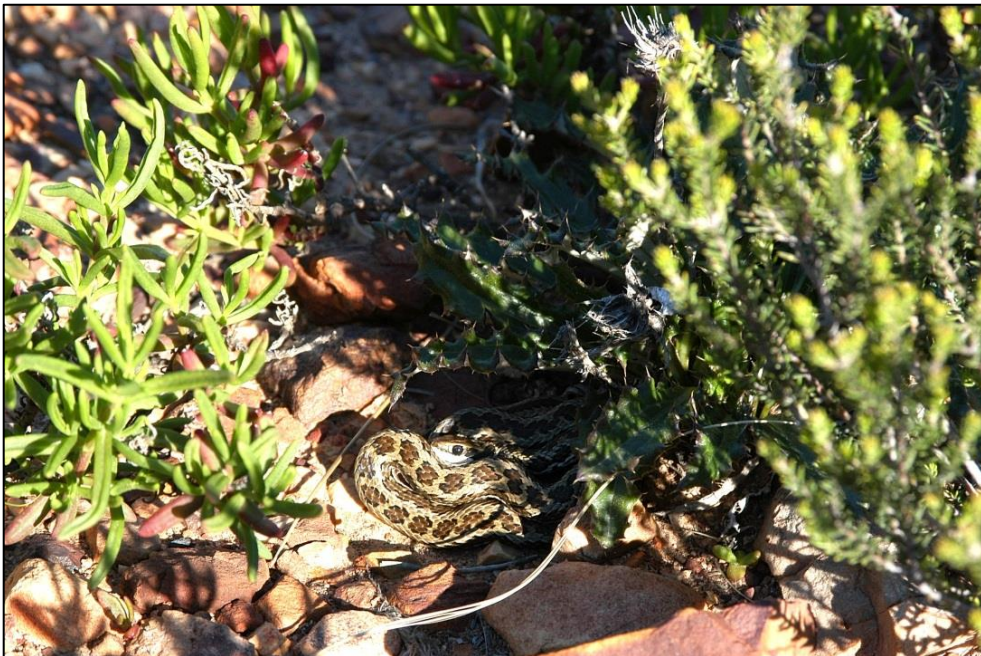


Figure 3.27: This Spotted Skaapsteker was on several visits, observed in exactly the same spot on the range of hills bordering the Greater Brandvlei Dam to the north.

Other reptiles inhabiting in the study area include the following species (Alexander and Marais 2007; Marais 2004): The Variegated Skink (*Trachylepis variegata*), Cape Skink (*Trachylepis capensis*), Graceful Crag Lizard (*Pseudocordylus capensis*), Cape Crag Lizard (*Pseudocordylus microlepidotus*), Karoo Girdled Lizard (*Cordylus polyzonus*) (Figure 3.28), Cape Girdled Lizard (*Cordylus cordylus*), Southern Rock Agama (*Agama atra*) (Figure 3.29), Southern Rock Lizard (*Australolacerta australis*), Spotted Sand Lizard (*Pedioplanis lineocellata*), Burchell's Sand Lizard (*Pedioplanis burchellii*), Common Mountain Lizard (*Tropidosaura montana*), Large-scaled Girdled Lizard (*Cordylus macropholis*) and the Ocellated Thick-toed Gecko (*Pachydactylus geitje*) (Figure 3.30).



Figure 3.28: This Karoo Girdled Lizard was observed between Dwyka rocks in the study area.



Figure 3.29: A female Southern Rock Agama well camouflaged within its surroundings near the Greater Brandvlei Dam.



Figure 3.30: This mottled little Ocellated Thick-toed Gecko was unexpectedly found near the Greater Brandvlei Dam. It typically lives under rocks and emits a loud sound when threatened.

Tortoises and terrapins inhabiting in the study area include the following species (Alexander and Marais 2007; Marais 2004): The Parrot-beaked Tortoise (*Homopus areolatus*), Angulate Tortoise (*Chersina angulata*), Marsh Terrapin (*Pelomedusa subrufa*), while the Little Karoo Dwarf Chameleon (*Bradypodion gutturale*) as well as the Cape Dwarf Chameleon (*Bradypodion pumilum*) also occur (Bayer 2006²; Tolley and Burger 2007).

The study area is home to several amphibians such as: The Cape Caco (*Cacosternum capense*), Raucous Toad (*Bufo rangeri*), Cape Mountain Rain Frog (*Breviceps montanus*), Cape Sand Frog (*Tomopterna delalandii*), Cape Sand Toad (*Bufo angusticeps*) and Clicking Stream Frog (*Strongylopus grayii*) (Carruthers 2001; Minter *et al.* 2004).

Freshwater fish species which occur in the greater Brandvlei Dam as well as farm dams include the Berg-Breede River Whitefish (*Pseudobarbus capensis*, previously *Barbus andrewi*), Clanwilliam Yellowfish (*Labeobarbus capensis*), Carp (*Cyprinus carpio*), Smallmouth Bass (*Micropterus dolomieu*). Tilapia and Catfish species were introduced to some of the farm dams in the area (Skelton 2001).

Countless arthropods such as Arachnida (spiders), Chilopoda (centipedes), Diplopoda (millipedes), Insecta (insects) (vital to the pollination of some flowers) occur in the study area. Figures 3.31 – 3.53 illustrate only a small number of such species (Prof. A. Dippenaar-Schoeman² pers. com.; Mr. A. Stander³ pers. com; Filmer 1991; Holm 2008; Picker *et al.* 2002).

Amongst the ground-living spiders, representatives of the Theraphosidae (Figure 3.31) and the Salticidae (Figure 3.32) were observed.

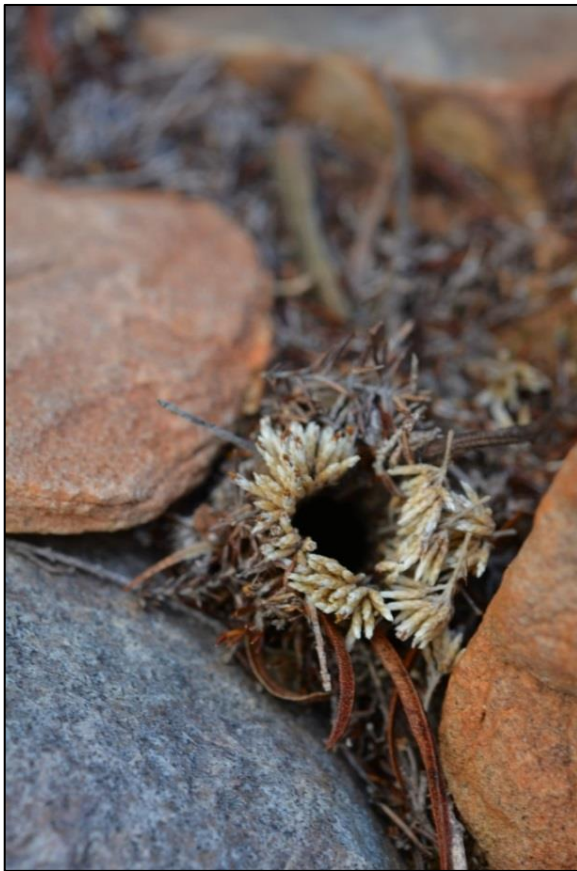


Figure 3.31: The burrow with turret of plant material, probably of a baboon spider (Theraphosidae), in Trappieskraalkloof.



Figure 3.32: *Pignus cf. simoni* (Salticidae) female near the Greater Brandvlei Dam.

Amongst the web-living spiders that occur in the study area are representatives of the families Araneidae (Figure 3.33) and Theridiidae (Figure 3.34) and Eresidae (Figure 3.35) (Prof A Dippenaar-Schoeman, pers. com.).

² Project manager of the South African National Survey of Arachnida (SANSA). Agricultural Research Council, South Africa.

³ Babylonstoren Farm, Simondium, South Africa.



Figure 3.33: A female orb-web spider *Argiope australis* (Araneidae).



Figure 3.34: Young spiders, probably of the family Araneidae or Theridiidae.



Figure 3.35: Young communal-nest spiders, *Stegodyphus dumicola* (Eresidae).

During the making of firebreaks, a roman spider (Solpugidae) was observed carrying soil and small stones while excavating its burrow on the range of hills north of the Greater Brandvlei Dam (Figure 3.36; Dippenaar-Schoeman 1993; Filmer 1991).



Figure 3.36: A roman spider (in all probability a *Solpugema* sp.) excavating its burrow in the study area.

Of the scorpions occurring in the study area the genera *Opisthacanthus* (Figure 3.37) and *Parabuthus* (Figure 3.38) were observed (Leeming 2003).



Figure 3.37: A thin-tailed rock-scorpion (*Opisthacanthus*) on Hammansberg.



Figure 3.38: A burrowing thick-tailed (*Parabuthus*) scorpion on the farm Droogeriviersberg.

Figures 3.39 – 3.53 illustrate only a few of the numerous insects that occur in the study area. Species such as honey bees, carpenter bees, bee-flies, wasps, cockroaches, ants and termites (Figure 3.39), silverfish, thrips, lice, mantids (Figure 3.40), locusts and grasshoppers (Figures 3.41 & 3.42), stick insects (Figure 3.43), butterflies and moths (Figures 3.44 – 3.48), bugs and beetles (Figures 3.49 – 3.51), flies, bee-flies (Figure 3.52), lacewings and antlions, damselflies and dragonflies live in the study area (Picker *et al.* 2002).



Figure 3.39: Termite mounds are common in the study area.

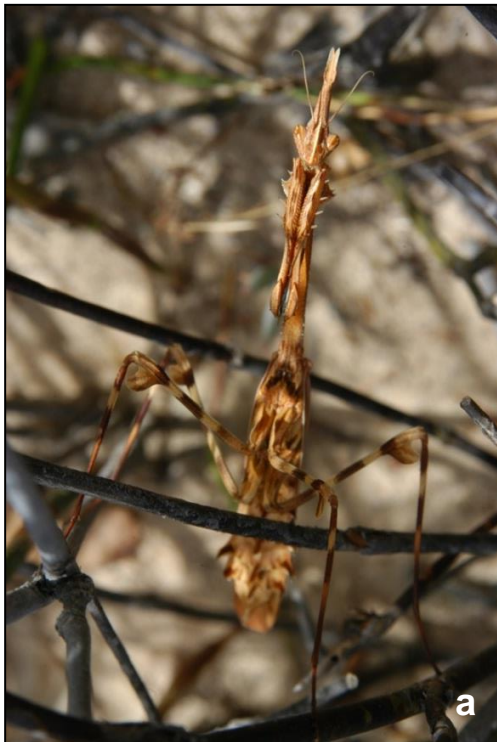


Figure 3.40: Among the mantids occurring in the study area, these (a & b) are representatives of the Empusidae (cone-headed mantids).



Figure 3.41: Different species of Toad Grasshoppers (Pamphagidae) occur in the study area.



Figure 3.42: The Silver-spotted Bladder Grasshopper (*Physemacris variolosus*) (Pneumoridae) (a), known to feed on renosterbos, here observed in major community 1. Rain locusts, possibly *Lamarckiana* sp. (Pamphagidae) (b) and grasshoppers of the Pyrgomorphidae family (c) also occur in the study area.



Figure 3.43: Thunberg's Stick-insect (*Macynia labiata*) (Bacillidae).



Figure 3.44: Larval stages of the Order Lepidoptera (moths and butterflies) occurring in the study area (a-e). Picture a illustrates the larval bag of a bagworm (a moth in the Psychidae) constructed with sticks in a *Drosanthemum hallii* flower. A Cherry Spot moth caterpillar (*Diaphone eumela*) (Noctuidae) is illustrated in picture d.



Figure 3.45: One of the 'geranium bronze' butterflies in the genus *Cacyreus*, sub-family Polyommatainae (Lycaenidae) in the study area.



Figure 3.46: One of the 'browns' in the sub-family Satyrinae (Nymphalidae) of butterflies in the study area.



Figure 3.47: The small Fynbos blue (*Tarucus thespis*) (Lycaenidae) on *Elytropappus gnaphaloides* in the study area.



Figure 3.48: The Painted lady (*Cynthia cardui*) (Nymphalidae) on Bergmelkbos (*Gomphocarpus cancellatus*) in the study area.

A small spittlebug (Cercopidae) species (Figure 3.49) occurs in the study area where in summer, the nymphs living in a ball of spittle (made by mixing air with anal secretions from plant sap) (Picker *et al.* 2002).



Figure 3.49: Balls of spittle found on renosterbos in summer months (a), housing the nymphs of a spittle bug (b) species in the study area.

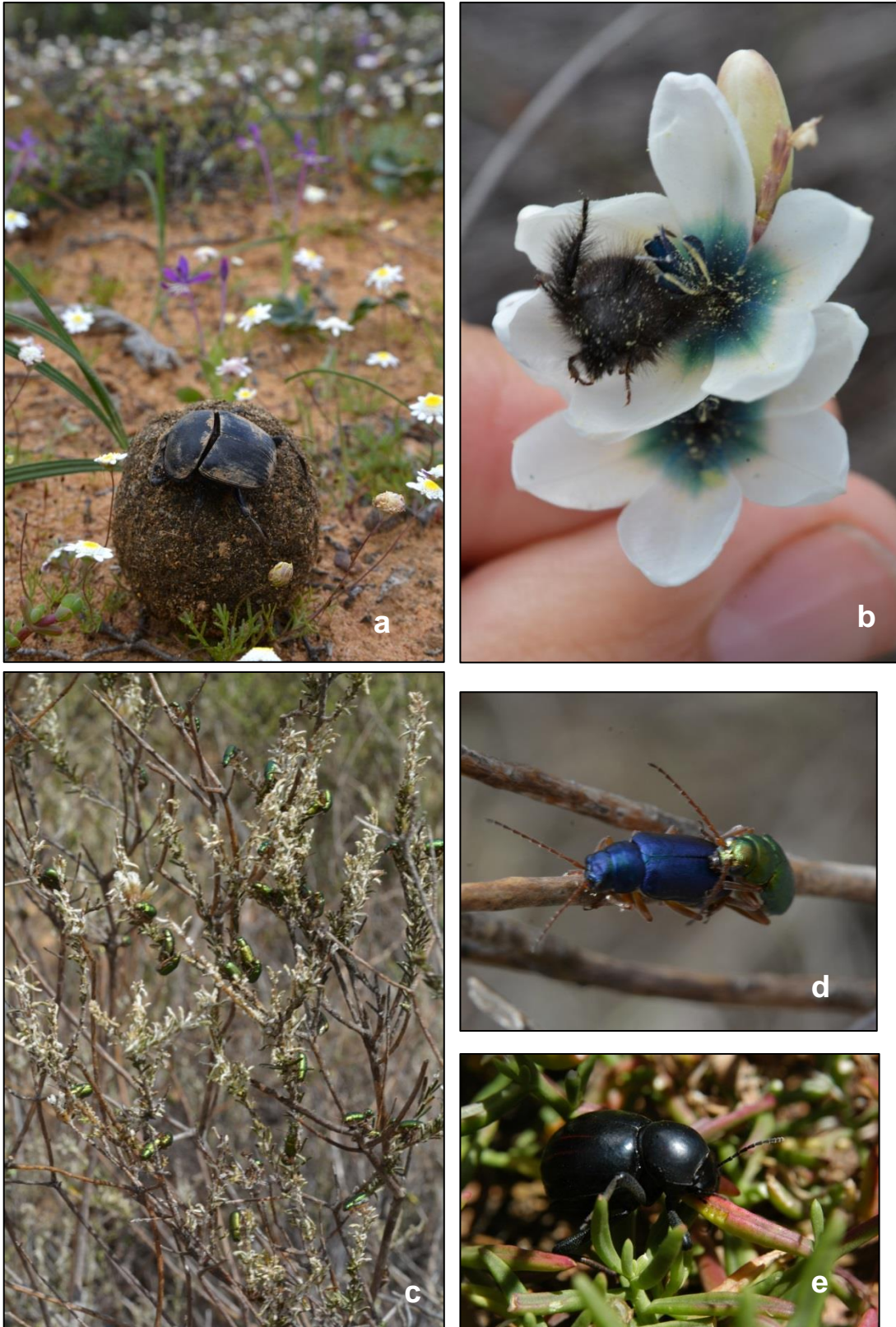


Figure 3.50: Representatives of the Coleoptera (beetles) include dung beetles (Scarabaeidae) (a), monkey beetles (Scarabaeidae) such as this oval hairy monkey beetle (probably *Peritrichia cinerea*) on an *Ixia* species (b), shiny green beetles (Chrysomelidae) feeding on *Elytropappus gnaphaloides* shrub near the Greater Brandvlei Dam (c & d). The Tenebrionidae (Darkling beetles) are represented with species such as the Striped toktokkie (*Psammodes striatus*) (e).

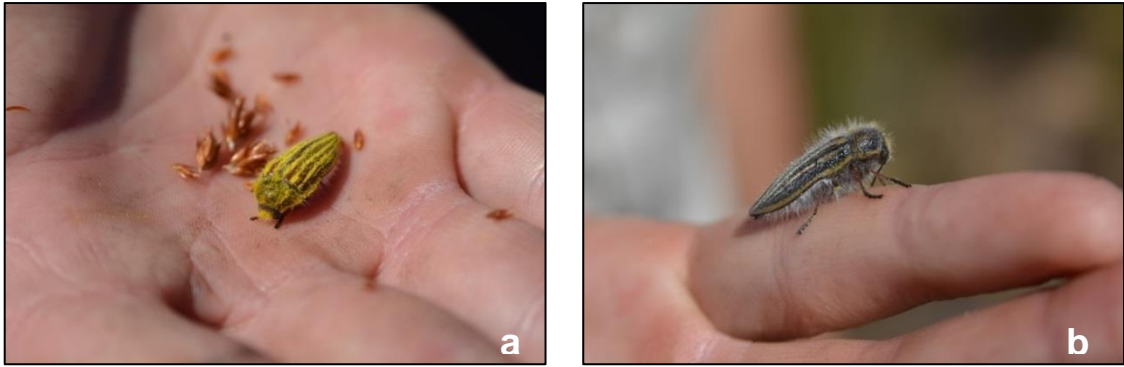


Figure 3.51: Brush jewel beetles (Buprestidae) (a & b) are frequently observed on flowers in spring.



Figure 3.52: A horse-fly (Tabanidae) species frequently visiting the flowers of *Pelargonium fergusoniae* in the study area.

3.6.3 Mosses, liverworts and lichens

Mosses and liverworts occur in moist habitats, especially on south-facing slopes in the study area (Figure 3.53).



Figure 3.53: Mosses and liverworts occur in moist habitats in the study area.

A small variety of lichens grow on the ground in the study area. These ground-growing lichens prefer the finer grained more fertile soils such as Dwyka tillite, or soil derived from the mudrock-dominated geological formations (Figure 3.54). Species of the Parmeliaceae, the genera *Xanthomaculina* and *Xanthoparmelia* (Rock shield lichens) are foliose lichens that can roll freely over

the ground (Figure 3.54 a & b), but can also be closely or loosely attached to rocks (Figure 3.55 a, b, d, f & i). These lichens prefer siliceous and non-calcareous rocks as well as mineral rich soil in relatively dry areas. Several species, such as *Xanthomaculina* cf. *hottentotta* (Figure 3.54 b; Figure 3.55 f) occur in the study area (Brodo *et al.* 2001; Hale 1990; Schieferstein and Loris 1992). The genus *Psora* (scale lichens) are known from dry climates where they are found on lime rich soil or on rocks (Brodo *et al.* 2001) *P. decipiens* is locally known as “verneukvygie” because the lichen can have the appearance of *Conophytum* clumps, especially in the dry season (Figure 3.54 c; C.T. Haumann⁴ pers. com.)



Figure 3.54: Lichens also occur on the ground in the study area. The light-grey coloured ground-lichens are often associated with localities of *Moraea vuvuzela* plants (b).

The largest variety of lichens in the study area grows on rocks, and is particularly abundant on moist south-facing slopes. Species of the genera *Buellia*, *Caloplaca*, *Xanthomaculina* (a genus only occurring in Africa) and

⁴ 24 Alexandra Avenue, Oranjezicht, Cape Town 8001

Xanthoparmelia occur (Figure 3.55; Brodo *et al.* 2001; Hale 1990; Schieferstein and Loris 1992; Williamson 2000). Figure 3.55 (i) could likely be *Xanthoparmelia worcesteri*, the most typical of the tightly adnate karoo lichens (Hale 1990). *Buellia* (button lichens) are crustose lichens that may be found on bark, wood, rock or soil (Figure 3.55 e & g; Brodo *et al.* 2001).

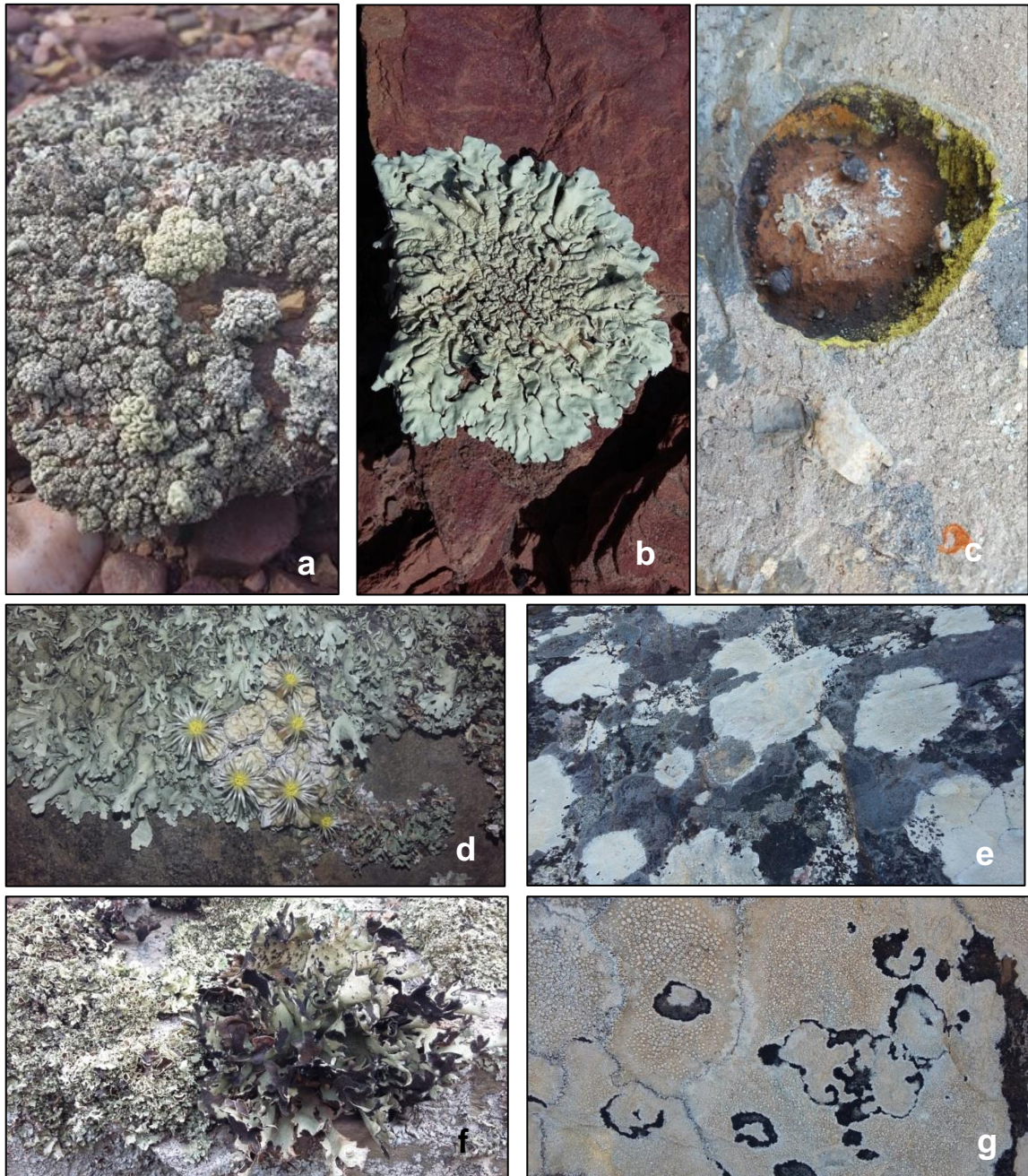


Figure 3.55: Different kinds of, sometimes colourful, lichens (a – m) grow in beautiful patterns on rocks in the study area (continue on page 93).

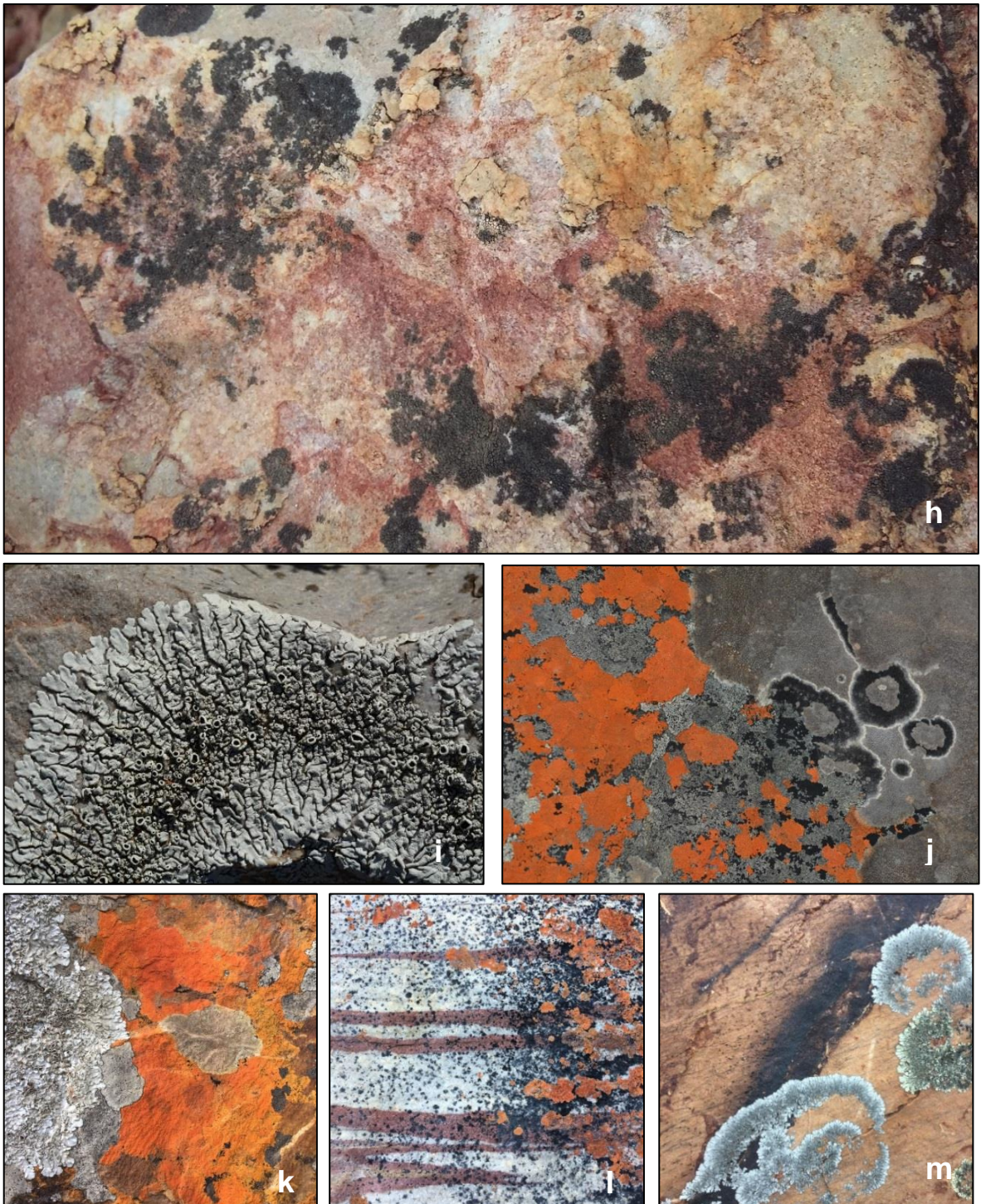


Figure 3.55 (continued): Pictures k, l and m were taken by Eduard Haumann⁵.

The same authors note that some species may be parasitic on other lichens. Most species of *Caloplaca* (firedot lichens, jewel lichens) are bright orange or yellow-orange (Figure 3.55 i - l).

⁵ HAUMANN SMAL DESIGN STUDIO, 42 Jonkershoek Way, Stellenbosch 7600.

Interesting and often colourful lichens are often found growing on dead wood in the study area (Figure 3.56).

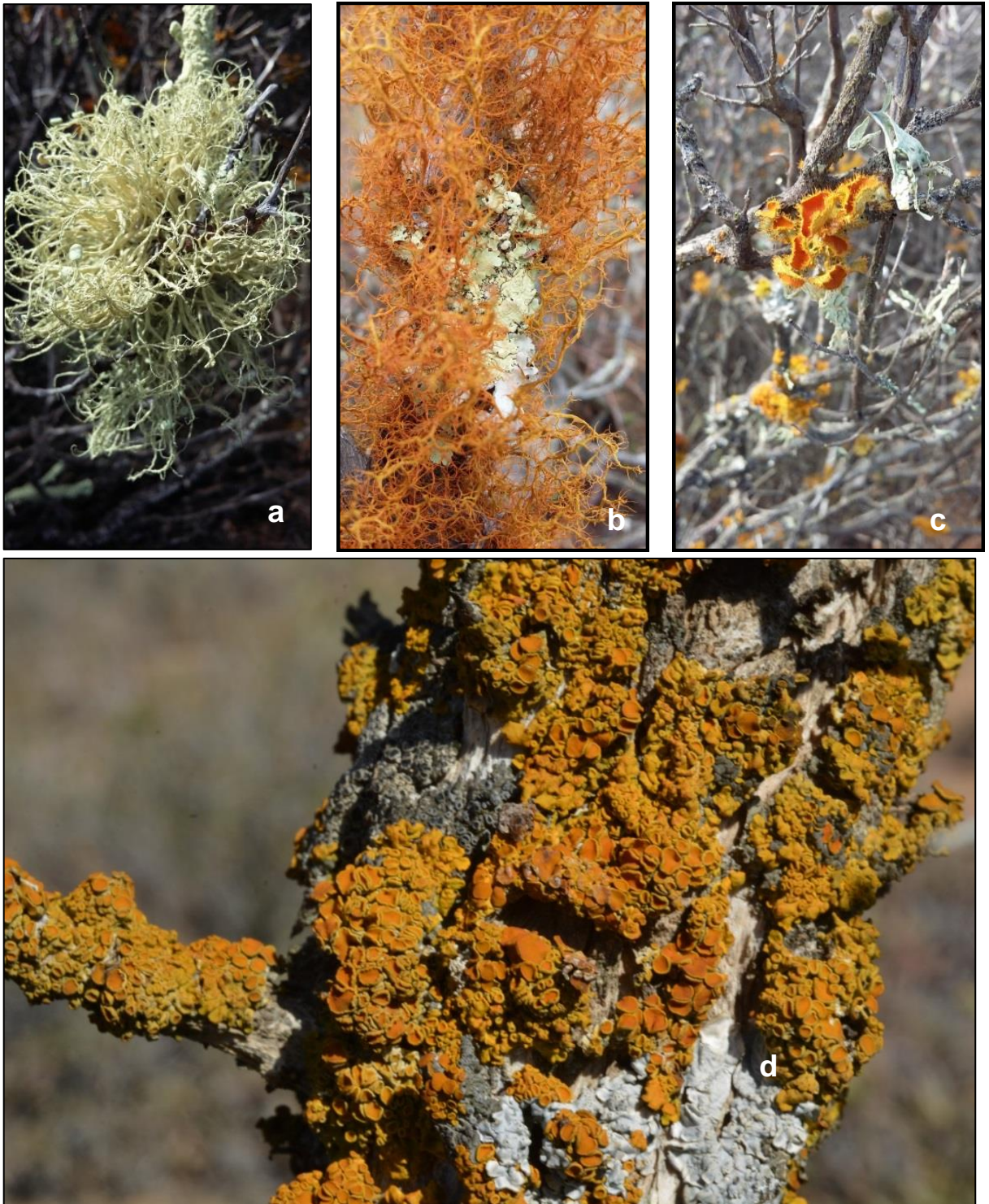


Figure 3.56: Examples of lichens that occur on wood in the study area (a – d).

Lichens of the genus *Ramalina* (Figure 3.56 a) are pendent or shrubby and are found on tree branches and trunks as well as on siliceous rocks (Brodo *et al.*

2001). Lichens of the genus *Teloschistes* (orange bush lichens) are bright orange to grey tufted fruticose lichen that may grow on shrubs, rocks as well as on the ground. *Teloschistes* cf. *capensis* (Figure 3.56 b), as well as *T. cf. chrysophthalmus* (Figure 3.56 c) occur in the study area (Brodo *et al.* 2001; Maphangwa *et al.* 2012; Williamson 2000). The sunburst lichens of the genus *Xanthoria* (Figure 3.56 d) are foliose orange, yellow-orange or reddish-orange lichens of which when fully exposed to the sun, the pigments are more intense (Brodo *et al.* 2001).

3.7 METHODS

This study was conducted over an eight-year period. The Braun-Blanquet approach to vegetation ecology as described by Westhoff and Van der Maarel (1978), Werger (1974) and Mueller Dombois and Ellenberg (1974) was followed.

The three main principles of the Zürich-Montpellier approach can be summarised as follows (Van der Maarel 1975):

- Plant communities are regarded as “types of vegetation” which are recognised by their floristic composition. The species composition of plant communities is the most important expression of the relationships between communities and their environments.
- Because of ecological relationships between some species in the floristic composition of a community, certain species can be used as indicators of the habitat as well as for classification.
- Such diagnostic species are used to organise plant communities in a hierarchal classification where the association forms the basic unit.

The practical implementation of the Zürich-Montpellier approach includes the following field survey methods (Brown *et al.* 2013):

- The sampling of vegetation in selected representative sample plots of a predetermined minimum size, placed in a stratified random manner within floristically homogenous and biophysical uniform units.

- The recording of all plant species and estimating the cover-abundance of each species on a cover-abundance scale.
- The recording of other qualitative and quantitative characteristics of the vegetation as well as environmental data.
- Phytosociological records are entered into a database from which the vegetation data are extracted and in a format that can be imported into programs such as JUICE (Tichý and Holt 2006).

3.7.1 Survey methods

The study area was delineated into visibly distinctive broad homogenous habitat units using aerial photographs (Spot 5 2005, DWAF) and Google Earth satellite imagery (DigitalGlobe 2017). Permanent sampling plots were placed in representative vegetation of each of the habitat components. Care was taken to sample the different aspects and elevations. The range of hills bordering the Greater Brandvlei Dam on the northern and eastern side formed the foundation of the study and was sampled in detail from 2006 to 2010. The area supported by the Witteberg Geological Series southeast of the dam, the transitional area between the Bokkeveld- and Witteberg Groups as well as the Dwyka tillite southeast of the dam were sampled between 2011 and 2014.

For Fynbos and Succulent Karoo vegetation, Brown *et al.* (2013) suggest a sample plot size between 100 m² and 400 m². In this study, the sample plot size was fixed at 400 m², as it was indicated by the minimal area from a species-area curve graph which was determined in nested quadrants with a pilot vegetation survey (Barbour *et al.* 1987). A total of 182 permanently marked plots were placed out on a randomly stratified basis within representative stands of vegetation so as to include as much homogeneity in terms of floristic composition, structure and habitat as possible (Barbour *et al.* 1987; Bezuidenhout 1994; Bezuidenhout 1996; Boucher and Moll 1981; Brown and Bredenkamp 1994; Brown 1997). If it was found that a pre-determined position of a sample plot was not representative of the general vegetation, the sample plot was moved to be “representative of the immediate vegetation and

environment in accordance with requirements for the traditional Braun Blanquet-type surveys” (Brown *et al.* 2013).

The location and elevation of each plot was recorded using a GPS. The position format used was hddd°mm’ss.s” and the Map Datum was WGS 84.

Although the majority of the data were collected during the growing season, the plots were monitored throughout the year in order to identify plant species with seasonal growth cycles such as geophytes.

3.7.1.1 Floristic data

Species composition: Data were recorded for all species observed within the sampling plots at the time of sampling. Plant species noticed on the perimeter of the sampling plot (not occurring within the boundaries thereof) were noted separately. Plant species that occurred on heuweltjies in the study area were noted separately.

Cover: Canopy cover, or “the percentage of plot area beneath the canopy of a given species” (Barbour *et al.* 1987) (cover abundance) was estimated using the modified Braun-Blanquet cover abundance scale (Mueller-Dombois and Ellenberg 1974) (Table 3.7). This was done for all species identified within each sample plot.

Table 3.7: Modified Braun-Blanquet cover abundance scale (Mueller-Dombois and Ellenberg, 1974).

SCALE	DESCRIPTION
r	One or a few species
+	Less than 5% cover of the total area of the plot and irregular occurrence
1	Abundant, but with low cover or less abundant but with greater cover, but less than 5% of the total plot area (single individuals)
2	Abundant but with 5 - 25% cover of the total plot area
3	25 - 50% cover of the total plot area regardless of amount of individuals
4	50 - 75% cover of the total plot area regardless of amount of individuals
5	75 - 100% cover of the total plot area regardless of amount of individuals

Plants were identified in the field. Indeterminate species were either photographed (if low in numbers) or collected, pressed and dried for identification purposes.

3.7.1.2 Habitat data

The main habitat variables that are correlated with differences in floristically defined plant communities according to Bredenkamp and Brown (2003) are geology, topography (landform, aspect, and slope) as well as altitude. Soil texture and depth are also considered important factors (Coetzee 1974; Bredenkamp 1975; Brown *et al.* 2013). Soil texture was noted for this study while soil depth and the percentage rock cover were estimated. Aspect was measured by using a compass. Topography was noted as: footslope, midslope, upper slope, crest, ridge, inter-ridge, plateau or drainage line. Slope was estimated as: even ($<3^{\circ}$), moderate ($4 - 15^{\circ}$), steep ($16 - 29^{\circ}$), very steep ($>30^{\circ}$). Pictures were taken throughout the study with a Nikon D100 camera with Nikon, Nikkor 28 – 105mm lens.

The geology of the area was studied by means of information from various reference works as well as assessment during field surveys. Where possible the specific geological formation was noted. Rock size was noted as follows: gravel (<10 mm), small ($10 - 50$ mm), medium $950 - 200$ mm and large (>200 mm).

Topsoil (A horizon) samples were taken at the roots of dominant plant species in the sample plots (<250 mm deep). Samples classified in the different plant units were mixed to get an average sample for each of the 35 clusters. Soil samples were analysed for texture, soil pH, electrical resistance, stoniness, water holding capacity, important elements (P, Na, K, Ca, Mg, Cu, Zn, Mn, B, Fe and organic C), as well as total of exchangeable cations, base saturation and soil acidity.

Soil texture: Clay, silt and sand percentages were interpreted according to the soil texture chart provided by MacVicar *et al.* (1977) and Soil Classification

Working Group (1991), while pH values were interpreted according to Hossner (2008) (Table 3.8).

Table 3.8: pH values are interpreted according to Hossner (2008).

Field pH rating	pH	Field interpretation
Extremely acid	4.0	Free acid present, usually of oxidation of iron sulphides (FeS_2) to sulphuric acid (H_2SO_4)
Strongly acid	5.0	Soluble Al, Fe and Mn
Moderately acid	5.5	Exchangeable Al^{3+} present
	6.0	Common range of soil pH for crop production on non-calcareous soils.
Slightly acid	6.5	Exchangeable cations dominated by Ca^{2+} , Mg^{2+} and K^+

3.7.1.3 Plant identification and taxon names

Dried and photographed specimens were identified by staff at the Compton Herbarium (Kirstenbosch National Botanical Garden) and National Herbarium (Pretoria National Botanical Garden). Taxonomic specialists were consulted for problematic families such as Aizoaceae, Hyacinthaceae, Geraniaceae and Oxalidaceae. All plant taxon names used in this study conforms to those listed in Germishuizen and Meyer (2003) with updates from taxonomic specialist studies and SANBI website.

3.7.1.4 Controlled burning

To determine the effect of fire on the renosterveld, it was decided that a section along the northern perimeter of the Brandvlei dam that have not been exposed to fire for more than 25 years is burnt. Controlled burning of a part of the study area was done in 2009 (Le Roux 2011). The same sampling methods were used in the assessment of before- and after fire vegetation data. Pre-fire data were gathered in September 2007 and post-fire data were gathered in September of 2010, 2011, 2012 and 2013 after the controlled burn in April 2009. Pre-fire sample plot numbers were given with the corresponding relevé

numbers of the post-fire samples (collected in the same marked sample plot) in Table 3.9.

Table 3.9: Relevé numbers of post fire samples matching the numbers of pre-fire sample plots.

Pre-fire relevés	Post-fire relevés for the same pre-fire sample plots			
	2010	2011	2012	2013
2007				
10	93	109	119	123
11	no data	no data	116	124
12	88	103	117	122
13	92	108	118	125
14	91	107	115	126
15	90	106	114	127
16	no data	105	112	129
17	89	104	113	128
18	87	102	110	121
21	no data	no data	111	120

3.7.1.5 Sample preparation for scanning electron microscope (SEM)

Plant material:

Leaf samples, 10 mm², were fixed in 70% ethanol for 24h, dehydrated in an ethanol series, (80%, 90% and 2X 100% for 45min each), critical-point dried with liquid CO₂. The samples were mounted on SEM-stubs with double-sided carbon tape, sputter-coated with a 15nm layer of gold/palladium (66:34%) and examined with an FEI Quanta 250 environmental scanning electron microscope (ESEM) with an integrated Oxford INCA X-20 Max EDS system. The ESEM's operating conditions were at 10kV under high vacuum mode.

Pollen grains were collected with a fine paint brush from already open anthers of the flowers and transferred to carbon-taped stubs. The same was done with dried seeds. The coating procedure was the same as for the leaves.

3.7.2 Data analysis

3.7.2.1 Vegetation classification

The vegetation relevé data from the 182 sample plots were captured into the computer software program TURBOVEG for Windows 1.97 (Hennekens 1996). The data were then exported as a Cornell Condensed (CC!) species file into the computer program JUICE 7.0.102 that is used for editing, classifying and analysing floristic data into phytosociological tables (Tichy 2002; Tichy and Holt 2006). The default percentage cover abundance conversion as set in JUICE ($r = 1\%$; $+ = 2\%$; $2 = 8\%$; $3 = 38\%$; $4 = 63\%$ and $5 = 88\%$) was used.

A classic TWINSpan classification algorithm (Hill 1979) as well as the modified TWINSpan classification algorithm (Roleček *et al.* 2009) were used to determine an initial phytosociological table of the dataset. This was then compared to an agglomerative clustering technique using PC-ORD v5.0 (McCune and Grace 2002) through JUICE.

The modified TWINSpan algorithm (Roleček *et al.* 2009) provided the best ecological interpretation of the dataset. This is a divisive clustering method which clusters vegetation relevés of similar internal heterogeneity within a hierarchical structure (Brown *et al.* 2013). Whittaker's beta-diversity, with the following pseudospecies cut-levels: 0, 1, 5, 25, 50, and 75 were used. The phytosociological table produced was refined following the Braun Blanquet procedure. No changes in the TWINSpan classification were made by moving any relevé. The manual rearrangement was done by moving species grouping them into species groups to improve the ecological interpretation of the species dataset. The first order of grouping was done using the dominance / co-dominance of species, where after species with lower dominance as well as rare or endangered species were added. The resultant groups were arranged into major communities, communities, sub-communities and variants based on associated species. The final phytosociological table was then exported to EXCEL for Windows 2016.

While the phytosociological table is generally used to describe the characteristic / dominant species of the community, synoptic tables summarises the results of the relevé classification (phytosociological table) and assists the researcher to understand complex associations between the species and the environment (Tichy and Holt 2006). Frequency and fidelity values provided by the synoptic table are used as confirmation and in support of the phytosociological table. A combined synoptic table was also created within JUICE. Diagnostic, constant and dominant species were determined by analysis of columns of the synoptic table. The analysis of the division of five clusters were used in description of the major communities, fifteen for the description of the communities, twenty-five for the description of the sub-communities and thirty-one for the description of the variants. The following threshold values were used for the analysis of the columns (Lower:upper):

Threshold fidelity value for diagnostic species: 75 (90)

'Diagnostic species' are those with fidelity higher than the 'Lower' fidelity threshold (Tichy and Holt 2006).

Threshold frequency value for constant species: 75 (90)

'Constant species' are those with relative frequency higher than the 'Lower' frequency threshold (Tichy and Holt 2006).

Threshold frequency value for dominant species with cover up to 50: (100)

'Dominant species' are defined as all species that have cover values higher than the cover threshold. A species appears in this list if its cover exceeds the threshold value in any relevé of the selected vegetation unit (Tichy and Holt 2006).

Frequency values are given for both constant and dominant species. Fidelity values are given for diagnostic species. Where two values are given in brackets for species, the first value reflects the frequency and the second value fidelity.

To determine if there is a difference in the classification of the vegetation regarding pre- and post-fire data, post fire relevés were initially included in the TWINSpan analysis. In avoiding replication of relevés in the analysis for the vegetation description, the post-fire relevés were then excluded from the total dataset before analysis. Pre- and post-fire relevés were thus again analysed separately in discerning if there is a difference in vegetation classification if data in burnt veld was to be included in a dataset.

3.7.2 Ordination

Soil samples were collected from representative sample plots of the lowest syntaxon level (sub-community or variant). These samples were then mixed and a representative soil sample was collected for analysis. This was done to cut the costs of the soil analysis. The other environmental data parameters such as slope aspect, position of sample plot in the landscape, rockiness, were collected for each sample plot.

The floristic classification was imported into PCOrd (McCune and Mefford 1999) where six different ordination methods were applied to the plant community data. These were the: Bray-Curtis ordination, Canonical Correspondence Analysis, Weighted Averaging, Reciprocal Averaging, Detrended Correspondence Analysis (DCA), and nonmetric multidimensional scaling (NMS). The Canonical Correspondence Analysis (CCA) was applied to the floristic data. The CCA was chosen to be presented in this study, as it emphasized the variation and combination of the plant communities and sub-communities. Various environmental factors thought to influence the distribution of the plant communities were superimposed on the ordination results to reveal the floristic - environmental relationships.

3.7.3 Plant community descriptions and names

The phytosociological- and the synoptic tables were both used in the description of the plant communities. The important species are listed in the discussion in relation to frequency (highest to lowest); species underlined are

also prominent in the synoptic table. The descriptions of the plant communities were done using diagnostic, constant and dominant species (Brown *et al.* 2013). Plant community names were assigned following the International Code of phytosociological Nomenclature (Weber *et al.* 2000) but no specified taxon epithets were used as recommended by Brown *et al.* (2013).

The structure of the vegetation was described according to Edwards (1983) and used in naming of major communities. The description of the sandveld vegetation units refers to the distinctive soil form that supports such vegetation (Mucina and Rutherford 2006).

3.7.4 Plant community diversity

Species richness, as a measure of alpha diversity, was determined for the study area, as well as for each of the main plant communities using Menhinick's Index (Mirzaie *et al.* 2013) as well as Margalef's Index (Brower *et al.* 1997). Species diversity was determined for each of the main plant communities using the Shannon-Wiener Index of diversity (H') and the Gini-Simpson Index of diversity (D). The cover-abundance data collected for the various sample plots were transformed to a numerical scale ($r=0.5$; $+ = 1$; $1 = 2$; $2a = 8.5$; $2b = 17.5$; $3 = 35$; $4 = 70$; $5 = 140$) for these purposes (Van der Maarel, 2007).

The Shannon-Wiener Diversity Index (H') was calculated for the plant communities surveyed using the following formula:

$$H' = \sum_{i=1}^s (p_i)(\ln p_i)$$

Where: H' = Shannon-Wiener Diversity Index

s = the number of species

p_i = proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N) belonging to the i -th species

\ln = is the natural log

The Simpson-Index was calculated for the plant communities using the following formula:

$$D = \sum n(n - 1)/N(N - 1)$$

Where: where N = the total number of organisms of all species and
 n = the total number of organisms of a particular species from which Simpson's Diversity Index, $1 - D$, is found.

Since the Shannon-Wiener and Gini-Simpson entropies are not diversities themselves, the values obtained from the analysis were converted to "effective number of species". Effective number of species derived from these analysis share a common set of mathematical properties and allow for unified interpretation and comparison of diversity (Jost 2006) between communities.

Community species richness and frequency distributions were investigated using chi-square tests to assess if observed frequencies differed from expected frequencies. Using standardised residuals, representation of species in the various communities were scrutinized.

Relationships between environmental variables and diversity were investigated using multiple regression analysis.

CHAPTER 4

A CLASSIFICATION AND DESCRIPTION OF THE PLANT COMMUNITIES SUPPORTED BY THE WITTEBERG- AND DWYKA GEOLOGICAL GROUPS SOUTH OF WORCESTER IN THE WESTERN CAPE



Ouhangsberg se kantellyne
Tweespoor vliegtuigpad nabo
tot waar jy spinnekopstaan.
Fyngeblaar tussen brokkelklip.
Gannaberg se boegoegeure,
waai uit klowe en skeure.
Van hier 'n witkruisvlug
oor Trappieskraal in wolketooi

bartholina haumannskloof september 2015

Eduard Haumann

TABLE OF CONTENTS

LIST OF TABLES	109
LIST OF FIGURES	110
4.1 INTRODUCTION	117
4.2 ECOLOGICAL DESCRIPTION OF PLANT COMMUNITIES	122
SECTION 4.2.1: MAJOR COMMUNITY 1	122
Major Plant Community 1: <i>Elytropappus rhinocerotis</i> shrubland.....	123
1. <i>Tylecodon ventricosus</i> – <i>Elytropappus rhinocerotis</i> community	132
2. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> community	137
2.1. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Limonium amoenum</i> sub- community.....	139
2.2. <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia mucronata</i> sub- community.....	144
3. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> community.....	148
3.1. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia tenuifolia</i> sub- community.....	151
3.2. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Pelargonium pillansii</i> sub-community.....	161
3.3. <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Crassula saxifraga</i> sub- community.....	164
4. <i>Lichtensteinia interrupta</i> – <i>Elytropappus rhinocerotis</i> community.....	175
5. <i>Erica boucheri</i> – <i>Elytropappus rhinocerotis</i> community.....	179
6. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> community	183
6.1. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> Typicum Sub-community ..	185
6.2. <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> – <i>Senecio anthemifolius</i> sub-community.....	188
Heuweltjies	193

Conclusion	195
SECTION 4.2.2: MAJOR COMMUNITIES 2-5.....	197
Major Plant Community 2: <i>Passerina truncata</i> shrubland	199
7. <i>Pentameris eriostoma</i> – <i>Passerina truncata</i> community	204
8. <i>Drosanthemum hallii</i> – <i>Passerina truncata</i> community.....	207
9. <i>Protea laurifolia</i> – <i>Passerina truncata</i> community	210
9.1. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community.....	212
9.2. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Secamone alpini</i> sub-community ...	224
9.3. <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Ruschia diversifolia</i> sub- community.....	227
Heuweltjies	231
Major Plant Community 3: <i>Capeochloa arundinacea</i> shrubland.....	232
10. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> community	238
10.1. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erica anguliger</i> sub- community.....	239
10.2. <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erepsia anceps</i> sub- community.....	248
11. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> community.....	252
11.1. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Tritonia flabellifolia</i> sub- community.....	253
11.2. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Othonna arbuscula</i> sub- community.....	256
11.3. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Scopelogenia verruculata</i> sub-community.....	259
11.4. <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Curio crassulifolius</i> sub- community.....	266
Heuweltjies	269
Major Plant Community 4: <i>Hirpicium integrifolium</i> shrubland	270

12. <i>Euphorbia hamata</i> – <i>Hirpicium integrifolium</i> community.....	274
13. <i>Pelargonium karoaicum</i> – <i>Hirpicium integrifolium</i> community	277
Heuweltjies	282
Major Plant Community 5: <i>Thamnochortus bachmannii</i> sandveld.....	284
14. <i>Leucospermum rodolentum</i> – <i>Thamnochortus bachmannii</i> community	288
15. <i>Willdenowia incurvata</i> – <i>Thamnochortus bachmannii</i> community	293
4.3 ORDINATION	297
4.4 CONCLUSION	301

LIST OF TABLES

Table 4.1: Analyses of the soil A horison for major community 1. T-value = sum of exchangeable Ca, Mg, Na and K.	130
Table 4.2: Mechanical analysis of the soil A horison for major community 1. SaLm = Sandy loam, LmSa = Loamy sand.....	131
Table 4.3: Analyses of the soil A horison for major community 2. T-value = sum of exchangeable Ca, Mg, Na and K.	201
Table 4.4: Mechanical analysis of the soil A horison for major community 2. SaLm = Sandy loam, LmSa = Loamy sand.	202
Table 4.5: Analyses of the soil A horison for major community 3. T-value = sum of exchangeable Ca, Mg, Na and K.	236
Table 4.6: Mechanical analysis of the soil A horison for major community 3. SaLm = Sandy loam, LmSa = Loamy sand.....	237
Table 4.7: Analyses of the soil A horison for major community 4. T-value = sum of exchangeable Ca, Mg, Na and K.	272
Table 4.8: Mechanical analysis of the soil A horison for major community 4. SaLm = Sandy loam.....	272
Table 4.9: Analyses of the soil A horison for major community 5. T-value = sum of exchangeable Ca, Mg, Na and K.	286

Table 4.10: Mechanical analysis of the soil A horizon for major community 5. Sa = Sand.	286
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LIST OF FIGURES

Figure 4.1: The <i>Elytropappus rhinocerotis</i> shrubland occurs on the southern slopes of Ouhangsberg.....	124
Figure 4.2: Folding of the Witteberg Group sediments is here visible in a road cutting north of the Greater Brandvlei Dam.....	127
Figure 4.3: The <i>Tylecodon ventricosus</i> – <i>Elytropappus rhinocerotis</i> community (Sample plot 100), on the eastern perimeter of the Greater Brandvlei Dam.	132
Figure 4.4: Sample plot 148 is situated at the edge of a small ravine east of the Greater Brandvlei Dam.	133
Figure 4.5: <i>Tylecodon ventricosus</i> (Klipnenta/Nenta) (Crassulaceae) (in the left hand side of the picture) grows in plant community 1 (Sample plot 100).....	136
Figure 4.6: The <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> community on a north-facing slope of the hills between the Greater Brandvlei Dam and the Breede River (Sample plot 45).....	137
Figure 4.7: <i>Selago triquetra</i> (Scrophulariaceae) grows on the southern slopes of the hills north of Greater Brandvlei Dam.....	139
Figure 4.8: The <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Limonium amoenum</i> sub-community (Sample plot 29) is found on the northern perimeter of the Greater Brandvlei Dam.....	140
Figure 4.9: Strong southeasterly winds occasionally erode the northern perimeter of the dam, such as in the area of Sample plot 27.....	142
Figure 4.10: <i>Limonium amoenum</i> flowering in summer. It occurs around the Greater Brandvlei Dam.	143
Figure 4.11: The <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia mucronata</i> sub-community. It occurs in a low-lying area between the hills on the northern side of the	144

Figure 4.12: Sample plot 53, illustrating the vegetation of the <i>Selago triquetra</i> – <i>Elytropappus rhinocerotis</i> – <i>Wiborgia mucronata</i> sub-community on the northern side of the dam.	147
Figure 4.13: The spiny, deciduous shrub <i>Wiborgia mucronata</i> (Fabaceae) (Silver Wing-pea, Silwer Vlerk-ertjie) flowering in summer.	148
Figure 4.14: The <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> community	150
Figure 4.15: <i>Euryops rehmannii</i> (Asteraceae) flowering in September.	150
Figure 4.16: <i>Wiborgia tenuifolia</i> (Fabaceae) flowering in August on the southern slopes of Gannaberg.	151
Figure 4.17: The flower colours (a – f) of <i>Drosanthemum speciosum</i> occurring in the study area.	153
Figure 4.18: The small geophyte, <i>Moraea helicoidea</i> (Iridaceae) at the type locality.	153
Figure 4.19: The <i>Cineraria platycarpa</i> variant of the <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> community (Sample plot 137) occurs at the southern footslope of Gannaberg.	154
Figure 4.20: The small annual, <i>Cineraria platycarpa</i> , growing on Rooiberg.	157
Figure 4.21: The <i>Pelargonium carneum</i> variant of the <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> community (Sample plot 136) occurs on the southwest facing slope of Gannaberg.	158
Figure 4.22: The summer flowering hysteranthous geophytic <i>Pelargonium</i> <i>carneum</i> (Geraniaceae) on Ouhangsberg (a) with the leaves following the flowers in spring (b).	160
Figure 4.23: The <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Pelargonium</i> <i>pillansii</i> sub-community (Sample plot 75).	162
Figure 4.24: The geophytic hysteranthous <i>Pelargonium pillansii</i> (Geraniaceae) bears flowers in March and leaves in the growing season (September/October). The sweet clove-scented flowers open at night.	163
Figure 4.25: <i>Crassula saxifraga</i> is of the earliest plants to produce flowers in the growing season (it flowers in May).	165
Figure 4.26: The <i>Drosanthemum striatum</i> variant of the <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Crassula saxifraga</i> sub-community (Sample plot 149) east of the Greater Brandvlei Dam.	166

Figure 4.27: <i>Drosanthemum striatum</i> (Aizoaceae) flowering in September on Hammansberg.	168
Figure 4.28: <i>Pelargonium</i> sp. nov. 1 (currently being described by Dr E.M. Marais), with leaves in early spring and flowers following in October when the leaves are dry.	169
Figure 4.29: The <i>Crassula saxifraga</i> Typicum variant of the <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Crassula saxifraga</i> sub-community (Sample plot 49).	170
Figure 4.30: The <i>Nerine humilis</i> variant of the <i>Euryops rehmannii</i> – <i>Elytropappus rhinocerotis</i> – <i>Crassula saxifraga</i> sub-community (Sample plot 78).	172
Figure 4.31: The hysteranthous <i>Nerine humilis</i> (Amaryllidaceae) (Berglelie) north of the Greater Brandvlei Dam, flowering in April before the leaves appear.	174
Figure 4.32: The <i>Lichtensteinia interrupta</i> – <i>Elytropappus rhinocerotis</i> community north of the Greater Brandvlei Dam (Sampling plot 13).	176
Figure 4.33: The intensely aromatic perennial herb <i>Lichtensteinia interrupta</i> (Apiaceae) flowers in summer when the leaves are dry.	178
Figure 4.34: The <i>Erica boucheri</i> – <i>Elytropappus rhinocerotis</i> community (Sample plot 131) on Droëriviersberg.	180
Figure 4.35: The soils of Community 5 are prone to natural erosion.	181
Figure 4.36: The summer flowering <i>Aspalathus</i> sp. nov. 2 (Fabaceae) is dominant in the <i>Erica boucheri</i> – <i>Elytropappus rhinocerotis</i> community.	183
Figure 4.37: <i>Struthiola confusa</i> (Thymelaeaceae) flowering north of the Greater Brandvlei Dam in July 2006.	184
Figure 4.38: The <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> Typicum sub-community (Sample plot 142).	186
Figure 4.39: <i>Moraea vuvuzela</i> was named in commemoration of South Africa's hosting of the first Soccer World Cup tournament on the African continent in June 2010.	188
Figure 4.40: <i>Struthiola confusa</i> – <i>Elytropappus rhinocerotis</i> – <i>Senecio anthemifolius</i> sub-community (Sample plot 101).	189
Figure 4.41: <i>Senecio anthemifolius</i> (Asteraceae), a diagnostic species for this sub-community.	192

Figure 4.42: <i>Chenolea convallis</i> (Chenopodiaceae), a small succulent-leaved shrub grows at the edge of the Greater Brandvlei Dam.	193
Figure 4.43: <i>Pteronia incana</i> is the dominant shrub on the Heuweltjies (a and b) in major community 1.	194
Figure 4.44: <i>Haemanthus coccineus</i> , <i>Mohria caffrorum</i> , <i>Searsia incisa</i> and <i>Pteronia incana</i> occur on the Heuweltjies in major community 1.	194
Figure 4.45: <i>Passerina truncata</i> dominates most of the north-facing mid-slopes on the range of hills north of the Greater Brandvlei Dam.	199
Figure 4.46: The <i>Pentameris eriostoma</i> – <i>Passerina truncata</i> community (Sample plot 31).	204
Figure 4.47: <i>Pentameris eriostoma</i> (Poaceae) with its typical woolly leaf sheaths and ligules.	206
Figure 4.48: <i>Pentameris eriostoma</i> (pictured here on Hammansberg in January 2015), <i>Capeochloa arundinacea</i> (Olifantsgras) and <i>Tenaxia stricta</i> (Bokbaardgras) are more abundant following years that had thundershowers in summer.	207
Figure 4.49: The <i>Drosanthemum hallii</i> – <i>Passerina truncata</i> community (Sample plot 3).	208
Figure 4.50: <i>Protea laurifolia</i> – <i>Passerina truncata</i> community (Sample plot 17).	210
Figure 4.51: <i>Protea laurifolia</i> (Laurel Sugarbush, Proteaceae family).	211
Figure 4.52: The <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community (Sample plot 17) on the hills between the Greater Brandvlei Dam and the Breede River.	212
Figure 4.53: <i>Erica inaequalis</i> (Ericaceae), is one of two heath (Heide) species that occur on the hills bordering the Greater Brandvlei Dam to the north.	214
Figure 4.54: The neat, round small shrublet, <i>Psammotropha</i> sp. nov. (Molluginaceae) was first collected in 2007 during data collection for this study.	215
Figure 4.55: <i>Protea laurifolia</i> Typicum variant of the <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community (Sample plot 22).	216
Figure 4.56: The <i>Psammotropha quadrangularis</i> variant <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community (Sample plot 33).	218

Figure 4.57: <i>Psammotropha quadrangularis</i> (Molluginaceae) occurs in sandy habitats in the study area.....	220
Figure 4.58: The <i>Leucadendron salignum</i> variant of the <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Erica inaequalis</i> sub-community (Sample plot 18).....	221
Figure 4.59: <i>Leucadendron salignum</i> (Proteaceae). This is an example of the female plant.	223
Figure 4.60: The <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Secamone alpini</i> sub-community (Sample plot 151).	225
Figure 4.61: The perennial climber <i>Secamone alpini</i> (Bobbejaantou) (Apocynaceae) grows on the quartzitic outcrops of the Witpoort Formation.....	226
Figure 4.62: The <i>Protea laurifolia</i> – <i>Passerina truncata</i> – <i>Ruschia diversifolia</i> sub-community (Sample plot 48).	228
Figure 4.63: <i>Ruschia diversifolia</i> (Aizoaceae).....	229
Figure 4.64: <i>Galenia africana</i> , <i>Pteronia incana</i> , <i>Pteronia paniculata</i> and <i>Searsia incisa</i> occur on Heuweltjies in major community 2.....	231
Figure 4.65: The <i>Capeochloa arundinacea</i> shrubland on Ouhangsberg.	233
Figure 4.66: <i>Capeochloa arundinacea</i> (Olifantsgras) (Poaceae).	234
Figure 4.67: <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> community (Sample plot 169).....	238
Figure 4.68: <i>Metalasia acuta</i> (Asteraceae),	239
Figure 4.69: <i>Erica anguliger</i> (Ericaceae) on Hammansberg.	240
Figure 4.70: <i>Staavia capitella</i> variant of the <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erica anguliger</i> sub-community (Sample plot 166).....	242
Figure 4.71: <i>Staavia capitella</i> (Bruniaceae),	243
Figure 4.72: <i>Syncarpha mucronata</i> variant of the <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erica anguliger</i> sub-community (Sample plot 181).....	245
Figure 4.73: <i>Syncarpha mucronata</i> (Asteraceae).	247
Figure 4.74: <i>Agathosma</i> sp. nov. 1 at the type locality on Gannaberg.....	248
Figure 4.75: The <i>Metalasia acuta</i> – <i>Capeochloa arundinacea</i> – <i>Erepsia anceps</i> sub-community with small <i>Protea nitida</i> trees in the background (Sample plot 97).	249
Figure 4.76: <i>Erepsia anceps</i> (Aizoaceae).....	251

Figure 4.77: <i>Ruschia caroli</i> (Aizoaceae)	252
Figure 4.78: The <i>Agathosma ovata</i> – <i>Ruschia caroli</i> – <i>Tritonia flabellifolia</i> sub-community (Sample plot 162).	254
Figure 4.79: <i>Tritonia flabellifolia</i> (Iridaceae) on the slopes of Droëriviersberg.	255
Figure 4.80: The <i>Agathosma ovata</i> – <i>Ruschia caroli</i> – <i>Othonna arbuscula</i> sub-community (Sample plot 65).	257
Figure 4.81: The deciduous succulent shrub, <i>Othonna arbuscula</i> (Asteraceae) flowering in summer.....	258
Figure 4.82: <i>Agathosma ovata</i> – <i>Ruschia caroli</i> – <i>Scopelogena verruculata</i> sub-community (Sample plot 82).	260
Figure 4.83: In the study area, <i>Scopelogena verruculata</i> (Aizoaceae) prefers the quartzitic outcrops and rock faces of the Witpoort Formation.	261
Figure 4.84: Rock rabbit colonies defecate and urinate in latrines (middens), where urine and decomposition of such middens can contribute to soil fertility, as evident from the fungi growing on the latrine in the picture.....	263
Figure 4.85: Small mammals living in rocky outcrops, such as dormice and rock mice, make nests of grass and sticks. Decomposition of this organic material contributes to soil fertility and texture.	264
Figure 4.86: A high accumulation of organic material (a) such as termite frass(b) contributes to the humus-rich soil (c) of the <i>Ruschia caroli</i> – <i>Capeochloa arundinacea</i> – <i>Scopelogena verruculata</i> sub-community.	264
Figure 4.87: Harvester ants and termites carrying plant material to their nests (a and b).....	265
Figure 4.88: The rocky habitat of the <i>Agathosma ovata</i> – <i>Ruschia caroli</i> – <i>Curio crassulifolius</i> sub-community (Sample plot 73).....	266
Figure 4.89: <i>Curio crassulifolius</i> (Asteraceae)	268
Figure 4.90: <i>Aloe microstigma</i> and <i>Pteronia incana</i> dominate the Heuweltjies in major community 3.	269
Figure 4.91: The <i>Hirpicium integrifolium</i> shrubland on Dwyka tillite.....	270
Figure 4.92: <i>Hirpicium integrifolium</i> (Haarbossie) (Asteraceae).....	271

Figure 4.93: The <i>Euphorbia hamata</i> – <i>Hirpicium integrifolium</i> community (Sample plot 174) on Hammansberg with <i>Euphorbia hamata</i> in the foreground.	274
Figure 4.94: <i>Euphorbia hamata</i> (Beesmelkbos, Olifantmelkbos) (Euphorbiaceae) on the Dwyka tillite in the study area.	276
Figure 4.95: The <i>Pelargonium karooicum</i> – <i>Hirpicium integrifolium</i> community on the lower western slope of Hammansberg with <i>Haworthia herbacea</i> in flower (Sample plot 172).	278
Figure 4.96: The deciduous <i>Pelargonium karooicum</i> (Geraniaceae) flowering in autumn.	280
Figure 4.97: The small deciduous shrub, <i>Pelargonium conradiae</i> (Geraniaceae).	281
Figure 4.98: A high density of Heuweltjies occur in soils derived from Dwyka tillite in the study area. As <i>Euphorbia mauritanica</i> dominates the Heuweltjies here, the patches are clearly distinct due to the yellow green colour of the <i>Euphorbia</i> shrubs.	282
Figure 4.99: Heuweltjies on Dwyka tillite is often dominated by <i>Carissa</i> <i>bispinosa</i> , <i>Euclea undulata</i> and <i>Euphorbia mauritanica</i>	283
Figure 4.100: Heuweltjies on Dwyka tillite can also be dominated by <i>Eriocephalus ericoides</i> and <i>Tylecodon paniculatus</i>	283
Figure 101: The <i>Thamnochortus bachmannii</i> Sandveld in the foreground. The dominance of certain members of the Restionaceae indicates the presence of deep aeolian sand deposits.	284
Figure 4.102: <i>Thamnochortus bachmannii</i> (Restionaceae) is a typical species of deep sand deposits in the study area.	285
Figure 4.103: The <i>Leucospermum rodolentum</i> – <i>Thamnochortus bachmannii</i> Sandveld (Sample plot 143) east for the Greater Brandvlei Dam.	288
Figure 4.104: <i>Leucospermum rodolentum</i> grows in deep sand east of the Greater Brandvlei Dam.	290
Figure 4.105: <i>Pelargonium</i> sp. nov. 2.	292
Figure 4.106: The <i>Willdenowia incurvata</i> – <i>Thamnochortus bachmannii</i> Sandveld occurs on the deep sand deposits north of the Greater Brandvlei Dam (Sample plot 20).	293

Figure 4.107: <i>Willdenowia incurvata</i> (Sonkwasriet) (Restionaceae), female plant (a), male plant (b) and in its sandy habitat (c).	295
Figure 4.108: The deciduous geophyte <i>Annesorhiza laticostata</i> (Apiaceae) at the type locality north of the Greater Brandvlei Dam. Leaves appear in winter (a) and are dead or dying at time of flowering. Flowering time is from January to February with prominent to narrowly winged mature fruits present from March to May (b).	296
Figure 4.109: An indication of the location of the different topographical units often associated with vegetation units.	298
Figure 4.110: Topography and rock cover were the strongest environmental characters influencing associations between the vegetation units.	297

4.1 INTRODUCTION

This chapter discusses the plant communities supported predominantly by the Witteberg Geological Group north, east and south of the Greater Brandvlei Dam as well as on the Hammansberg, Ouhangsberg, Droëriviersberg and Gannaberg south of Worcester. The vegetation supported by the Witteberg Geological Group was the main focus of this study, but plant communities supported by parts of the Bokkeveld-Witteberg geological contact area east of the Greater Brandvlei Dam, on Gemsbokkop and on Rooiberg near Robertson, as well as areas underlain by Dwyka tillite on Hammansberg and Droëriviersberg south of Worcester are also included (Figures 3.2 & 3.11).

The Department of Water Affairs and Sanitation (DWS) owns the hills bordering the Greater Brandvlei Dam on the northern side as well as parts of the hills on the eastern side of the dam. Most of the properties east and southeast of the dam, as well as Hammansberg, Droëriviersberg and Gannaberg, are privately owned. The private landowners use the land predominantly for the production of grapes, wheat, fruit and to a lesser extent livestock grazing. Conservation of the mountainous areas is a priority as these mountains are important catchment areas.

Prior to this study, no extensive surveys of this area have been undertaken. The diverse mosaic of plant communities is the result of interplay of a complex mosaic of various geological formations and variable topography, which result in many microclimatic factors influencing the distribution of plant species (Gresse and Theron 1992; Van Wyk and Smith 2001).

Van Wyk and Smith (2001) recognise the Worcester-Robertson Karoo as a Regional Centre of Endemism. The aim of the study was to produce a floristic analysis as well as to describe and map the plant communities of the mountains south of Worcester towards Robertson.

PLANT COMMUNITIES

From the data analyses a total of 31 plant communities that can be grouped into 15 communities and five major plant communities were identified namely (Annexure 1):

MAJOR PLANT COMMUNITY 1: *Elytropappus rhinocerotis* shrubland

1. *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community

2. *Selago triquetra*–*Elytropappus rhinocerotis* community

2.1 *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community

2.2 *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community

3. *Oedera genistifolia*–*Elytropappus rhinocerotis* community

3.1 *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community

i *Cineraria platycarpa* variant

ii *Pelargonium carneum* variant

3.2 *Oedera genistifolia*–*Elytropappus rhinocerotis*– *Pelargonium pillansii* sub-community

3.3 *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community

i *Drosanthemum striatum* variant

ii *Crassula saxifraga* Typicum variant

iii *Nerine humilis* variant

4. *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community

5. *Erica boucheri*–*Elytropappus rhinocerotis* community

6. *Struthiola confusa*–*Elytropappus rhinocerotis* community

6.1 *Struthiola confusa*–*Elytropappus rhinocerotis* Typicum sub-community

- 6.2 *Struthiola confusa–Elytropappus rhinocerotis–Senecio anthemifolius* sub-community

MAJOR PLANT COMMUNITY 2: *Passerina truncata* shrubland

7. *Pentameris eriostoma–Passerina truncata* community

8. *Drosanthemum hallii–Passerina truncata* community

9. *Protea laurifolia–Passerina truncata* community

- 9.1 *Protea laurifolia–Passerina truncata–Erica inaequalis* sub-community
- i *Protea laurifolia* Typicum variant
 - ii *Psammotropha quadrangularis–Variant*
 - iii *Leucadendron salignum–Variant*
- 9.2 *Protea laurifolia–Passerina truncata–Secamone alpini* sub-community
- 9.3 *Protea laurifolia–Passerina truncata–Phylica constricta* sub-community

MAJOR PLANT COMMUNITY 3: *Capeochloa arundinacea* shrubland

10. *Metalasia acuta–Capeochloa arundinacea* community

- 10.1 *Metalasia acuta–Capeochloa arundinacea–Erica anguliger* sub-community
- i *Staavia capitella* variant
 - ii *Syncarpha mucronata* variant
- 10.2 *Metalasia acuta–Capeochloa arundinacea–Erepsia anceps* sub-community

11. *Ruschia caroli–Capeochloa arundinacea* community

- 11.1 *Ruschia caroli–Capeochloa arundinacea–Tritonia flabellifolia* sub-community
- 11.2 *Ruschia caroli–Capeochloa arundinacea–Othonna arbuscula* sub-community

- 11.3 *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogenia verruculata* sub-community
- 11.4 *Ruschia caroli*–*Capeochloa arundinacea*–*Curio crassulifolius* sub-community

MAJOR PLANT COMMUNITY 4: *Hirpicium integrifolium* shrubland

- 12. *Euphorbia hamata*–*Hirpicium integrifolium* community**
- 13. *Pelargonium karooicum*–*Hirpicium integrifolium* community**

MAJOR PLANT COMMUNITY 5: *Thamnochortus bachmannii* Sandveld

- 14. *Leucospermum rodolentum*–*Thamnochortus bachmannii* community**
- 15. *Willdenowia incurvata*–*Thamnochortus bachmannii* community**

The descriptions of the five major plant communities are presented in two sections (4.2.1 and 4.2.2) based on geology. The first section (4.2.1) describes the vegetation of major community 1 that is predominantly found on the mudrock-dominated formations of the Witteberg Group as well as the contact area of the Witteberg- and older Bokkeveld Group. These geological formations typically yield acidic, manganese rich sandy-loam soils with a higher amount of silt in comparison to the soils of the other major communities (Table 3.1; Table 4.1; Table 4.2).

The second section (4.2.2) describes the vegetation of major communities 2-3. The soils are mostly extremely acidic, shallow and rocky. They are the weathered product of the predominantly sandstone-dominated formations of the Witteberg Group. This major community occurs on midslopes and plateaus where the sandstone-dominated and mudrock-dominated layers of the Witteberg Group are greatly folded and intermixed (Table 3.1). This chapter furthermore includes major community 4 that is predominantly located on Dwyka tillite, as well as major community 5 which grows in deep aeolian sand deposits (Table 3.1).

In the descriptions the reference to species groups in the description of each community refers to those indicated in the phytosociological table (Annexure 1). Reference is also made to the synoptic table (Annexure 2). The species indicated in bold under the heading “constant species” are those that have a 100% constancy in that specific plant community. The important species are listed in the discussion in relation to frequency (highest to lowest); species underlined are also prominent in the synoptic table. The phytosociological table is generally used to describe the important dominant species of the community, however frequency and fidelity values provided by the synoptic table are used as confirmation and in support of the phytosociological table.

4.2 ECOLOGICAL DESCRIPTION OF PLANT COMMUNITIES

SECTION 4.2.1: MAJOR COMMUNITY 1

Major plant community 1 is divided into 13 different communities that can be grouped into five variants, seven sub-communities and six communities as listed below (Annexure 1):

Major Plant Community 1: *Elytropappus rhinocerotis* shrubland

- 1. *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community**
- 2. *Selago triquetra*–*Elytropappus rhinocerotis* community**
 - 2.1 *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community
 - 2.2 *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community
- 3. *Oedera genistifolia*–*Elytropappus rhinocerotis* community**
 - 3.1 *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community
 - i *Cineraria platycarpa* variant

- ii *Pelargonium carneum* variant
- 3.2 *Oedera genistifolia*–*Elytropappus rhinocerotis*– *Pelargonium pillansii* sub-community
- 3.3 *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community
 - i *Drosanthemum striatum* variant
 - ii *Crassula saxifraga* Typicum variant
 - iii *Nerine humilis* variant

4. *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community

5. *Erica boucheri*–*Elytropappus rhinocerotis* community

6. *Struthiola confusa*–*Elytropappus rhinocerotis* community

- 6.1 *Struthiola confusa*–*Elytropappus rhinocerotis* Typicum sub-community
- 6.2 *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community

Major Plant Community 1: *Elytropappus rhinocerotis* shrubland

The *Elytropappus rhinocerotis* (renosterbos) Major community (Figure 4.1) is a shrubland composed of medium (<2 m) to low (<1 m) shrub vegetation. Thompson (1996) defines shrubland as vegetation comprising of deciduous bushes that is typical of the Karoo biome. From the range of hills north, east and south-east of the Greater Brandvlei Dam, this major community extends south-eastwards towards Robertson. It forms the dominant vegetation type on many slopes and plateaus of Hammansberg, Ouhangsberg, Gannaberg, Gembokkop, and Rooiberg where it is being supported by soils derived from mudrock-dominated geological formations (Figure 3.11; Gresse 1997).

Phytosociological table

Species Group A: Important species for the *Elytropappus rhinocerotis* shrubland:

Important species for Species Group A are *Mohria caffrorum*, *Berkheya armata*, *Cyphia volubilis*, *Antimima microphylla*, *Pterygodium alatum*, *Nenax hirta*, *Chamarea gracillima* and *Eriospermum pubescens* (Annexure 1).

Synoptic table

Number of relevés: 56

Diagnostic species: None

Constant species: ***Elytropappus rhinocerotis* 98**, *Eriocephalus africanus* 80, *Oedera genistifolia* 80, *Satyrium erectum* 89, *Tribolium hispidum* 79 and *Ursinia anthemoides* 77 (Annexure 2).



Figure 4.1: The *Elytropappus rhinocerotis* shrubland on the southern slopes of Ouhangsberg.

Dominant species: *Antimima microphylla* 2, *Ehrharta calycina* 2, *Ehrharta capensis* 2, *Ehrharta villosa* 4, *Elytropappus rhinocerotis* 45, *Erica boucheri* 4, *Eriocephalus africanus* 5, *Felicia filifolia* ssp. *schaeferi* 2, *Helichrysum hamulosum* 2, *Helichrysum rosum* 4, *Restio capensis* 2, *Restio sieberi* 4, *Tenaxia stricta* 2, *Metalasia acuta* 2, *Mohria caffrorum* 4, *Nenax hirta* 2, *Oedera genistifolia* 4, *Oedera squarrosa* 2, *Othonna retrofracta* 2, *Pentameris airoides*

ssp. airoides 9, *Pentameris eriostoma* 2, *Pteronia fasciculata* 4, *Pteronia paniculata* 11, *Ruschia caroli* 4, *Troglophyton parvulum* 2, *Ursinia anthemoides* 5, *Wiborgia mucronata* 2 and *Willdenowia incurvata* 2 (Annexure 2).

Discussion:

Mohria caffrorum and *Cyphia volubilis* are important in this major community but are also constant species in sub-community 10.2. *M. caffrorum* is furthermore constant in Community 13. Although *Berkheya armata* is dominant in Major community 1, it is also prominent in Major community 3 (Annexure 1).

This major community includes five different land types and is located predominantly in the following areas:

- West- and south facing mid- and footslopes flanking the Greater Brandvlei Dam on the eastern side: Land Type Bb41a, terrain unit 3 (Table 2.2); Land Type Fb123 a and b, terrain unit 3 and 4 (Table 2.5).
- South facing mid- and footslopes of the hills flanking the dam on the northern side: Land type Fa198a, terrain units 3 and 4 (Table 2.3).
- The west-, south and east facing mid- and footslopes of the hills southeast of the dam: Land Type Fb123 a and b, terrain unit 3 and 4 (Table 2.5).
- Depending on the degree of folding of the sedimentary layers, it also includes parts of the mid- and footslopes of the southern, southeastern and eastern slopes of the Hammansberg (Land Type Fa 198a, terrain unit 3 and 4, Table 2.3), as well as Ouhangsberg, Gannaberg, Gembokkop, and Rooiberg: (Land Type Ic116a, terrain units 3 and 4 (Table 2.6; Gresse 1997).

Although the geology associated with this *Elytropappus rhinocerotis* shrubland often involves the contact zone of the Bokkeveld- and Witteberg Groups in this part of the study area, it is predominantly underlain by the mudrock-dominated sedimentary deposits of the Witteberg Group, namely the Wagen Drift, Swartruggens, Kweekvlei and Waaipoort Formations. Depending on thickness of the geological formations, the degree of folding (Figure 3.16; Figure 4.2) and

topography, the alternating sandstone Formations (Blinkberg-, Witpoort and Floriskraal) between these mudrock-dominated formations influence the soils supporting this major community in various ways especially with regard to texture and rockiness (Table 4.2; Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982).

The Wagen Drift Formation, the oldest layer of the Witteberg Geological Group “consists of alternating beds of grey to black siltstone, sandy shale and mudstone, and lithic sandstone with interspersed light-grey sandstone” (Table 3.1; Gresse and Theron 1992). These beds are exceptionally mica-rich and weather red brown to light grey (Gresse and Theron 1992, Gresse 1997). Quartzitic sandstone of the Blinkberg Formation (Table 3.1; Gresse and Theron 1992, Gresse 1997) overlies the Wagen Drift Formation. Following the Blinkberg Formation, the Swartruggens Formation consists of siltstone and mudstone with two important sandstone horizons (Table 3.1; Gresse and Theron 1992, Gresse 1997). Micaceous shale and siltstone of the Wagen Drift-, Swartruggens-, Kweekvlei- and Waaipoort Formations underlie sample plots of this *Elytropappus rhinocerotis* shrubland east of the Greater Brandvlei Dam as well as in areas on Hammansberg and Droëriviersberg (Table 3.1; Gresse and Theron 1992, Gresse 1997). *Zoophycos* (*Spirophyton*) (Figure 13.12) and *Skolithos* (Figure 3.12; Figure 3.13 e) trace fossils occur.

The folded alternating mudrock and sandstone beds of the Witteberg Group, which support this major community, largely weather to lithic soil of the Glenrosa and Mispah soil forms where an orthic surface horizon (A horizon) dominates the study area (Figure 3.17; MacVicar *et al.* 1977).



Figure 4.2: Folding of the Witteberg sediments of the Group exposed in a road cutting north of the Greater Brandvlei Dam.

The extremely acidic soils that support this major community are finer grained and have higher clay and silt contents due to their origin from mudrock-dominated formations (Table 4.2). The sandstone components present in these mudrock-dominated formations, as well as the influence of the neighbouring quartzitic formations however give rise to rocky loamy sand and sandy loam soils. Sand (mostly fine sand) primarily contributes to soil texture while clay and silt are present in lower quantities (Table 4.1). Rock fragments of various sizes cover the soil in different proportions.

Apart from climate and geology, basic soil information and the water-holding capacity of soils are important environmental factors determining ecological conditions that in return determine plant community distribution (Piedallu *et al.* 2011). Soil properties as well as the soil water regime are important factors for plant growth as it influence carbon allocation, microbial activity, nutrient cycling, as well as the rate of photosynthesis (Coudun *et al.* 2006; Breda *et al.* 2006; Lebourgeois *et al.* 2005; Piedallu *et al.* 2011).

Chemical and mechanical analyses of the soil A horizon for major community 1 are given in Tables 4.1 and 4.2.

In this major community, natural soil erosion may sometimes occur in areas where no physical soil disturbance (caused by roads, overgrazing or trampling) took place, and where the environment bears no apparent geomorphic traits such as steep slopes or watersheds where erosion may be a result of runoff (personal observation). The cause of erosion rills and gullies, especially in the mudrock-derived soil of the study area, may therefore relate to chemical and structural properties of the soil. When the concentration of exchangeable magnesium (Mg) is relatively higher than that of calcium (Ca), Mg can cause dispersion, which can decrease water infiltration and leads to soil erosion (Rengasamy and Churchman 1999; Dontsova and Norton 2002). It is also known that high exchangeable Mg levels can enhance the dispersive potential of soils that also contain exchangeable sodium (Na). However, deterioration of the structure of soils that do not have sodic properties is also possible because high levels of exchangeable Mg can cause surface sealing, decreased infiltration, and increased runoff that can consequently cause erosion (Dontsova and Norton 2002). Conyers (1999) states that “clayey soils with exchangeable Ca:Mg < 2:1 tend to be dispersive.” McKenzie (1998) states that “a Ca:Mg ratio of less than 2.0 (and particularly less than 1.0) indicates a tendency towards clay dispersion and poor soil structure.”

In a study about the effects of exchangeable Ca:Mg ratio on soil clay flocculation, infiltration and erosion, Dontsova and Norton (2002) found that the hydration energy and radius of Mg on the exchange sites is a possible reason for the increased dispersion (the separation of sand, silt and clay in the field). Decrease in infiltration may consequently cause erosion (Bohn *et al.* 1985; Dontsova and Norton 2002). According to McKenzie (2003), “strongly hydrated ions such as Mg²⁺ are surrounded by a shell of water which effectively increases their distance from the surface of the particle and decreases the attraction of the electrical force acting on the ion”. This low ionic strength can lead to dispersion where separated particles and smaller soil aggregates can block pores and decrease infiltration (Dontsova and Norton 2002). The same authors showed that Mg-saturated soils are not only more prone to surface

sealing but also to erosion through the redistribution of forces that act on the soil particles (Dontsova and Norton 2002).

Bemlab guidelines state that a Mg:Ca ratio $>1:4$ (0.25) indicates to the possibility of poor internal drainage and subsoil salinity (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>). The references quoted above indicate that some of the soils supporting this major community may possibly be prone to erosion such as the soils supporting sub-communities 2.2, 3.2, 3.3 var iii, community 5 and sub-community 6.2 where the base saturation percentage of Mg exceeds that of Ca (Table 4.1).

Table 4.1: Analyses of the soil A horizon for major community 1. T-value = sum of exchangeable Ca, Mg, Na and K.

Plant communities and subunits		pH (KCl)	Electrical resistance (ohm)	H (cmol/kg)	P (Bray II mg/kg)	Exchangeable cations				Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)	C (%)	Dissolvable S (mg/kg)	Base saturation					
						Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)								Na %	K %	Ca %	Mg %	T-value (cmol/kg)	% Acid saturation
1	Community 1	4.9	2730	0.64	7	0.10	0.18	1.47	1.03	0.5	1.0	71.2	0.13	33.52	1.36	8.53	3.03	5.12	43.05	30.09	3.42	18.71
2	Sub-community 2.1	3.9	4820	0.93	7	0.05	0.09	0.53	0.48	0.3	0.4	58.4	0.06	27.99	0.74	11.69	2.60	4.42	25.42	22.86	2.08	44.71
	Sub-community 2.2	3.8	2680	1.06	8	0.09	0.10	0.52	0.61	0.3	0.4	14.2	0.09	52.44	0.83	11.53	3.78	4.39	21.61	25.75	2.38	44.46
3	Sub-community 3.1 var i	4.3	430	1.6	24	0.22	0.21	3.30	2.77	1.2	1.8	178.7	0.34	170.21	2.39	43.73	2.76	2.54	40.73	34.20	8.09	19.78
	Sub-community 3.1 var ii	4.6	840	1.08	14	0.21	0.26	1.91	1.71	0.9	1.0	107.4	0.26	100.9	1.46	23.1	4.10	5.09	36.88	33.06	5.17	20.87
	Sub-community 3.2	4	1960	1.43	13	0.17	0.31	0.9	1.14	0.5	0.5	29.9	0.23	134.36	1.58	18.58	4.20	7.76	22.82	28.94	3.94	36.28
	Sub-community 3.3 var i	4.3	2080	1.33	9	0.14	0.26	2.18	1.29	1.3	1.0	211.7	0.23	114.89	1.94	14.92	2.63	5.06	41.99	24.75	5.20	25.57
	Sub-community 3.3 var ii	5	2070	0.83	8	0.16	0.35	2.23	1.63	0.4	0.5	42.9	0.13	83.26	1.10	11.71	3.01	6.69	42.96	31.39	5.20	15.96
	Sub-community 3.3 var iii	3.8	2210	1.9	8	0.20	0.20	0.77	1.15	0.4	0.5	40.1	0.12	83.57	1.71	14.78	4.79	4.77	18.16	27.24	4.22	45.05
4	Community 4	4.2	4510	1.06	6	0.07	0.21	0.88	0.85	0.7	8.7	177.2	0.09	52.99	1.19	12.17	2.34	6.89	28.59	27.71	3.08	34.46
5	Community 5	4.3	380	1.08	6	0.27	0.23	1.57	1.88	0.5	0.8	49.9	0.33	82.37	1.88	25.04	5.41	4.56	31.13	37.44	5.03	21.47
6	Sub-community 6.1	4.2	4840	0.75	5	0.09	0.11	0.55	0.54	0.3	0.3	30.7	0.13	16.38	0.72	12.74	4.39	5.46	26.98	26.39	2.04	36.78
	Sub-community 6.2	3.8	5330	0.71	5	0.12	0.06	0.37	0.62	0.2	0.1	9.5	0.12	8.02	0.41	10.28	6.57	3.22	19.48	32.95	1.88	37.77
Average for major community		4.2	2683	1.11	9.2	0.15	0.2	1.32	1.21	0.6	1.3	78.6	0.2	73.9	1.33	16.83	3.82	5.07	30.75	29.44	3.98	30.91
Average for entire study		4.1	2525	1.18	21	0.2	0.2	1.65	1.39	0.5	1.7	53.8	0.32	77.59	1.48	18.98	4.4	4.95	29.38	26.85	4.64	34.43

Table 4.2: Mechanical analysis of the soil A horizon for major community 1. SaLm = Sandy loam, LmSa = Loamy sand

Plant communities and subunits		Clay %	Silt %	Sand %	Fine sand %	Med sand %	Coarse sand %	Stone %	Texture	Water-holding capacity mm/m
1	Community 1	11	10	79	60.4	13.0	5.4	13.8	SaLm	122.88
2	Sub-community 2.1	9	12	79	68.9	6.4	3.4	10.9	LmSa	143.71
	Sub-community 2.2	11	12	77	60	11.0	6.0	10.0	SaLm	131.06
3	Sub-community 3.1 var i	15	12	73	55.6	6.5	10.7	20.9	SaLm	113.00
	Sub-community 3.1 var ii	17	18	65	52.8	6.0	6.0	13.5	SaLm	125.00
	Sub-community 3.2	17	10	73	52.2	11.0	9.6	22.5	SaLm	103.00
	Sub-community 3.3 var i	19	16	65	46.6	9.0	9.0	20.0	SaLm	107.00
	Sub-community 3.3 var ii	15	14	71	53	7.0	12.0	22.0	SaLm	110.00
	Sub-community 3.3 var iii	15	12	73	53	6.0	13.0	25.0	SaLm	105.00
4	Community 4	19	20	61	47	5.0	9.0	19.0	SaLm	113.00
5	Community 5	11	10	79	58.2	9.4	11.2	24.8	LmSa	107.32
6	Sub-community 6.1	9	8	83	70.6	8.6	3.6	22.1	LmSa	123.19
	Sub-community 6.2	13	6	81	58.1	16.5	6.2	13.3	LmSa	115.55
Average for major community		14	12	74	57	9	8	18		116.93
Average for entire study		13	9	78	59	11	8	19		114

This Major community comprises six plant communities:

1. *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community

Locality: The west-facing slopes of the range of hills bordering the Greater Brandvlei Dam to the east, as well as a footslope at the fringe of a small ravine east of the dam (Figure 4.3).

Sample plots: 147, 148, 98 and 100.



Figure 4.3: *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community (Sample plot 100) on the eastern perimeter of the Greater Brandvlei Dam.

Land Type: Fb123a and Fb123b, terrain units 3 and 4 (Table 2.5).

Geology and soil: The geology of the *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community in the Greater Brandvlei Dam area includes the contact zone of the Witteberg- and Bokkeveld Groups in some areas. Where not inundated by the dam, alluvial sand and mud of varying thicknesses covers extensive areas of Bokkeveld Group outcrops (Le Roux *et al.* in prep; Annexure 13). Although colluvium and shallow soils cover most of the slopes built by the Witteberg Group, aeolian sand, blown up from the alluvium during the dry spells, covers some of these deposits (Le Roux *et al.* in prep; Annexure 13).

The soils of the footslopes here are primarily derived from siltstone, sandy shale, mudstone, as well as sandstone of the Wagen Drift formation of the Witteberg Group (Gresse and Theron 1992, Gresse 1997). These factors give rise to relatively shallow (depending on the amount of accumulated windblown sand) sandy loam soils, of which fine sand comprises the larger percentage together with almost even amounts of clay (11%) and silt (10%) and 13.8% stone volume (Table 4.1; Table 4.2). Rock fragments of various sizes (<10 mm to >200 mm) cover 40% to 80% of the substrate. Fine windblown sand particularly contributes to the soil texture in the area of sample plot 148 at the edge of a small ravine (Figure 4.4). Lichen-covered rocks are common in this habitat.



Figure 4.4: Sample plot 148 at the edge of a small ravine east of the Greater Brandvlei Dam.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Although strongly acidic, the soil here is less acidic in comparison with most of the soils supporting the major community (apart from that of sub-community 3.3 var ii). Compared to the rest of the major community, the soil here has the lowest amount of H (0.65 cmol/kg), the lowest amount of dissolvable S (8.53 mg/kg) and less Fe than most of the soil sampled in the major community (with exception of sub-community 2.1 and community 6) (Table 4.1).

Useful indices of the mineral fertility, the degree of soil development and buffering capacity to limit changes in pH are the cation exchange capacity (CEC) and the base saturation percentage (Gobat *et al.* 2004). The CEC of a soil depends on soil texture as well as the quantity and quality of the organic matter (Gobat *et al.* 2004). According to the Bemlab guidelines, “the T-value is the sum of all the exchangeable cations in the soil, including soluble (free) and those on the exchange sites” (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>).

Compared to the rest of the major community (with exception of sub-community 3.3 var ii), the base saturation of the soil here (81.29%) is high. Ca^{2+} and Mg^{2+} dominate the percentage base saturation, where Ca^{2+} is the highest compared to the rest of the soil of the major community. The total of exchangeable cations is slightly lower (T-value 3.42) than most of the soils supporting the major community (Table 4.1).

Gradient: Moderately sloped

Height above sea-level: 208 to 271 m

Aspect: SE, SW to W

Land-cover and use: Vegetation structure is a low shrubland (<1 m). While sampling plots 98, 100 and 147 are pristine veld, Sample plot 148 is situated in an area that is periodically grazed by cattle (Figure 4.4).

Phytosociological table

Species Group B: Important species for the *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community:

Important species for Species Group B are *Geissorhiza ornithogaloides* ssp. *ornithogaloides*, *Oxalis pes-caprae*, *Tylecodon ventricosus*, *Aspalathus muraltioides*, *Bulbinella cauda-felis*, *Drimia elata* and *Sparaxis maculosa* (Annexure 1).

Synoptic table

Number of relevés: 4

Diagnostic species: None

Constant species: ***Antimima microphylla* 100, *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Geissorhiza ornithogaloides* ssp. *ornithogaloides* 100, *Nenax hirta* 100, *Oxalis obtusa* 100, *Oxalis pes-caprae* 100, *Satyrium erectum* 100, *Tribolium hispidum* 100, *Tribolium utriculosum* 100, *Tylecodon ventricosus* 100 and *Ursinia anthemoides* 100** (Annexure 2).

Dominant species: *Ehrharta capensis* 25, *Elytropappus rhinocerotis* 25, *Mohria caffrorum* 25, *Nenax hirta* 25 and *Pteronia paniculata* 25 (Annexure 2).

Discussion

Being along the low-lying perimeter of the dam, mist (Figures 3.3 & 4.3) contributes to soil moisture in this area, especially during the autumn months. *Tylecodon ventricosus* occurs in all four sampling plots. While it also grows in other communities, the species has a high fidelity (68.1) in this plant community (Annexure). Although *Drimia elata* has a higher fidelity than *T. ventricosus*, the latter was chosen to name this community due to the geophytic life form of *D. elata* rendering the species not visible during the dry season.

Tylecodon ventricosus (Figure 4.5) is also important in Community 3, *Geissorhiza ornithogaloides* ssp. *ornithogaloides* in Sub-community 2.2,

Community 4 and in Community 6. *Oxalis pes-caprae* is also important in Sub-community 3.3 var. ii and in Sub-community 9.1 var. ii (Annexure 1).



Figure 4.5: *Tylecodon ventricosus* (Klipnenta/Nenta) (Crassulaceae) in the left hand side of the picture (Sample plot 100).

Apart from cover-abundance, *Aspalathus muraltioides*, *Drimia elata*, *Eriospermum graminifolium* and *Pelargonium myrrhifolium* are also significant regarding fidelity (Annexure 1).

Species only found in this community during the study are *Apatesia* species, *Argyrobium argenteum*, *Colchicum hughocymbion*, *Cotula macroglossa*, *Drimia filifolia*, *Drosanthemum ambiguum*, *Felicia bergeriana*, *Indigofera incana*, *Lobostemon argenteus*, *Spiloxene gracilipes*, *Pelargonium magenteum*, *Pelargonium myrrhifolium*, and *Tetragonia sarcophylla* (Annexure 1).

Species with Red List conservation status (<http://redlist.sanbi.org>) are *Colchicum hughocymbion* (Vulnerable) and *Sparaxis maculosa* (Endangered). *Antimima microphylla* and *Drimia elata* are considered to be Data Deficient / Taxonomically Problematic (<http://redlist.sanbi.org>).

2. *Selago triquetra*–*Elytropappus rhinocerotis* community

This community comprises two sub-communities located on the lower south- and north-facing slopes of the hills flanking the Greater Brandvlei Dam (Figure 4.6).



Figure 4.6: The *Selago triquetra*–*Elytropappus rhinocerotis* community on a north-facing slope of the hills between the Greater Brandvlei Dam and the Breede River (Sample plot 45).

Phytosociological table

Species Group C: Important species for the *Selago triquetra*–*Elytropappus rhinocerotis* community:

Important species (Species Group C) shared by sub-community 2.1 and sub-community 2.2 are *Nylandtia spinosa*, *Albuca flaccida*, *Senecio arenarius*, *Pelargonium rapaceum*, *Helichrysum incarnatum*, *Ruschiella lunulata*, *Crassula bergioides*, *Lachenalia unifolia*, *Selago triquetra*, *Lampranthus spiniformis*, *Heliophila coronopifolia*, *Moraea inconspicua* and *Wachendorfia parviflora* (Annexure 1).

Synoptic table

Number of relevés: 9

Diagnostic species: None

Constant species: *Adenogramma glomerata* 89, *Albuca flaccida* 78, *Babiana patula* 89, ***Chrysocoma ciliata* 100**, *Crassula bergioides* 89, *Crassula tetragona* ssp. *acutifolia* 78, *Cyphia digitata* 78, ***Elytropappus rhinocerotis* 100**, *Eriocephalus africanus* 89, *Helichrysum incarnatum* 78, ***Helichrysum rutilans* 100**, *Heliophila pendula* 89, *Restio capensis* 78, *Lachenalia unifolia* 89, *Lampranthus spiniformis* 89, ***Microloma sagittatum* 100**, *Moraea inconspicua* 78, *Moraea virgata* 78, *Pelargonium rapaceum* 78, *Pentameris airoides* ssp. *airoides* 89, *Pharnaceum aurantium* 89, *Ruschiella lunulata* 89, ***Satyrium erectum* 100**, ***Selago triquetra* 100** (Figure 4.7), *Senecio arenarius* 78, *Struthiola confusa* 78, ***Tribolium hispidum* 100**, ***Ursinia anthemoides* 100** and *Wachendorfia parviflora* 78 (Annexure 2).

Dominant species: *Antimima microphylla* 11, *Ehrharta calycina* 11, *Ehrharta villosa* 11, *Elytropappus rhinocerotis* 44, *Restio capensis* 11, *Ursinia anthemoides* 22, *Wiborgia mucronata* 11 and *Willdenowia incurvata* 11 (Annexure 2).

Although *Selago triquetra* (Figure 4.7) does not have the highest fidelity (59.0), the species has a frequency of 100% and the highest cover abundance in this community. *Moraea inconspicua* (78, 60.7), *Wachendorfia parviflora* (78, 71.4) and *Aspalathus spinosa* ssp. *flavispina* (67, 69.7) have higher fidelity values but lower frequency and lower cover abundance values (Annexure 2).

Selago triquetra is also important in Sub-communities 6.2 and 9.2. *Galenia sarcophylla* (33, 56.4) was only found in this community.

Species with Red List conservation status are *Crassula bergioides* (Near Threatened) and *Antimima microphylla*, which is considered to be Data Deficient / Taxonomically Problematic (<http://redlist.sanbi.org>).



Figure 4.7: *Selago triquetra* (Scrophulariaceae) on the southern slopes of the hills north of Greater Brandvlei Dam.

Discussion:

This community comprises two sub-communities located on the lower south- and north-facing slopes of the hills flanking the Greater Brandvlei Dam.

2.1. *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community

Locality: The southern slopes of the hills bordering the Greater Brandvlei Dam to the north, east and southeast (Figure 4.8).

Sample plots: 29, 28 and 27

Land Type: Fa198a, terrain unit 4 (Table 2.3).

Geology and soil: Rocks of the oldest layers of the Witteberg Group, the Wagen Drift- and Blinkberg Formations, underlie this sub-community. The Wagen Drift Formation comprises siltstone, sandy shale and mudstone as well as sandstone where the Blinkberg Formation consists of quartzitic sandstone with thin interlaced micaceous siltstone beds (Gresse and Theron 1992, Gresse 1997; Tankard *et al.* 1982). The Formations here give rise to loamy sand, of which fine sand comprises the larger percentage with clay (9%), silt (12%) and 10.9% stone volume (Table). Rocks, consisting of gravel with medium-sized (<200 mm) rock fragments, cover between 10 – 50 % of the area (Table 4.2).

Soil forms include Mispah and Glenrosa (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.8: The *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community (Sample plot 29) on the northern perimeter of the Greater Brandvlei Dam.

Extremely acidic (pH 3.9) loamy sand supports the vegetation of this sub-community. The high resistance to the flow of an electric current (4820 Ω) shows that the soil here is less saline compared to the most of the soil supporting the major community (with exception of community 4 and sub-community 6.2) (Table 4.1).

Organic matter gives rise to the organic carbon in the soil (Rasmussen and White 2010; Sparks 2012). The water holding capacity of soils is a function of the clay and organic matter content of the soil (Gobat *et al.* 2004). Although the organic carbon content is low (0.74%), the soil here has the highest water holding capacity (143.71 mm/m) compared to the soil supporting the rest of the major community. The good water holding capacity may be a result of the lowest amount of coarse sand, and low volume of stones in the soil of this sub-community compared to the soils supporting the rest of the major community (Tables 4.1 and 4.2).

The soil here has a lower ability to retain and exchange cations (T-value 2.08) than most of the soils for the rest of the major community (with the exception of community 6) (Table 4.1).

Gradient: Gentle to moderately sloped

Height above sea-level: 210 – 216 m

Aspect: S

Land-cover and use: Vegetation structure is a low shrubland (<1 m). Situated on the edge of the dam, this area is prone to erosion by wave action eroding the slope especially when strong south-easterly winds prevail (Figures 3.3 & 4.9). Trampling adds to damage and deterioration of the vegetation cover when people occasionally use this area for picnic, angling and camping (Le Roux 2012; Annexure 9).

Phytosociological table

Species Group D: Important species for the *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community:

Important species for Species Group D are *Wurmbea marginata*, *Moraea virgata*, *Hesperantha radiata*, *Itasina filifolia*, *Lotononis rigida*, *Limonium amoenum* (Figure 4.10) and *Tribolium echinatum* (Annexure 1).



Figure 4.9: Strong southeasterly winds occasionally erode the northern perimeter of the dam, such in the area of Sample plot 27.

Synoptic table

Number of relevés: 3

Diagnostic species: *Limonium amoenum* 88.0 and *Tribolium echinatum* 100.0 (Annexure 2).

Constant species: *Limonium amoenum* 100, *Antimima microphylla* 100, *Aspalathus submissa* 100, *Babiana patula* 100, *Bulbine frutescens* 100, *Chrysocoma ciliata* 100, *Cyanella hyacinthoides* 100, *Drosanthemum parvifolium* 100, *Ehrharta capensis* 100, *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 100, *Helichrysum rutilans* 100, *Heliophila coronopifolia* 100, *Heliophila pendula* 100, *Hesperantha radiata* 100, *Restio capensis* 100, *Itasina filifolia* 100, *Microloma sagittatum* 100, *Mohria caffrorum* 100, *Moraea inconspicua* 100, *Moraea virgata* 100, *Oedera squarrosa* 100, *Pentameris airoides* ssp. *airoides* 100, *Ruschia species* 100, *Satyrium erectum* 100, *Selago triquetra* 100, *Stipa capensis* 100, *Thesium subnudum* 100, *Trachyandra muricata* 100, *Tribolium*

***echinatum* 100, *Tribolium hispidum* 100, *Ursinia anthemoides* 100 and *Wurmbea marginata* 100** (Annexure 2).

Dominant species: *Antimima microphylla* 33, *Ehrharta calycina* 33, *Elytropappus rhinocerotis* 67 and *Ursinia anthemoides* 67 (Annexure 2).

Discussion

Although *Limonium amoenum* (Figure 4.10) also occurs in other plant communities, the species has the highest frequency and fidelity values in this sub-community.

In terms of fidelity, *Itasina filifolia* (100, 60.8) and *Moraea inconspicua* (100, 59.7) are also statistically significant in this sub-community, while *Tribolium echinatum* (100, 100.0) was only found to be present in this sub-community (Annexure 2).



Figure 4.10: *Limonium amoenum* flowering in summer. It occurs around the Greater Brandvlei Dam.

Antimima microphylla is considered to be Data Deficient / Taxonomically Problematic (<http://redlist.sanbi.org>).

2.2. *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community

Locality: On middle southern and northern slopes of the hills bordering the Greater Brandvlei Dam on the northern side, as well as low-lying areas between these hills (Figures 4.11 and 4.12).

Sample plots: 52, 45, 53, 25, 24 and 56



Figure 4.11: The *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community. It occurs in a low-lying area between the hills on the northern side of the Greater Brandvlei Dam (Sample plot 56).

Land Type: Fa198a, terrain unit 3 (Table 2.3).

Geology and soil: Rocks of the older mudrock dominated layers of the Witteberg Group underlie this sub-community north of the Greater Brandvlei Dam. These include the Wagen Drift- (siltstone, sandy shale and mudstone as well as sandstone) and the Swarttruggens (siltstone and shale with thin

interbedded sandstone) Formations. Sandstone of the Blinkberg Formation (quartzitic sandstone with thin interlaced micaceous siltstone beds), which occur between the aforementioned mudstone-dominated formations, influences the soil in this habitat (Gresse and Theron 1992, Gresse 1997; Tankard *et al.* 1982). As the area is exposed to north-westerly as well as south-easterly winds, sand was in the past blown from the Breede River as well as from the former floodplains to the south, which the Brandvlei Dam now inundates. This aeolian sand contributes to the soil texture to various degrees. The sandy loam soil consists of 10% stone volume with rock fragments of various sizes (<10 mm to >200 mm) covering 30 – 50% of the area (Table 4.2).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). Extremely acidic sandy loam (pH 3.8) supports the vegetation of this sub-community. As in the case of sub-community 2.1, the organic carbon content is low (0.83%), while the water holding capacity of the soil here (131.06 mm/m) is high compared to the soil supporting the rest of the major community (Table 4.1).

The soil has a lower ability to retain and exchange cations (T-value 2.38) than most of the soils for the rest of the major community (with the exception of community 6) (Table 4.1). Bemlab guidelines state that a Mg:Ca ratio higher than 1:4 (0.25) indicates to the possibility of poor internal drainage (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>). The base saturation Mg:Ca ratio of 1.19 indicates that the soil here may have a tendency towards clay dispersion and poor soil structure, which may consequently cause erosion (Table 4.1).

Gradient: Gentle to moderately sloped

Height above sea level: 212 – 216 m

Aspect: S, N, Neutral

Land-cover and use: Vegetation structure is a medium shrubland (<2 m). Disturbances in this area comprise gravel roads and Eskom power lines that cut across this area. Apart from the initial disturbance, the frequent use of Eskom service tracks along the power lines could cause further damage to

vegetation cover, especially since the area is characterised by a higher degree of sandiness (Figure 4.12).

Phytosociological table

Species Group E: Important Species for the *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community:

Important species for Species Group E are *Crassula strigosa*, *Restio gaudichaudiana*, *Wahlenbergia ramulosa*, *Helichrysum asperum*, *Diascia capensis*, *Wiborgia mucronata*, *Rumex lativalvis*, *Gladiolus alatus*, *Dorotheanthus bellidiformis*, *Gladiolus virescens*, *Cotula turbinata*, *Albuca longipes*, *Aspalathus spinosa* ssp. *flavispinosa*, *Drimia exuviata*, *Corycium orobanchoides*, *Oxalis glabra*, *Athanasia trifurcata*, *Ornithogalum suaveolens*, *Asparagus undulatus*, *Gladiolus orchidiflorus* and *Leysera tenella* (Annexure 1).

Synoptic table

Number of relevés: 6

Diagnostic species: None

Constant species: ***Adenogramma glomerata* 100**, *Albuca flaccida* 83, *Babiana patula* 83, ***Chrysocoma ciliata* 100**, *Cliffortia ruscifolia* 83, ***Crassula bergioides* 100**, ***Crassula strigosa* 100**, *Crassula tetragona* ssp. *tetragona* 83, *Cyphia digitata* 83, *Dorotheanthus bellidiformis* 83, ***Elytropappus rhinocerotis* 100**, *Eriocephalus africanus* 83, *Gladiolus venustus* 83, *Gladiolus virescens* 83, *Helichrysum asperum* 83, *Helichrysum incarnatum* 83, ***Helichrysum rutilans* 100**, *Heliophila pendula* 83, ***Lachenalia unifolia* 100**, ***Lampranthus spiniformis* 100**, ***Microloma sagittatum* 100**, *Nylandtia spinosa* 83, *Oxalis purpurea* 83, *Pelargonium rapaceum* 83, *Pentameris airoides* ssp. *airoides* 83, ***Pharnaceum aurantium* 100**, *Rumex lativalvis* 83, *Ruschiella lunulata* 83, ***Satyrium erectum* 100**, ***Selago triquetra* 100**, *Senecio arenarius* 83, *Struthiola confusa* 83, *Thesium dissitiflorum* 83, ***Tribolium hispidum* 100**, ***Troglophyton parvulum* 100**, ***Ursinia anthemoides* 100**, *Wachendorfia parviflora* 83, *Wahlenbergia ramulosa* 83 and *Willdenowia incurvata* 83 (Annexure 2).



Figure 4.12: Sample plot 53, illustrating the vegetation of the *Selago triquetra*–*Elytropappus rhinocerotis*–*Wiborgia mucronata* sub-community on the northern side of the dam.

Dominant species: *Ehrharta villosa* 17, *Elytropappus rhinocerotis* 33, *Restio capensis* 17, *Wiborgia mucronata* 17 (Figure 4.13) and *Willdenowia incurvata* 17 (Annexure 2).

Discussion

Although *Wiborgia mucronata* has a 100% frequency in variant ii of community 6 as well as the highest fidelity in community 15, it is a dominant species in this sub-community. Because the presence of *Wiborgia mucronata* (Figure 4.13) is associated with a higher degree of sandiness, the species is also characteristic for community 15 (Annexure 1).

Aspalathus spinosa ssp. *flavispina*, (67 51.5) is also significant here with a relatively high fidelity (Annexure 2).

Species only found in this sub-community during the study are *Aspalathus hispida* ssp. *hispida*, *Drosanthemum calycinum*, *Lampranthus debilis*, *Leysera tenella*, *Moraea ciliata*, *Spergularia media*, *Crotalaria excisa*, *Pauridia aquatica*, *Anisodontea fruticosa* and *Plantago coronopus* (Annexure 1).

Species with Red List conservation status are *Crassula bergioides* (Near Threatened) and *Lampranthus debilis* (Endangered) (<http://redlist.sanbi.org>).



Figure 4.13: The spiny, deciduous shrub *Wiborgia mucronata* (Fabaceae) (Silver Wing-pea, Silwer Vlerk-ertjie) flowering in summer.

3. *Euryops rehmannii*–*Elytropappus rhinocerotis* community

This community (Figure 4.14) consist of three sub-communities. Sub-community 3.1 is divided into two variants and Sub-community 3.3 into three variants.

Phytosociological table

Species group F: Important species for the *Euryops rehmannii*–*Elytropappus rhinocerotis* community:

Important species for Species Group F are *Pteronia paniculata*, *Euryops rehmannii*, *Crassula nudicaulis*, *Crassula subulata* var. *subulata*, *Oxalis pardalis*, *Heliophila elata*, *Ursinia pilifera*, *Selago aspera* and *Polygala scabra* (Annexure 1).

Synoptic table

Number of relevés: 29

Diagnostic species: None

Constant species: *Crassula atropurpurea* 76, *Crassula nudicaulis* 90, ***Elytropappus rhinocerotis* 97**, *Eriocephalus africanus* 76, *Euryops rehmannii* 79 (Figure 4.14), *Felicia filifolia* ssp. *schaeferi* 79, *Mohria caffrorum* 79, ***Oedera genistifolia* 100**, *Pentameris airoides* ssp. *airoides* 86, *Pteronia incana* 76, *Pteronia paniculata* 79, *Satyrium erectum* 86 and *Troglophyton parvulum* 86 (Annexure 2).

Dominant species: *Ehrharta villosa* 3, *Elytropappus rhinocerotis* 41, *Eriocephalus africanus* 3, *Felicia filifolia* ssp. *schaeferi* 3, *Helichrysum hamulosum* 3, *Restio sieberi* 3, *Oedera genistifolia* 7, *Oedera squarrosa* 3, *Othonna retrofracta* 3, *Pentameris airoides* ssp. *airoides* 3, *Pentameris eriostoma* 3, *Pteronia fasciculata* 7, *Pteronia paniculata* 17 and *Ruschia caroli* 7 (Annexure 2).

Discussion:

Euryops rehmannii (79, 38.9) (Figure 4.14) has the highest frequency as well as fidelity in this sub-community. *E. rehmannii* is also important in sub-communities 9.3, 11.1 and 11.3. Although *Oedera genistifolia* has high frequency here, the species does not have the highest fidelity. It also occurs in other communities, and it is especially important in communities 4 and 5. *Ursinia pilifera* is also important in sub-community 11.1 and in communities 12 and 13 (Annexures 1 & 2).

Pteronia paniculata is dominant here, but also important in community 1, sub-community 9.3 and in communities 11, 12 and 13 (Annexure 1).



Figure 4.14: *Euryops rehmannii*–*Elytropappus rhinocerotis* community



Figure 4.15: *Euryops rehmannii* (Asteraceae) flowering in September.

3.1. *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community

Phytosociological table

Species Group G: Important species shared by the two variants of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community:

Important species for Species Group G are *Indigofera heterophylla*, *Sutera glabrata*, *Moraea gawleri*, *Euphorbia burmannii*, *Oxalis engleriana*, *Drosanthemum speciosum*, *Helichrysum hamulosum*, *Antimima stokoei*, *Wiborgia tenuifolia* (Figure 4.16) and *Muraltia macrocarpa* (Annexure 1).



Figure 4.16: *Wiborgia tenuifolia* (Fabaceae) flowering in August on the southern slopes of Gannaberg.

Synoptic table

Diagnostic species: None

Constant species: *Antimima stokoei* 89, ***Crassula atropurpurea* 100**, ***Crassula nudicaulis* 100**, *Crassula subulata* var. *subulata* 78, *Crassula tetragona* ssp.

acutifolia 89, ***Drosanthemum speciosum* 100**, ***Elytropappus rhinocerotis* 100**, *Eriocephalus africanus* 89, *Heliophila pendula* 78, *Indigofera heterophylla* 78, ***Mohria caffrorum* 100**, *Moraea gawleri* 89, ***Oedera genistifolia* 100**, *Oedera squarrosa* 78, *Ornithogalum dubium* 78, *Oxalis engleriana* 78, *Oxalis obtusa* 78, *Pelargonium carneum* 78, *Pteronia incana* 89, *Pteronia paniculata* 89, ***Ruschia caroli* 100**, *Spiloxene flaccida* 89, ***Sutera glabrata* 100**, *Troglophyton parvulum* 89 and *Ursinia anthemoides* 89 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 67, *Helichrysum hamulosum* 11, *Pteronia paniculata* 11 and *Ruschia caroli* 11 (Annexure 2).

Discussion

Although *Wiborgia tenuifolia* (67, 57.9) also occurs in Communities 3, 5 and 8, it has the highest cover abundance and frequency, as well as high fidelity here. Other species with high frequency and fidelity (higher than 50%) are *Oxalis* sp. (56, 60.5), *Ruschia lineolata* (44, 60.5), *Babiana* sp. (33, 56.9), *Bulbine longifolia* (33, 56.9) *Crassula pubescens* ssp. *pubescens* (33, 50.9) and *Ficinia trichodes* (33, 50.9) (Annexures 1 & 2).

In the study area, *Drosanthemum speciosum* is not found on the hills around the Greater Brandvlei Dam, but occurs to the southeast of the dam. Hartmann (2008) describes the colour variation of the species throughout its distribution area. Figure 4.17 illustrates the difference in flower colour occurring in the study area.



Figure 4.17: The flower colours (a – f) of *Drosanthemum speciosum* occurring in the study area.

A localized endemic, *Moraea helicoidea* has recently been described from this sub-community where it grows on the farm Droogeriviersberg (Figure 4.18; Goldblatt *et al.* 2015; Annexure 10; Chapter 5.1.3.1; Figure 5.4).



Figure 4.18: The small geophyte, *Moraea helicoidea* (Iridaceae) at the type locality.

i *Cineraria platycarpa* variant

Locality: Lower slopes of Gannaberg, Gemsbokkop and Rooiberg (Figure 4.19).

Land Type: Ic116a, terrain unit 4 (Table 2.6).

Sample Plots: 139, 138, 137

Geology and soil: Bokkeveld–Witteberg contact zone. Mudstone of the upper layer of the Bokkeveld Group, the Klipbakkop Formation, as well as alternating beds of siltstone, sandy shale and mudstone with interbedded sandstone of the oldest layer of the Witteberg Geological Group, the Wagen Drift Formation (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982) underlie this sub-community. Rock fragments of various sizes (<10 mm to >200 mm) occur.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.19: The *Cineraria platycarpa* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis* community (Sample plot 137) at the southern footslope of Gannaberg.

The vegetation of sub-community 3.1 variant i is supported by an extremely acidic (pH 4.3) sandy loam soil with 20.9% stone volume. Electrical resistivity relates to various soil properties and is regularly used to evaluate soil salinity

(Pozdnyakova 1999; Rhoades *et al.* 1990). According to the Bemlab guidelines, the lower the resistance value the higher the salt content. Soil with resistance <300 Ω can be regarded as saline (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>). The soil of this variant has a much lower resistance to the flow of an electric current (430 Ω) compared to the rest of the soils supporting this major community and is close to what is regarded by the Bemlab as saline (Table 4.1; Table 4.2).

The mineral rich soil that support this variant has particularly high quantities of C, Mg, Mn and Fe compared to the rest of the soils of the major community. The soil here has a high ability to retain and exchange cations (T-value 8.09) and the acid saturation is low (Table 4.1).

Gradient: Moderate to steeply sloped

Height above sea-level: 298 – 469 m

Aspect: S, SE

Land-cover and use: Vegetation structure is a low shrubland (<1 m). Sample plot 137 is in natural veld on private land, Sample plot 138 is in the Amathunzi Private Nature Reserve and Sample plot 139 in the Graham Beck Private Nature Reserve.

Phytosociological table

Species Group H: Important species for the *Cineraria platycarpa* variant:

Important species for Species Group H are *Ornithogalum dubium*, *Sebaea exacoides*, *Ehrharta calycina*, *Tetragonia verrucosa*, *Lampranthus haworthii*, *Tripteris aghillana*, *Zygophyllum pygmaeum*, *Gloveria integrifolia*, *Ficinia trichodes*, *Brianhuntleya intrusa* and *Cineraria platycarpa* (Figure 4.20; Annexure 1).

Synoptic Table

Number of relevés: 3

Diagnostic species: *Cineraria platycarpa* 81.2 (Annexure 1).

Constant species: *Albuca species* 100, *Chrysocoma ciliata* 100, *Cotyledon orbiculata* var. *orbiculata* 100, *Crassula atropurpurea* 100, *Crassula nudicaulis* 100, *Crassula tetragona* ssp. *acutifolia* 100, *Drosanthemum speciosum* 100, *Ehrharta calycina* 100, *Elytropappus rhinocerotis* 100, *Euphorbia burmannii* 100, *Heliophila elata* 100, *Indigofera heterophylla* 100, *Lampranthus haworthii* 100, *Mesembryanthemum longistylum* 100, *Mohria caffrorum* 100, *Oedera genistifolia* 100, *Oedera squarrosa* 100, *Ornithogalum dubium* 100, *Ornithogalum hispidum* 100, *Pteronia incana* 100, *Pteronia paniculata* 100, *Ruschia caroli* 100, *Sebaea exacoides* 100, *Sutera glabrata* 100, *Tetragonia verrucosa* 100, *Thesium dissitiflorum* 100, *Troglophyton parvulum* 100 and *Ursinia anthemoides* 100 (Annexure 1).

Dominant species: *Elytropappus rhinocerotis* 67, *Helichrysum hamulosum* 33, *Pteronia paniculata* 33 and *Ruschia caroli* 33 (Annexure 1).

Discussion

The *Cineraria platycarpa* (Figure 4.20) variant is distinguished from the *Pelargonium carneum* variant by the absence of *Drosanthemum papillatum* in variant i, as well as the absence of *Cineraria platycarpa*, *Ehrharta calycina*, *Tetragonia verrucosa*, *Gloveria integrifolia* and *Brianhuntleya intrusa* in variant ii (Annexure 1).

Other significant species in terms of frequency and fidelity are *Gloveria integrifolia* (67 65.6) and *Brianhuntleya intrusa* (67 65.6). *Ornithogalum dubium* is also important in community 3, in sub-community 9.3 and in community 13. *Sebaea exacoides* is also important in community 13. *Ehrharta calycina* is important in communities 2, 12, 13 and 15 (Annexure 2).

Species only found in this variant during the study are *Delosperma inconspicuum*, *Moraea polyanthos*, *Ixia collina*, *Lepidium africanum*, *Anisodonteia* species, *Bulbine favosa* and *Pelargonium abrotanifolium* (Annexure 1).



Figure 4.20: The small annual, *Cineraria platycarpa* on Rooiberg.

Species with Red List conservation status are *Wiborgia tenuifolia* (Near Threatened) *Brianhuntleya intrusa* (Near Threatened) and *Ixia collina* (Endangered) (<http://redlist.sanbi.org>).

ii *Pelargonium carneum* variant

Locality: On the southern slopes of Droëriviersberg and Ouhangsberg, as well as on the south-western slope of Gannaberg in Trappieskraalkloof (Figure 4.21).

Sample plots: 135, 134, 130, 136, 132 and 133



Figure 4.21: The *Pelargonium carneum* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis* community (Sample plot 136) on the southwest facing slope of Gannaberg.

Land Type: lc116, terrain units 3 and 4 (Table 2.6)

Geology and soil: Rocks of the three different mudrock dominated layers of the Witteberg Group, namely: the Wagen Drift- (alternating beds of siltstone, sandy shale and mudstone with interbedded sandstone); Swartruggens- (mudstone and siltstone with thin alternating sandstone beds); and Waaipoort Formation (shale, mudstone, siltstone and thin alternating sandstone beds) underlie this variant (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Rock fragments of various sizes (<10 mm to >200 mm) occur.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of the *Pelargonium carneum* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community occurs on a strongly acidic (pH 4.6) sandy loam soil with 13.5% stone volume. The soils of this variant are less stony, and less nutrient rich compared to the soils of the *Cineraria platycarpa* variant. However a higher resistance to the flow of an electric current (840 Ω) than the soil of the *Cineraria platycarpa* variant, the

soils supporting the *Pelargonium carneum* variant are more saline compared to the rest of the soils supporting the major community (Table 4.1).

Gradient: Gentle, moderate to steeply sloped

Height above sea-level: 460 – 500 m

Aspect: S, SW

Land-cover and use: Natural veld on private land, vegetation structure consists of a low shrubland (<1 m).

Phytosociological Table

Species Group I: Important species group for the *Pelargonium carneum* variant:

Important species for Species Group I are *Drosanthemum papillatum*, *Hesperantha falcata*, *Pelargonium carneum* (Figure 4.22), *Oxalis species* (Annexure 1).

Synoptic Table

Number of relevés: 6

Diagnostic species: None

Constant species: ***Antimima microphylla* 100, *Antimima stokoei* 100, *Crassula atropurpurea* 100, *Crassula nudicaulis* 100, *Crassula subulata* v. *subulata* 100, *Crassula tetragona* ssp. *tetragona* 83, *Cyphia volubilis* 100, *Drosanthemum papillatum* 83, ***Drosanthemum speciosum* 100, *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 100, *Felicia filifolia* ssp. *schaeferi* 83, *Heliophila pendula* 83, *Hesperantha falcata* 83, ***Mohria caffrorum* 100, *Moraea gawleri* 100, *Oedera genistifolia* 100, *Othonna auriculifolia* 83, *Oxalis engleriana* 83, *Oxalis obtusa* 83, *Oxalis purpurea* 83, ***Pelargonium carneum* 100, *Pteronia fasciculata* 83, *Pteronia incana* 83, *Pteronia paniculata* 83, ***Ruschia caroli* 100, *Satyrium erectum* 100, *Spiloxene flaccida* 100, *Sutera glabrata* 100, *Troglophyton parvulum* 83, *Ursinia anthemoides* 83** (Annexure 2).********

Dominant species: *Elytropappus rhinocerotis* 67 (Annexure 2).



Figure 4.22: The summer flowering hysteranthous geophytic *Pelargonium carneum* (Geraniaceae) on Ouhangsberg (a) with the leaves following the flowers in spring (b).

Discussion

Although *Antimima stokoei* has the highest fidelity here, *Pelargonium carneum* was chosen to name this variant due to the highest frequency and cover abundance and significance regarding fidelity (58.7). *P. carneum* also grows in other communities, but is dominant here. Species only found in this variant during the study are *Bulbinella punctulata*, *Centella asiatica*, *Chironia baccifera*, *Felicia hyssopifolia*, *Ixia* sp. aff. *I. dieramoides*, *Ixia simulans*, *Moraea thomasiae*, *Polygala microlopha* var. *microlopha* and *Romulea tortilis* var. *dissecta* (Annexures 1 & 2).

Antimima microphylla and *Romulea tortilis* var. *dissecta* is considered to be a Data Deficient / Taxonomically Problematic species (<http://redlist.sanbi.org>).

3.2. Euryops rehmannii–Elytropappus rhinocerotis–Pelargonium pillansii sub-community

Locality: Southern slopes of the hills bordering the Greater Brandvlei Dam to the north (Figure 4.23).

Sample plots: 77, 75, 84, 44, 30, 26 and 1

Land Type: Fa198a, terrain units 3 and 4 (Table 2.3)

Geology and soil: Rocks of the oldest formation of the Wittteberg Group, the Wagen Drift formation, underlie this sub-community. The Wagen Drift formation consists of alternating beds of siltstone, sandy shale and mudstone with interbedded sandstone (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982) and contain from 50 – 80% covering with rock fragments of various sizes (<10 mm to >200 mm).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of sub-community 3.2 is supported by extremely acidic (pH 4) sandy loam soil with 22.5% stone volume. The soil here has a higher amount of H, as well as Fe compared to the rest of the soils that support this major community. Though the total amount of exchangeable cations is relatively low, the base saturation percentage of exchangeable K is high. The base saturation Ca:Mg ratio of 0.79 indicates a tendency towards clay dispersion and poor soil structure (Table 4.1).



Figure 4.23: The *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Pelargonium pillansii* sub-community (Sample plot 75).

Gradient: Moderate to steeply sloped

Height above sea level: 218 - 254 m

Aspect: S

Land-cover and use: Vegetation structure is a low natural shrubland (<1 m) on land owned by the National Department of Water Affairs (DWA).

Phytosociological Table

Species Group J: Important species for the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Pelargonium pillansii* sub-community:

Important species for Species Group J are *Xenoscapa fistulosa*, *Cyanella lutea* *Pelargonium pillansii* (Figure 4.24) and *Tulbaghia capensis* (Annexure 1).



Figure 4.24: The geophytic hysteroanthous *Pelargonium pillansii* (Geraniaceae) bears flowers in March and leaves in the growing season (September/October). The sweet clove-scented flowers open at night.

Synoptic Table

Number of relevés: 7

Diagnostic species: None

Constant species: *Crassula nudicaulis* 86, ***Cyanella lutea* 100**, ***Elytropappus rhinocerotis* 100**, *Euryops rehmannii* 86, *Felicia filifolia* ssp. *schaeferi* 86, *Helichrysum rutilans* 86, ***Hesperantha acuta* 100**, ***Restio sieberi* 100**, ***Tenaxia stricta* 100**, *Muraltia trinervia* 86, ***Oedera genistifolia* 100**, *Pelargonium radiatum* 86, *Pentameris airoides* ssp. *airoides* 86, ***Satyrrium erectum* 100**, ***Tribolium hispidum* 100**, *Troglophyton parvulum* 86, *Ursinia anthemoides* 86, *Wurmbea variabilis* 86 and *Xenoscapa fistulosa* 86 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 57, *Pteronia fasciculata* 14 and *Pteronia paniculata* 14 (Annexure 2).

Discussion

Pelargonium pillansii (57, 44.7) shows the highest cover abundance, frequency and fidelity for this sub-community. *Xenoscapa fistulosa* as well as *Cyanella*

lutea are furthermore important in variant ii and iii of sub-community 3.3. Species only found in this sub-community during the study are *Romulea hirsuta* var. *hirsuta*, *Chenopodium mucronatum* and *Lachenalia lutea* (Annexures 1 & 2).

3.3. *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community

Phytosociological Table

Species Group K: Important Species for the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community:

Crassula saxifraga (Figure 4.25) is important in all the three variants of Sub-community 3.3 (Annexure 1).

Synoptic Table

Number of relevés: 13

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 77, *Crassula nudicaulis* 85, *Crassula saxifraga* 77, *Ehrharta capensis* 85, ***Elytropappus rhinocerotis* 92**, ***Euryops rehmannii* 92**, ***Felicia filifolia* ssp. *schaeferi* 92**, ***Hesperantha acuta* 92**, *Capeochloa arundinacea* 77, *Tenaxia stricta* 77, *Mohria caffrorum* 77, ***Oedera genistifolia* 100**, *Pelargonium radiatum* 85, ***Pentameris airoides* ssp. *airoides* 100**, *Pentameris eriostoma* 85, *Pteronia fasciculata* 77, *Pteronia paniculata* 77, ***Satyrrium erectum* 92** and *Troglophyton parvulum* 85 (Annexure 2).

Dominant species: *Ehrharta villosa* 8, *Elytropappus rhinocerotis* 15, *Eriocephalus africanus* 8, *Felicia filifolia* ssp. *schaeferi* 8, *Restio sieberi* 8, *Oedera genistifolia* 15, *Oedera squarrosa* 8, *Othonna retrofracta* 8, *Pentameris airoides* ssp. *airoides* 8, *Pentameris eriostoma* 8, *Pteronia fasciculata* 8, *Pteronia paniculata* 23 and *Ruschia caroli* 8 (Annexure 2).



Figure 4.25: *Crassula saxifraga*, of the earliest plants to produce flowers in the growing season (it flowers in May).

Discussion

Capeochloa arundinacea, a dominant species in major community 3 is also a prominent species in this sub-community with a relatively high constancy. *Nerine humilis* (38, 43.2) is significant regarding fidelity (Annexure 2).

The *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community has three variants.

i *Drosanthemum striatum* variant

Locality: The hills bordering the Greater Brandvlei Dam to the east as well as on Hammansberg (Figure 4.26).

Sample plots: 149, 165 and 140

Land Type: Fb122a and Fb123b (Table 2.4; Table 2.5).



Figure 4.26: The *Drosanthemum striatum* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community (Sample plot 149) east of the Greater Brandvlei Dam.

Geology and soil: Rocks of the three different mudrock dominated layers of the Witteberg Group, the Wagen Drift (shale and siltstone with interbedded sandstone), Swartruggens (siltstone and shale with thin interbedded sandstone), and Waaipoort (mudstone, rhythmite, greywacke and thin conglomerate) Formations (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982) underlie the *Drosanthemum striatum* variant. Rock fragments of various sizes (<10 mm to >200 mm) occur.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of this variant is supported by extremely acidic (pH 4.3) sandy loam soil with 20.0% stone volume. Regarding soil texture, the soil here has a higher percentage of clay and a lower percentage of fine sand compared to the rest of the soils that support this major community (Table). The soil of this variant has a high amount of Mn and Cu and a high percentage of exchangeable Ca. The amounts of Cu and Fe in the soil here is highest compared to the rest of the soils supporting the major community. The quantity of Mn is also relatively high in comparison to most of the soils supporting the major community (Table 4.1).

Aspect: Neutral, SO, S

Gradient: Moderate to very steeply sloped

Height above sea-level: 332 - 430 m

Land-cover and use: Vegetation structure is a low shrubland (<2 m).

Phytosociological Table

Species group L: Important species for the *Drosanthemum striatum* variant:

Important species for Species Group L are *Asparagus declinatus* and *Drosanthemum striatum* (Figure 4.27; Annexure 1).

Synoptic Table

Number of relevés: 3

Diagnostic species: None

Constant species: ***Anthospermum spathulatum* 100, *Crassula nudicaulis* 100, *Ehrharta capensis* 100, *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 100, *Euryops rehmannii* 100, *Tenaxia stricta* 100, *Mohria caffrorum* 100, *Oedera genistifolia* 100, *Oedera squarrosa* 100, *Pentameris airoides* ssp. *airoides* 100 and *Pteronia fasciculata* 100** (Annexure 2).

Dominant species: *Ehrharta villosa* 33, *Elytropappus rhinocerotis* 67, *Eriocephalus africanus* 33 and *Oedera squarrosa* 33 (Annexure 2).



Figure 4.27: *Drosanthemum striatum* (Aizoaceae) flowering in September on Hammansberg.

Discussion

The *Drosanthemum striatum* variant is characterised by the presence of *Asparagus declinatus*, *Othonna retrofracta* and *Drimia anomala*. *Nerine humilis* and *Syncarpha canescens* are absent from this variant (Annexure 1).

Cotula tenella, *Pelargonium* sp. nov. 1 (collected during the data collection for this study) (Figure 4.28; Chapter 5.1.9.3; Figure 5.32).

Oxalis punctata, *Crassula ciliata*, *Nerine sarniensis* and *Strumaria tenella* were only found in this Typicum variant during the study (Annexure 1). The moist cool slopes in this variant is furthermore the habitat of *Crassula* sp. nov. 1 which was collected during data collection on Hammansberg in May 2014 and is currently being described by Dr Peter Bruyns¹ (Chapter 5.1.7.1; Figure 5.22).

¹ Bolus Herbarium, Department of Biological Sciences, University of Cape Town, 7701 Rondebosch, South Africa.



Figure 4.28: *Pelargonium* sp. nov. 1 (currently being described by Dr E.M. Marais²), with leaves in early spring and flowers following in October when the leaves are dry.

ii *Crassula saxifraga* Typicum variant

Locality: The hills bordering the Greater Brandvlei Dam to the north (Figure 4.29).

Sample plots: 60, 62, 49 and 2

Land Type: Fa198a, terrain unit 3 (Table 2.3).

² Department Forest and Wood Science, University of Stellenbosch, Stellenbosch, Private Bag X1, Matieland 7602, South Africa

Geology and soil: This sub-community is supported mostly by shallow rocky sandy loam soil of the oldest predominantly mudrock formation of the Witteberg Group, the Wagen Drift Formation (shale and siltstone with interbedded sandstone) (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Because of colluvium soils and folding, material derived from the Swartruggens Formation may also contribute here to the soil in some degree. Due to the influence of the adjoining quartz arenite of the Blinkberg formation, the soil is shallow and gravel to rock fragments of various sizes (<10 mm to >200 mm) cover 50 – 80% of the soil.



Figure 4.29: The *Crassula saxifraga* Typicum variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community (Sample plot 49).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). The vegetation of the *Crassula saxifraga* Typicum variant grows on a strongly acidic (pH 5) sandy loam soil with 22.0% stone volume. Regarding soil texture, the soil here have a higher percentage of clay and silt, and a slightly lower percentage of sand compared to the other soils supporting the major community (Tables 4.1 and 4.2).

The percentage acid saturation of the soil here is lower in comparison to the rest of the soils supporting the major community (Table 4.1).

Aspect: Neutral, S

Gradient: Gentle, moderate to very steeply sloped

Height above sea-level: 249 – 287 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

The Phytosociological Table indicates no important species for this variant (Annexure 1).

Synoptic Table

Number of relevés: 4

Diagnostic species: None

Constant species: ***Elytropappus rhinocerotis* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Hesperantha acuta* 100, *Oedera genistifolia* 100, *Oxalis depressa* 100, *Pelargonium radiatum* 100, *Pentameris airoides* ssp. *airoides* 100, *Pteronia paniculata* 100, *Satyrium erectum* 100, *Troglophyton parvulum* 100 and *Xenoscapa fistulosa* 100** (Annexure 2).

Dominant species: *Felicia filifolia* ssp. *schaeferi* 25, *Oedera genistifolia* 50, *Pentameris airoides* ssp. *airoides* 25 and *Pteronia paniculata* 75 (Annexure 2).

Discussion:

The *Crassula saxifraga* Typicum variant is characterised by the presence of *Othonna retrofracta* and *Asparagus declinatus* and the absence of *Drimia anomala*, *Nerine humilis* and *Syncarpha canescens*. *Cotula bipinnata* was only found to be present within this variant (Annexures 1 & 2).

iii *Nerine humilis* variant

Locality: The hills bordering the Greater Brandvlei Dam to the north (Figure 4.30).

Sample plots: 76, 74, 78, 66, 61 and 64

Land Type: Fa198a, terrain unit 3 (Table 2.3).



Figure 4.30: The *Nerine humilis* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community (Sample plot 78).

Geology and soil: This variant is supported mostly by shallow rocky sandy loam soil of the oldest predominantly mudrock (siltstone and shale with sandstone interbeds) formation of the Witteberg Group, the Wagen Drift Formation (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Due to the folded character of the area, colluvium quartz arenite of the Blinkberg Formation that overlies the Wagen Drift Formation (Table 3.1; Figure 3.11) contributes to the substrate. Fragments of rock varying in sizes (<10 mm to >200 mm) cover 50 – 80% of the soil in this habitat.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of the *Nerine humilis* variant is supported by an extremely acidic (pH 3.8) sandy-loam soil with 25.0% stone volume. The soil here has a higher amount of hydrogen compared to the rest of the soils that support this major community (Table). Compared to the rest of the soils of this major community, the soil here has the largest base saturation percentage of Mg^{2+} (27.24%). The Ca:Mg ratio of 0.67, together with a relatively high Na^+ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion. The soil of this variant has almost equal base- and acid saturation percentages (Tables 4.1 & 4.2).

Aspect: SE, S, E

Gradient: Steep to very steeply sloped

Height above sea-level: 233 – 305 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

Phytosociological Table

Species Group M: Important species for the *Nerine humilis* variant:

Important species for Species Group M are *Othonna retrofracta*, *Drimia anomala*, *Syncarpha canescens* and *Nerine humilis* (Annexure 1).

Synoptic Table

Number of relevés: 6

Diagnostic species: *Nerine humilis* 76.0 (Figure 4.31; Annexure 2).



Figure 4.31: The hysteranthous *Nerine humilis* (Amaryllidaceae) (Berglelie) north of the Greater Brandvlei Dam, flowering in April before the leaves appear.

Constant species: *Anthospermum spathulatum* 100, *Berkheya armata* 100, *Bulbine praemorsa* 83, *Chamarea gracillima* 83, *Crassula nudicaulis* 83, *Crassula saxifraga* 83, *Cyphia volubilis* 83, *Drimia anomala* 83, *Drosanthemum hallii* 83, *Ehrharta capensis* 100, *Elytropappus rhinocerotis* 83, *Euryops rehmannii* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Helichrysum rutilans* 83, *Hesperantha acuta* 100, *Hesperantha radiata* 100, *Restio sieberi* 100, *Capeochloa arundinacea* 83, *Tenaxia stricta* 83, *Mesembryanthemum longistylum* 83, *Mohria caffrorum* 83, *Montinia caryophyllacea* 100, *Nerine*

humilis 83, *Oedera genistifolia* 100, *Oedera squarrosa* 100, *Othonna retrofracta* 100, *Oxalis engleriana* 100, *Pelargonium radiatum* 100, *Pentameris airoides* ssp. *airoides* 100, *Pentameris eriostoma* 100, *Ruschia caroli* 83, *Satyrium candidum* 100, *Satyrium erectum* 100, *Tribolium hispidum* 83, *Troglophyton parvulum* 83 and *Xenoscapa fistulosa* 83 (Annexure 2).

Dominant species: *Restio sieberi* 17, *Othonna retrofracta* 17, *Pentameris eriostoma* 17, *Pteronia fasciculata* 17 and *Ruschia caroli* 17 (Annexure 2).

Discussion:

The *Nerine humilis* variant is differentiated from the other variant by the presence of *Othonna retrofracta*, *Drimia anomala*, *Nerine humilis* and *Syncarpha canescens* where *Nerine humilis* is the diagnostic species. During the study, *Drosanthemum pulchrum* was only found in this variant (Annexures 1 & 2). Species with Red List conservation status are *Drosanthemum hallii* (Endangered) and *D. pulchrum* (Vulnerable) (<http://redlist.sanbi.org>).

Drosanthemum pulchrum was only found in this variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community on the hills bordering the Greater Brandvlei Dam to the north (where *D. speciosum* does not occur). Although Hartmann (2008) and Hartmann and le Roux (2011) (Annexure 8) treat this as a distinct species, Bayer (2006) considers the species nothing less than *D. speciosum* (Chapter 5.3.1; Figure 5.48; Figure 5.55).

4. *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community

Locality: The lower southern slopes of the hills bordering the Greater Brandvlei Dam to the north (Figure 4.32).

Sample plots: 8, 11, 12, 10, 13 and 14

Land Type: Fa198a, terrain unit 3 (Table 2.3).

Geology and soil: Rocks of the oldest layer of the Witteberg Group, the Wagen Drift Formation underlie this community. The Wagen Drift Formation consists of shale and siltstone with interbedded sandstone (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). A 30 – 95% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.32: The *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community north of the Greater Brandvlei Dam (Sampling plot 13).

The vegetation of the *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community is supported by extremely acidic (pH 4.2) sandy loam soil with 19.0 % stone volume. Regarding soil texture, the soil here has a high percentage of clay and the highest percentage of silt in comparison with the rest of the soils supporting the major community. The relatively high resistance to the flow of an electric current (4510 Ω) indicates that the soil here is less saline compared to most of the soils that support this major community. The soil here contains a low amount of Na and a high amount of Mn, while the amount of Zn is the highest compared to the rest of the soil supporting this major community. The

total of exchangeable cations is low (T-value 3.08) in comparison with most of the soils of this major community (Tables 4.1 and 4.2).

Aspect: S

Gradient: Moderate to very steeply sloped

Height above sea-level: 225 – 294 m

Land-cover and use: Vegetation structure is a medium shrubland (<2 m)

Phytosociological Table

Species Group N: Important species for the *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community:

Important species for Species Group N are *Wurmbea variabilis*, *Cheilanthes hastata*, *Eriospermum dielsianum* ssp. *dielsianum*, *Stipa capensis*, *Moraea unguiculata*, *Cyanella hyacinthoides*, *Satyrium candidum*, *Bulbinella triquetra*, *Lichtensteinia interrupta*, *Helichrysum rosum*, *Tripteris tomentosa*, *Euphorbia silenifolia*, *Pterygodium catholicum*, *Agathosma serpyllacea*, *Pterygodium pentherianum*, *Perdicion capense*, *Sonderina tenuis*, *Berkheya heterophylla*, *Printzia polifolia*, *Corymbium glabrum* var. *glabrum*, *Cheilanthes capensis*, *Corymbium africanum* ssp. *scabridum* var. *scabridum*, *Pentaschistis glandulosa*, *Satyrium coriifolium*, *Agathosma virgata*, *Briza minor** and *Othonna digitata* (Annexure 1).

Synoptic Table

Number of relevés: 6

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 83, *Babiana patula* 83, *Berkheya armata* 83, ***Cheilanthes hastata* 100**, *Cyanella lutea* 83, ***Ehrharta capensis* 100**, ***Elytropappus rhinocerotis* 100**, *Eriocephalus africanus* 83, *Felicia filifolia* ssp. *schaeferi* 83, *Helichrysum rosum* 83, ***Restio capensis* 100**, ***Restio sieberi* 100**, ***Lichtensteinia interrupta* 100** (Figure 4.33), ***Tenaxia stricta* 100**, *Mohria caffrorum* 83, *Montinia caryophyllacea* 83, *Muraltia trinervia*

83, *Nenax hirta* 100, *Oedera genistifolia* 83, *Oedera squarrosa* 83, *Pelargonium radiatum* 100, *Pentameris airoides* ssp. *airoides* 100, *Pterygodium alatum* 83, *Pterygodium catholicum* 83, *Satyrium candidum* 83, *Satyrium erectum* 100, *Stipa capensis* 83, *Tribolium utriculosum* 100, *Troglophyton parvulum* 83, *Ursinia anthemoides* 100, and *Wurmbea variabilis* 100 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 17, *Helichrysum rosum* 33, *Restio sieberi* 17, *Tenaxia stricta* 17, *Mohria caffrorum* 17, *Pentameris airoides* ssp. *airoides* 67, *Troglophyton parvulum* 17 and *Ursinia anthemoides* 17 (Annexure 2).



Figure 4.33: The intensely aromatic perennial herb *Lichtensteinia interrupta* (Apiaceae) flowers in summer when the leaves are dry.

Discussion:

Other species with high fidelity (higher than 50%) are *Printzia polifolia* (67, 71.6), *Berkheya heterophylla* (67, 64.8), *Pterygodium pentherianum* (67, 64.8) and *Perdicium capense* (67, 55.1) (Annexure 2).

Species only found in this community during the study are *Cysticapnos cracca*, *Satyrium erectum* x *coriifolium* and *Romulea cruciata* var. *intermedia* (Annexure 1).

5. *Erica boucheri*–*Elytropappus rhinocerotis* community

Locality: Hammansberg and Droëriviersberg (Figure 4.34).

Sample plots: 167, 170, 154 and 131

Land Type: Fb122a and Ic116, terrain unit 3 (Table 2.4; Table 2.6).

Geology and soil: Mudstone of the Kweekvlei Formation of the Witteberg geological group underlies this plant community. The Kweekvlei Formation consists of black fissile shale, dark-grey micaceous shale and siltstone that weather to a light-grey or reddish and brown colour (Gresse and Theron 1992; Tankard *et al.* 1982). A 5% to 90% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of the *Erica boucheri*–*Elytropappus rhinocerotis* community is supported by extremely acidic (pH 4.3) loamy sand with 24.8 % stone volume. The low resistance to the flow of an electric current (380 Ω , the lowest measured compared to the rest of the soils supporting this major community) is close to what is regarded by the Bemlab guidelines as saline (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>) (Table 4.1). The base saturation Ca:Mg ratio of 0.83 of the soil here, as well as a high Na⁺ saturation, indicates a tendency towards clay dispersion and poor soil structure which may consequently cause erosion (Tables 4.1 & 4.2; Figure 4.35).



Figure 4.34: The *Erica boucheri*–*Elytropappus rhinocerotis* community (Sample plot 131) on Droëriviersberg.



Figure 4.35: The soils of Community 5 are prone to natural erosion.

Compared to most of the rest of the soils supporting this major community, the soil here has a high amount of dissolvable S and a high ability to retain and exchange cations (T-value 5.03) (Table 4.1).

Aspect: Neutral, S, SE

Gradient: Gentle to moderately sloped

Height above sea-level: 482 – 652 m

Land-cover and use: Vegetation structure is a low natural shrubland (<1 m).

Phytosociological Table

Species Group O: Important species group for the *Erica boucheri*–*Elytropappus rhinocerotis* community:

Important species for Species Group O are *Thesium imbricatum*, *Drosanthemum micans*, *Muraltia heisteria*, *Pteronia hirsuta*, *Polygala umbellata*, *Restio gossypina*, *Selago thomii*, *Erica setacea*, *Prismatocarpus pedunculatus*, *Erica boucheri*, *Zygophyllum fulvum*, *Geissorhiza delicatula*, *Oedera capensis*, *Leucadendron teretifolium*, *Ixia atrandra*, *Ficinia tristachya*, *Dicoma spinosa*, *Acrodon bellidiflorus*, *Prismatocarpus fruticosus*, *Aspalathus* sp. nov. and *Erepsia bracteata* (Annexure 1).

Synoptic Table

Number of relevés: 4

Diagnostic species: *Aspalathus* sp. nov. 83.8, ***Dicoma spinosa* 91.4**, *Erica boucheri* 82.9 and *Prismatocarpus fruticosus* 76.2 (Annexure).

Constant species: ***Anthospermum spathulatum* 100**, ***Berkheya armata* 100**, ***Dicoma spinosa* 100**, ***Ehrharta capensis* 100**, ***Elytropappus rhinocerotis* 100**, ***Erica boucheri* 100**, ***Felicia filifolia* ssp. *schaeferi* 100**, ***Capeochloa arundinacea* 100**, ***Tenaxia stricta* 100**, ***Mesembryanthemum longistylum* 100**, ***Metalasia acuta* 100**, ***Muraltia heisteria* 100**, ***Oedera genistifolia* 100**, and ***Ornithogalum dubium* 100** (Annexure 2).

Dominant species: *Erica boucheri* 50 (Annexure 2).

Discussion:

Leucadendron teretifolium (75, 57.4), *Muraltia heisteria* (100, 73.7), *Ixia atrandra* (75, 56.4), *Oedera capensis* (75, 63.1), *Acrodon bellidiflorus* (75, 72.3) and *Metalasia acuta* (100, 58.3) are significant species in this community regarding fidelity and frequency. *Thesium imbricatum* is also important in sub-communities 3.2 and 9.3. *Drosanthemum micans* and *Geissorhiza delicatula* are also important in sub-community 3.1. Although dominant here, *Erica boucheri* is also important in sub-community 11.1 (Annexures 1 & 2).

Species only found in this community are *Aspalathus flexuosa*, *Agathosma parva* and *Senecio glutinarius* (Annexures 1 & 2). Although *Aspalathus* sp. nov. 2 (Figure 4.36; Chapter 5.1.8.3; Figure 5.27) also grows in community 3.1 variant ii, the species is dominant within this community (Annexure 2).



Figure 4.36: The summer flowering *Aspalathus* sp. nov. 2 (Fabaceae) is dominant in the *Erica boucheri*–*Elytropappus rhinocerotis* community.

Erica boucheri (Rare) is a range-restricted species, previously only known from one population on Ouhangsberg. The conservation status of *Ixia atrandra* is classified as endangered. (<http://redlist.sanbi.org>).

6. *Struthiola confusa*–*Elytropappus rhinocerotis* community

Plant Community 6 comprises of two sub-communities.

Phytosociological Table

Species group P: Important species shared by Sub-community 1 and Sub-community 2 of the *Struthiola confusa*–*Elytropappus rhinocerotis* community:

Important species for Species Group P are *Struthiola confusa* (Figure 4.37), *Oxalis flava*, *Moraea vuvuzela*, *Drosera cistiflora*, *Wachendorfia paniculata*, *Heliophila pusilla*, *Lampranthus aurantiacus* and *Willdenowia arescens* (Annexure 1).



Figure 4.37: *Struthiola confusa* (Thymelaeaceae) flowering north of the Greater Brandvlei Dam in July 2006.

Synoptic Table

Number of relevés: 4 Diagnostic species: *Heliophila pusilla* 77.8 (Annexure 2).

Constant species: *Antimima microphylla* 100, *Babiana patula* 100, *Drosera cistiflora* 100, *Elytropappus rhinocerotis* 100, *Ficinia nigrescens* 100, *Helichrysum rutilans* 100, *Heliophila pusilla* 100, *Restio capensis* 100,

***Restio gaudichaudiana* 100, *Lampranthus spiniformis* 100, *Moraea vuvuzela* 100, *Pharnaceum aurantium* 100, *Satyrium erectum* 100, *Struthiola confusa* 100, *Tribolium hispidum* 100 and *Wachendorfia paniculata* 100** (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 50, *Eriocephalus africanus* 25 and *Metalasia acuta* 25 (Annexure 2).

Discussion:

Struthiola confusa and *Oxalis flava* are also important species in Communities 1 and 2, though different species combinations exist in all of them (Annexure 1).

6.1. *Struthiola confusa*–*Elytropappus rhinocerotis* Typicum sub-community

Locality: Hills bordering the Greater Brandvlei Dam on the southeastern side (Figure 4.38).

Sample plots: 144 and 142

Land Type: Fb123b, terrain unit 3 (Table 2.5).

Geology and soil: Mudstone and sandstone of the Swartruggens Formation (siltstone and shale with thin interbedded sandstone) and mudstone of the Kweekvlei Formation (black, fissile shale) of the Witteberg Group underlie this Typicum sub-community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). These Formations weather to a shallow pebbly loamy sand in the area with 80% to 90% covering of rock fragments of various sizes (<10 mm to >200 mm). Aeolian sand influences the soil texture in the area of Sample plot 144 and colluvium of the adjacent quartzitic Witpoort Formation contribute to the substrate in the area of Sample plot 142 (Figure 4.38).



Figure 4.38: *The Struthiola confusa–Elytropappus rhinocerotis* Typicum sub-community (Sample plot 142).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of this sub-community is supported by extremely acidic (pH 4.2) loamy sand with 22.1 % stone volume. In comparison to the texture of the rest of the soils supporting this major community, the soil here has a low percentage of clay and silt, but more sand (specifically fine sand). The high resistance to the flow of an electric current (4840 Ω) indicates the low salinity of soil here. Compared to the rest of the soil for the major community, the nutrient content of the soil here is relatively low (with especially low amounts of Fe and Mn) and the soil has a low ability to attract, retain and exchange cations (T-value 2.04) (Tables 4.1 and 4.2).

Aspect: N, S

Gradient: Moderately sloped

Height above sea-level: 244 and 259 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

The phytosociological table indicates no important species for this variant (Annexure 1).

Synoptic table

Number of relevés: 2

Diagnostic species: None

Constant species: *Antimima species* 100, *Babiana patula* 100, *Berkheya armata* 100, *Crassula tetragona* ssp. *tetragona* 100, *Drosera cistiflora* 100, *Elytropappus rhinocerotis* 100, *Eriocephalus africanus* 100, *Ficinia nigrescens* 100, *Helichrysum rutilans* 100, *Heliophila pusilla* 100, *Restio capensis* 100, *Restio gaudichaudiana* 100, *Restio sieberi* 100, *Lampranthus aurantiacus* 100, *Lampranthus spiniformis* 100, *Leucadendron teretifolium* 100, *Moraea vuvuzela* 100, *Oxalis flava* 100, *Oxalis obtusa* 100, *Passerina truncata* 100, *Pharnaceum aurantium* 100, *Satyrium erectum* 100, *Senecio arenarius* 100, *Struthiola confusa* 100, *Tribolium hispidum* 100, *Tribolium utriculosum* 100, *Tripteris tomentosa* 100 and *Wachendorfia paniculata* 100 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 50 and *Metalasia acuta* 50 (Annexure 2).

Discussion

This Typicum sub-community is distinguished from the *Senecio anthemifolius* sub-community by the absence of all the typical species except for *Struthiola confusa* and *Moraea vuvuzela* (Figure 4.39; Chapter 5.1.3.2; Figures 5.6 – 5.11) (Annexure 1).

Erica quadrangularis was only found within this sub-community (Annexure 1).

The conservation status of the previously unknown species, *Moraea vuvuzela* (firstly collected in 2009 during data collection for this study) is endangered (Goldblatt and Manning 2010; Chapter 5.1.3.2; <http://redlist.sanbi.org>).



Figure 4.39: *Moraea vuvuzela* was named in commemoration of South Africa's hosting of the first Soccer World Cup tournament on the African continent in June 2010.

6.2. *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community

Locality: Hills bordering the Greater Brandvlei Dam on the eastern side (Figure 4.40).

Sample plots: 99 and 101

Land Type: Although this area is within a transition of Bb41a into Fb123a, these sample plots are on the footslope (terrain unit 3) and have the character of Bb41a rather than that of Fb123a (Tables 2.2 and 2.4).

Geology and soil: Although the area is a transitional zone between the Witteberg- and Bokkeveld Groups, varying thicknesses of alluvial sand and mud of varying thicknesses largely covers the outcrops of the Bokkeveld Group. In areas where it is not covered by the dam's water, colluvium and shallow soils cover most of the slopes built by the Witteberg Group. (Figure 4.40; Le Roux *et al.* in prep; Annexure 13). Mudstone and sandstone of the Wagen Drift Formation (shale and siltstone with interbedded sandstone) underlie this part of the study area (Gresse and Theron 1992; Gresse 1997;

Tankard *et al.* 1982). Gravel to medium sized rock fragments (<200 mm) cover between 60 and 80% of the area.



Figure 4.40: *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community (Sample plot 101).

Soil forms include Mispah and Glenrosa (Figure 3.17; Soil Classification Working Group 1991).

The vegetation of this sub-community is supported by extremely acidic (pH 3.8) loamy sand with 13.3 % stone volume. In comparison to the texture of the rest of the soils supporting this major community, the soil here has a low percentage of silt and a high percentage of sand. The high resistance to the flow of an electric current (5330 Ω), the highest compared to the rest of the soils supporting this major community) indicates the low salinity of soil here. Compared to the rest of the soil for the major community, the nutrient content of the soil here is relatively low (with especially low amounts of Fe and Mn) and the soil has a low ability to attract, retain and exchange cations (T-value 1.88) (Tables 4.1 and 4.2).

Compared to the rest of the soils supporting the major community, the base saturation percentage of Na^+ is the highest for this major community. The

Ca:Mg ratio of 0.59, together with the high Na⁺ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Table 4.1).

Aspect: W

Gradient: Gentle

Height above sea-level: 121 and 202 m

Land-cover and use: Vegetation structure is a low natural shrubland (<1 m).

Phytosociological Table

Species group Q: Important species for the *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community:

Important species for Species Group Q are *Euphorbia tuberosa*, *Lotononis hirsuta*, *Gazania krebsiana* ssp. *arctotoides*, *Mesembryanthemum caudatum*, *Romulea hirsuta* var. *cuprea*, *Tribolium uniolae*, *Lessertia herbacea*, *Ficinia indica*, *Lampranthus scaber*, *Cyphia incisa* var. *cardamines*, *Aizoon sarmentosum*, and *Senecio anthemifolius* (Figure 4.41; Annexure 1).

Synoptic Table

Number of relevés: 2

Diagnostic species: *Aizoon sarmentosum* 100.0, *Cyphia incisa* var. *cardamines* 100.0, *Heliophila descurva* 100.0, *Senecio anthemifolius* 100 (Annexure 2).

Constant species: *Aizoon sarmentosum* 100, *Antimima microphylla* 100, *Arctopus echinatus* 100, *Aspalathus muraltioides* 100, *Aspalathus spicata* 100, *Babiana patula* 100, *Bulbinella triquetra* 100, *Chrysocoma ciliata* 100, *Corymbium africanum* ssp. *scabridum* var. *scabridum* 100, *Crassula subulata* var. *subulata* 100, *Cyanella species* 100, *Cyphia incisa* var. *cardamines* 100, *Drosanthemum parvifolium* 100, *Drosera cistiflora* 100, *Ehrharta capensis* 100, *Ehrharta villosa* 100, *Elytropappus rhinocerotis* 100, *Eriospermum graminifolium* 100, *Euphorbia tuberosa* 100, *Ficinia*

indica 100, *Ficinia nigrescens* 100, *Gazania krebsiana* ssp. *arctotooides* 100, *Geissorhiza ornithogaloides* ssp. *ornithogaloides* 100, *Helichrysum incarnatum* 100, *Helichrysum rutilans* 100, *Heliophila descurva* 100, *Heliophila pusilla* 100, *Indigofera heterophylla* 100, *Restio capensis* 100, *Restio gaudichaudiana* 100, *Lampranthus scaber* 100, *Lampranthus spiniformis* 100, *Lessertia herbacea* 100, *Lotononis hirsuta* 100, *Tenaxia stricta* 100, *Microloma sagittatum* 100, *Mohria caffrorum* 100, *Montinia caryophyllacea* 100, *Moraea vuvuzela* 100, *Moraea virgata* 100, *Nenax hirta* 100, *Nylandtia spinosa* 100, *Oedera genistifolia* 100, *Othonna pinnata* 100, *Oxalis depressa* 100, *Oxalis pulchella* var. *tomentosa* 100, *Oxalis purpurea* 100, *Pelargonium rapaceum* 100, *Pharnaceum aurantium* 100, *Mesembryanthemum caudatum* 100, *Romulea hirsuta* var. *cuprea* 100, *Rumex sagittatus* 100, *Satyrium erectum* 100, *Selago triquetra* 100, *Senecio anthemifolius* 100, *Struthiola confusa* 100, *Thamnochortus bachmannii* 100, *Thesium dissitiflorum* 100, *Thesium subnudum* 100, *Trachyandra muricata* 100, *Tribolium hispidum* 100, *Tribolium uniolae* 100, *Ursinia anthemoides* 100, *Wachendorfia paniculata* 100 and *Wiborgia mucronata* 100 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 50 and *Eriocephalus africanus* 50 (Annexure 2).

Discussion:

Species only found in this community are *Chenolea convallis*, *Nemesia gracilis*, *Muraltia divaricata*, *Hebenstretia dentata*, *Bartholina burmanniana* and *Ruschia costata* (Annexures 1 & 2).

Chenolea convallis (Figure 4.42) is a recently described species that was first collected in 2010 during the course of this study, is considered Critically Endangered (Snijman and Manning 2013; Chapter 5.1.6.1; Figures 5.20 – 5.22).



Figure 4.41: *Senecio anthemifolius* (Asteraceae), a diagnostic species for this sub-community.

Members of the Chenopodiaceae family often favour saline habitats. Although the leaves of *C. convallis* have the specialized anatomy apparently related to the xeric and saline habitats (Snijman and Manning 2013), the species grows in extremely acidic, nutrient poor soil (with high base saturation percentage of Na^+ and Mg^{2+}) at the edge of the Greater Brandvlei Dam (Table 4.1). The soil samples for this study were collected in the A horizon, but *C. convallis* has an exceptionally deep root system. Because the area is a transitional zone between the Witteberg- and Bokkeveld Groups, the deep root system could possibly relate to the utilisation of more mineral rich subsoil. Furthermore can the high Mg saturation percentage (highest for this major community), especially together with high Na^+ saturation, destabilise soil structure. Although the Mg:Ca ratio is not $>1:4$ (as indicated by Bemblab guidelines) the possibility of poor internal drainage and subsoil salinity may possibly exist (Bemblab: <http://www.bemblab.co.za/quickref.php?id=21>).



Figure 4.42: *Chenolea convallis* (Chenopodiaceae), a small succulent-leaved shrub grows at the edge of the Greater Brandvlei Dam.

Moraea vuvuzela is considered endangered and *Senecio anthemifolius* Data Deficient - Taxonomically Problematic (<http://redlist.sanbi.org>).

Heuweltjies

The silvery grey foliage of *Pteronia incana*, the dominant shrub on the Heuweltjies in major community 1, marks the mounds as distinct patches in the landscape (Figure 4.43).

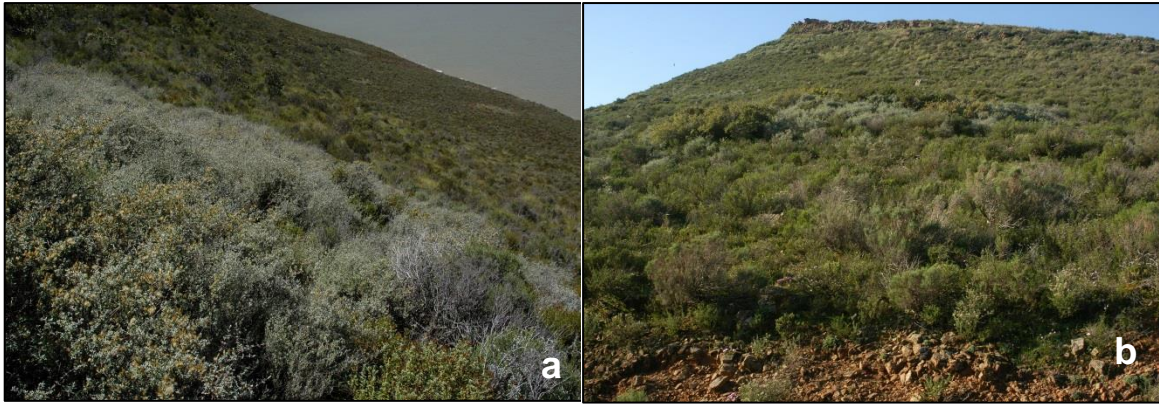


Figure 4.43: *Pteronia incana* is the dominant shrub on the Heuweltjies (a and b) in major community 1.

Plant species occurring on Heuweltjies in major community 1 includes: *Albucca maxima*, *Lichtensteinia interrupta*, *Bulbine caudafelis*, *Crossyne guttata*, *Drosanthemum parvifolium*, *Galenia africana*, *Haemanthus coccineus*, *Hemimeris racemosa*, *Lycium ferocissimum*, *Massonia depressa*, *Mohria caffrorum*, *Oedera genistifolia*, *Oxalis pes-caprae*, *Pteronia incana*, *Pteronia paniculata*, *Searsia incisa*, *Senecio erosus*, *Tetragonia fruticosa*, and *Tetragonia spicata* (Figure 4.44).



Figure 4.44: *Haemanthus coccineus*, *Mohria caffrorum*, *Searsia incisa* and *Pteronia incana* occur on the Heuweltjies in major community 1.

Conclusion

Compared to most of the soils supporting the other major communities (apart from the leached aeolian sand supporting major community 5), the soils supporting major community 1 contain the largest proportion of silt and the smallest proportion of sand. The soils of major community 1 are furthermore the least saline, has high amounts of Mn and lower amounts of Fe as well as dissolvable S (Tables 4.1 and 4.2).

Compared to community 1, which frequently occurs on rocky ridges, community 2 occurs on the slopes where the habitat is less rocky and where the soil has a slightly higher water-holding capacity.

The differences in vegetation likely relate to the noticeable difference in the salinity of the soil of sub-communities 2.1 and 2.2, where the soil supporting sub-community 2.2 is almost twice as saline as that supporting sub-community 2.1 (Table 4.1). Compared to sub-community 2.1, the soil of sub-community 2.2 is furthermore richer in Mg and Fe, but has much less Mn. Compared to the soils supporting the rest of the major community, the good water holding capacity of the soil of sub-community 2.1 may be due to the occurrence of the lowest amount of coarse sand together with a low volume of stones (Tables 4.1 and 4.2).

Soil differences are also likely to influence differences in the vegetation of the sub-divisions of community 3.

The following are differences in the soil of the two variants of sub-community 3.1:

- The soil of variant i is rockier, sandier and more saline, where variant ii has more clay and silt, and is slightly less saline.
- The soil of variant i is notably richer in H, P, Ca, Mg, Cu, Zn, Mn, B, Fe (the second highest measure in all the soils analysed), C and dissolvable S (the second highest measure in all the soils analysed).
- The soil of variant i has a high total of exchangeable cations (the second highest measure in all the soils analysed) (Tables 4.1 and 4.2).

Where *Pelargonium carneum* (variant ii) occurs on less nutrient rich soils derived from Witteberg Group, populations of *Cineraria platycarpa* (variant i) occur in the more saline, nutrient rich soil on the geological contact area of the Witteberg- and Bokkeveld Groups in the study area. *Cineraria platycarpa* also occurs in soil derived from the Malmesbury Group (which is not included in this study) (personal observation).

The soil of sub-community 3.1 is considerably more saline compared to sub-communities 3.2 and 3.3. The soil of sub-community 3.2 contains the smallest amount of Mn and the smallest number of exchangeable cations compared to the other soils of this community. The soils supporting sub-community 3.3 are somewhat less saline than the rest of the soils supporting this community. The soil of the *Drosanthemum striatum* variant contains higher amounts of Cu, Zn, Mn, B, Fe and dissolvable C compared to the soils supporting the other two variants. The soil of the *Crassula saxifraga* Typicum variant has a higher pH, while the soil supporting the *Nerine humilis* variant has the lowest pH and least amount of Ca compared to that of the other two variants (Table 4.1).

In comparison to the rest of the soils of the major community, the soil of community 4 has more silt and higher amounts of Zn and Mn while the soil supporting community 5 is more saline and inclined to clay dispersion (Table 4.1).

Compared to most of the soils supporting major community 1, the soils supporting community 6 have a higher sand proportion, are less saline, are relatively nutrient poor, with especially low amounts of Fe and Mn, and have a low ability to attract, retain and exchange cations (Tables 4.1 and 4.2). While the soils supporting sub-community 6.1 consist predominantly of fine sand, the soils of sub-community 6.2 have a higher amount of clay and more medium sand (Table 4.2). Compared to the soils supporting sub-community 6.1, the soils supporting sub-community 6.2 furthermore have less amounts of Fe and Mn, a lower ability to attract, retain and exchange cations, and have a higher tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Table 4.1).

The *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community most likely is a remnant of one of the alluvium vegetation types of the Brandvlei Valley that has been inundated by the Greater Brandvlei Dam (Figures 1.3, 2.1 & 2.2). Located at the lowermost footslopes of the hills around the dam, this vegetation is most probably a relic of larger tracts of Breede Alluvium Renosterveld vegetation, which still occur to the east of the larger study area (Le Roux *et al.* in prep; Annexure 13).

SECTION 4.2.2: MAJOR COMMUNITIES 2-5

Major plant communities 2-5 are described within this section and are listed below:

MAJOR PLANT COMMUNITY 2: *Passerina truncata* shrubland

7. *Pentameris eriostoma*–*Passerina truncata* community

8. *Drosanthemum hallii*–*Passerina truncata* community

9. *Protea laurifolia*–*Passerina truncata* community

9.1 *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community

i *Protea laurifolia* Typicum variant

ii *Psammotropha quadrangularis*–variant

iii *Leucadendron salignum*–variant

9.2 *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community

9.3 *Protea laurifolia*–*Passerina truncata*–*Phylica constricta* sub-community

MAJOR PLANT COMMUNITY 3: *Capeochloa arundinacea* shrubland**10. *Metalasia acuta*–*Capeochloa arundinacea* community**

- 10.1 *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community
 - i *Staavia capitella* variant
 - ii *Syncarpha mucronata* variant
- 10.2 *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community

11. *Ruschia caroli*–*Capeochloa arundinacea* community

- 11.1 *Ruschia caroli*–*Capeochloa arundinacea*–*Tritonia flabellifolia* sub-community
- 11.2 *Ruschia caroli*–*Capeochloa arundinacea*–*Othonna arbuscula* sub-community
- 11.3 *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogena verruculata* sub-community
- 11.4 *Ruschia caroli*–*Capeochloa arundinacea*–*Curio crassulifolius* sub-community

MAJOR PLANT COMMUNITY 4: *Hirpicium integrifolium* shrubland**12. *Euphorbia hamata*–*Hirpicium integrifolium* community****13. *Pelargonium karoicum*–*Hirpicium integrifolium* community****MAJOR PLANT COMMUNITY 5: *Thamnochortus bachmannii* Sandveld****14. *Leucospermum rodolentum*–*Thamnochortus bachmannii* community****15. *Willdenowia incurvata*–*Thamnochortus bachmannii* community**

Major Plant Community 2: *Passerina truncata* shrubland

This major community can be divided into eight communities that can be grouped into three variants, three sub-communities and three communities.

The *Passerina truncata* major community (Figure 4.45) is a medium tall shrubland (<2 m) with small *Protea laurifolia* trees that can grow taller than 4 m. From the range of hills north, east and southeast of the Greater Brandvlei Dam this major community extends south-eastwards towards Robertson. The vegetation dominated by *Passerina truncata* (Thymelaeaceae) is supported by extremely acidic shallow rocky soils mainly of the sandstone dominated crests as well as mid-slopes in the study area where colluvium of the sandstone-dominated formations of the Witteberg Group largely contributes to the substrate (Table 3.1; Figure 3.11).



Figure 4.45: *Passerina truncata* dominates most of the north-facing mid-slopes on the range of hills north of the Greater Brandvlei Dam.

This shrubland includes three different land types and comprises three plant communities located predominantly in the following areas:

- Mostly the crests and north facing mid-slopes, but also some mid-slopes on the south facing slopes of the hills flanking the Greater Brandvlei Dam on the northern side: Land type Fa198a, terrain units 1 and 3 (Table 2.3).
- Sandstone ridges of the hills southeast of the dam: Land type Fb123b, terrain unit 1 (Table 2.5).

Sandstone ridges on Hammansberg: Land type Fb122a terrain unit 1 (Table 2.4). The geology associated with this major community includes the Blinkberg- (light-grey quartzitic sandstone with thin micaceous siltstone beds); the Swartruggens- (siltstone and shale with thin interbedded sandstone), the Witpoort- (grey quartzitic sandstone with shale interbeds) and the Floriskraal Formation (yellow-brown-weathering quartzitic sandstone with alternating beds of siltstone and micaceous shale) of the Witteberg Group (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). This major community is also present on Ouhangsberg, Droëriviersberg and Gannaberg.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). Soil analyses of the A horizon are given in Tables 4.3 and 4.4 for major community 2. Sand (mostly fine sand) primarily contributes to soil texture (65-89%) of the loamy sand and sandy loam soils supporting the *Passerina truncata* shrubland, while clay and silt are present in lower quantities. Pockets of aeolian sand occur in some parts. Rock fragments of various sizes cover the soil in different proportions. Compared to most of the soils supporting the other major communities, the soil of this major community has a higher degree of rockiness (Table 4.4).

Compared to most of the soils supporting the other major communities, the soil of this major community is poorer in nutrients (with the exception of hydrogen and phosphorus), have a lower base saturation, and a lower total of exchangeable cations (Table 4.3).

Table 4.3: Analyses of the soil A horizon for major community 2. T-value = sum of exchangeable Ca, Mg, Na and K.

Plant communities and subunits	pH (KCl)	Electrical resistance (ohm)	H (cmol/kg)	P (Bray II mg/kg)	Exchangeable cations				Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)	C (%)	Dissolvable S (mg/kg)	Base saturation						
					Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)								Na %	K %	Ca %	Mg %	T-value (cmol/kg)	% Acid saturation	
7	Com 7	3.8	1050	2.14	135	0.20	0.16	1.38	0.90	0.4	1.4	27.20	0.30	159.57	0.48	20.87	4.16	3.40	28.8	18.83	4.78	44.82
8	Com 8	3.5	650	2.45	16	0.14	0.13	0.41	0.62	0.3	0.5	5.20	0.17	109.42	1.49	28.54	3.75	3.59	10.84	16.57	3.75	65.25
9	Sub-com 9.1 var i	3.8	2070	0.94	7	0.12	0.14	0.55	0.70	0.2	0.3	9.30	0.14	36.92	0.95	13.02	4.79	5.54	22.57	28.64	2.44	38.46
	Sub-com 9.1 var ii	3.4	4580	1.29	8	0.04	0.10	0.28	0.20	0.2	0.2	2.80	0.20	58.55	1.19	12.13	2.34	5.12	14.62	10.29	1.91	67.63
	Sub-com 9.1 var iii	3.9	3080	1.14	5	0.07	0.14	0.60	0.45	0.2	0.3	6.30	0.38	56.64	1.37	11.56	3.03	5.73	25.12	18.74	2.41	47.38
	Sub-com 9.2	3.9	4480	1.0	7	0.06	0.09	0.53	0.52	0.1	0.3	5.90	0.23	51.96	1.34	9.09	2.69	4.08	24.14	23.49	2.22	45.59
	Sub-com 9.3	4	1090	1.28	8	0.20	0.20	0.86	1.10	0.3	0.7	11.10	0.38	70.09	1.21	16.75	5.54	5.56	23.53	30.23	3.64	35.14
Average for major community		3.8	2429	1.46	27	0.12	0.14	0.66	0.64	0.24	0.53	9.69	0.26	77.59	1.15	15.99	3.76	4.72	21.37	20.97	3.02	49.18
Average for entire study		4.1	2525	1.18	21	0.2	0.22	1.65	1.39	0.5	1.7	53.8	0.32	77.59	1.48	18.98	4.4	4.95	29.38	26.85	4.64	34.43

Table 4.4: Mechanical analysis of the soil A horizon for major community 2. SaLm = Sandy loam, LmSa = Loamy sand.

Plant communities and subunits		Clay %	Silt %	Sand %	Fine sand %	Med sand %	Coarse sand %	Stoniness %	Texture	Water-holding capacity mm/m
7	Com 7	9	26	65	56.6	4.6	3.6	10.2	LmSa	142.20
8	Com 8	17	10	73	54.4	7.2	11.2	25.6	SaLm	103.73
9	Sub-com 9.1 var i	11	4	85	68.2	10.6	6.0	23.3	SaLm	115.02
	Sub-com 9.1 var ii	9	4	87	81.8	3.4	1.6	3.9	LmSa	167.52
	Sub-com 9.1 var iii	9	4	87	64.6	14.6	7.6	33.7	LmSa	94.00
	Sub-com 9.2	9	2	89	75.2	9.0	4.6	22.7	LmSa	122.94
	Sub-com 9.3	13	8	79	63.5	6.6	8.7	29.9	SaLm	105.51
Average for major community		11	8	81	66.3	8.0	6.2	21.3		121.56
Average for entire study		13	9	78	59.0	11.0	8.0	19.0		114.00

Phytosociological Table:**Species group R: Important species for the *Passerina truncata* shrubland:**

Important species for Species Group R are *Albuca papyracea*, *Drosanthemum hallii*, *Bulbine praemorsa*, *Bulbine frutescens*, *Gladiolus floribundus*, *Elytropappus gnaphaloides*, *Helichrysum hebelepis*, *Mesembryanthemum grossus*, *Lapeirousia pyramidalis* and *Othonna lingua* (Annexure 1).

Synoptic Table

Number of relevés: 36

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 86, *Crassula atropurpurea* 86, *Elytropappus rhinocerotis* 81, *Felicia filifolia* ssp. *schaeferi* 81, *Restio sieberi* 89, ***Oedera squarrosa* 94**, ***Passerina truncata* 94**, *Pentameris eriostoma* 81 and *Satyrium erectum* 81 (Annexure 2).

Dominant species: *Aspalathus tuberculata* 3, *Elytropappus gnaphaloides* 3, *Elytropappus rhinocerotis* 11, *Erica inaequalis* 6, *Eriocephalus africanus* 3, *Felicia filifolia* ssp. *schaeferi* 3, *Restio gaudichaudiana* 3, *Restio sieberi* 8, *Capeochloa arundinacea* 3, *Mesembryanthemum longistylum* 3, *Oedera squarrosa* 3, *Passerina truncata* 11, *Pentameris airoides* ssp. *airoides* 3, *Pentameris eriostoma* 3, *Phylica constricta* 3, *Phylica rogersii* 3, *Protea laurifolia* 3 and *Pteronia fasciculata* 6 (Annexure 2).

Discussion:

Mesembryanthemum grossus (58, 51.7) and *Gladiolus floribundus* (67, 52.9) are significant with regard to frequency and fidelity. *Bulbine frutescens* is a common species, but especially has high cover abundance in sub-communities 2.1, 2.2 and 2.3 (Annexures 1 & 2).

7. *Pentameris eriostoma*–*Passerina truncata* community

Locality: Hills bordering the Greater Brandvlei Dam on the northern side (Figure 4.46).



Figure 4.46: The *Pentameris eriostoma*–*Passerina truncata* community (Sample plot 31).

Sample plots: 6, 5, 9, 31 and 32

Land Type: Fa198a, terrain units 1 and 3 (Table 2.3).

Geology and soil: The Blinkberg (light-grey quartzitic sandstone with thin micaceous siltstone beds), Swartruggens (siltstone and shale with thin interbedded sandstone) as well as Witpoort (grey quartzitic sandstone with shale interbeds) Formations of the Witteberg Geological Group underlie this community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). An 80% to 100% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). Extremely acidic (pH 3.8) loamy sand with 10% stone volume supports the vegetation of

this community. The soil here has a higher amount of silt and lower amount of sand compared to the rest of the soil supporting the major community (Table 4.4). Although most of the soils supporting the major community are poor in nutrients, the soil supporting this community is mostly higher in nutrients (especially H, P and Fe) than the rest of the soils supporting this major community (Table 4.3).

Aspect: S

Gradient: Steep to very steeply sloped

Height above sea-level: 232 – 277 m

Land-cover and use: Vegetation structure is a medium shrubland (< 2 m).

Phytosociological Table

Species Group S: Important species for the *Pentameris eriostoma*–*Passerina truncata* community:

Important species for Species Group S are *Ehrharta melicoides*, *Cleretum papulosum* ssp. *papulosum* and *Syncarpha staehelina* (Annexure 1).

Synoptic Table

Number of relevés: 5

Diagnostic species: None

Constant species: *Albuca papyracea* 80, *Anthospermum spathulatum* 80, *Aspalathus submissa* 80, ***Elytropappus rhinocerotis* 100**, *Eriocephalus africanus* 80, *Gladiolus floribundus* 80, *Helichrysum rutilans* 80, ***Restio sieberi* 100**, ***Tenaxia stricta* 100**, ***Oedera squarrosa* 100**, *Passerina truncata* 80, *Pentameris airoides* ssp. *airoides* 80, *Pentameris eriostoma* 80 and *Satyrium erectum* 80 (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 60, *Restio sieberi* 20, *Pentameris airoides* ssp. *airoides* 20 and *Pentameris eriostoma* 20 (Annexure 2).

Discussion:

The dominant grass species such as *Pentameris eriostoma* (Figure 4.47), *Capeochloa arundinacea* (Olifantsgras) and *Tenaxia stricta* (Bokbaardgras) grew more prolific following years where the study area received thundershowers in summer. These grass species were especially abundant in 2014 and 2015 following good summer rains in 2013 and 2014 (Figure 4.48).



Figure 4.47: *Pentameris eriostoma* (Poaceae) with its typical woolly leaf sheaths and ligules.

Although *Pentameris eriostoma* occurs throughout the study area, the species has the highest cover abundance recorded within this community and is regarded as being co-dominant with the other species listed above. Species that were only found to be present in this community are *Helichrysum litorale*, *Drosanthemum vandermerwei*, *Gladiolus recurvus*, *Ursinia nudicaulis* and *Tetragonia microptera* (Annexure 1).



Figure 4.48: *Pentameris eriostoma* (pictured here on Hammansberg in January 2015), *Capeochloa arundinacea* (Olifantsgras) and *Tenaxia stricta* (Bokbaardgras) are more abundant following years that had thundershowers in summer.

8. *Drosanthemum hallii*–*Passerina truncata* community

Locality: Hills bordering the Greater Brandvlei Dam on the northern side (Figure 4.49).

Sample plots: 15, 4, 16 and 3

Land Type: Fa198a, terrain units 1 and 3 (Table 2.3).

Geology and soil: The oldest sandstone layer of the Witteberg Group, the Blinkberg Formation underlies this community (Gresse and Theron 1992, Gresse 1997). In the Worcester–Robertson area, the Blinkberg Formation comprises of fine-grained quartzitic sandstone with thin micaceous siltstone beds (Gresse and Theron 1992; Tankard *et al.* 1982). A 70 – 95 % covering of gravel to large rock fragments (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.49: The *Drosanthemum hallii*–*Passerina truncata* community (Sample plot 3).

Extremely acidic (pH 3.5) sandy loam soil with 26% stone volume supports the vegetation of this community. The low resistance to the flow of an electric current (650 Ω), shows that the soil here is more saline than the rest of the soils supporting this major community. The soil contains more clay and silt, as well as higher amounts of H and dissolvable S in comparison to most of the soils supporting the rest of the major community. The amount of Fe is higher than most of the soils supporting the major community. The base saturation Ca:Mg ratio of 0.65 indicates a tendency towards clay dispersion and poor soil structure (Tables 4.3 and 4.4).

Aspect: Neutral, N, NW, W

Gradient: Steep to very steeply sloped

Height above sea-level: 257 – 295 m

Land-cover and use: Vegetation structure is of a medium shrubland (<2 m).

Phytosociological Table

Species Group T: Important species for the *Drosanthemum hallii*–*Passerina truncata* community:

Important species for Species Group T are *Drimia platyphylla* and *Albuca namaquensis* (Annexure 1).

Synoptic Table

Number of relevés: 4

Diagnostic species: None

Constant species: ***Babiana patula* 100, *Crassula atropurpurea* 100, *Drosanthemum hallii* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Helichrysum rutilans* 100, *Holothrix secunda* 100, *Restio sieberi* 100, *Lapeirousia pyramidalis* 100, *Tenaxia stricta* 100, *Mesembryanthemum longistylum* 100, *Oedera squarrosa* 100, *Oxalis convexula* 100, *Passerina truncata* 100, *Pelargonium radiatum* 100, *Pentameris eriostoma* 100 and *Satyrium erectum* 100** (Annexure 2).

Dominant species: *Elytropappus rhinocerotis* 25, *Felicia filifolia* ssp. *schaeferi* 25, *Restio sieberi* 25, *Mesembryanthemum longistylum* 25, *Oedera squarrosa* 25 and *Passerina truncata* 25 (Annexure 2).

Discussion:

Although *Drosanthemum hallii* is also listed under the important species for this major community, this species has the highest cover abundance in this community. *Searsia angustifolia* was only found in this community during the study, while *Albuca namaquensis* (75 69.1) is significant regarding fidelity (Annexures 1 & 2).

The hills around the Greater Brandvlei Dam are the type locality of *Drosanthemum hallii* where Harry Hall, at that time the senior horticulturist in charge of the succulent plant section of the Kirstenbosch National Botanic Garden (Glen and Germishuizen 2010), first collected the species in October 1960 (Chapter 5.3.1; Figure 5.43).

9. *Protea laurifolia*–*Passerina truncata* community

Phytosociological Table

Species Group U: Important species for the *Protea laurifolia*–*Passerina truncata* community:

Important species shared by sub-communities 9.1 - 9.3 (Species Group U) (Figure 4.50) are *Ruschia diversifolia*, *Phylica rogersii*, *Protea laurifolia*, *Oxalis pulchella* var. *tomentosa*, *Erica inaequalis*, *Aspalathus tuberculata* and *Pelargonium triste* (Annexure 1).



Figure 4.50: *Protea laurifolia*–*Passerina truncata* community (Sample plot 17).

Synoptic Table

Number of relevés: 27

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 89, *Chrysocoma ciliata* 78, ***Crassula atropurpurea* 93**, *Elytropappus rhinocerotis* 78, *Felicia filifolia* ssp. *schaeferi* 89, *Restio sieberi* 85, ***Oedera squarrosa* 93**, ***Passerina truncata* 96**,

Pentameris eriostoma 78, *Searsia dissecta* 78 and *Satyrium erectum* 78 (Annexure 2).

Dominant species: *Aspalathus tuberculata* 4, *Elytropappus gnaphaloides* 4, *Erica inaequalis* 7, *Eriocephalus africanus* 4, *Restio gaudichaudiana* 4, *Restio sieberi* 4, *Capeochloa arundinacea* 4, *Passerina truncata* 11, *Phylica constricta* 4, *Phylica rogersii* 4, *Protea laurifolia* 4 (Figure 4.51) and *Pteronia fasciculata* 7 (Annexure 2).

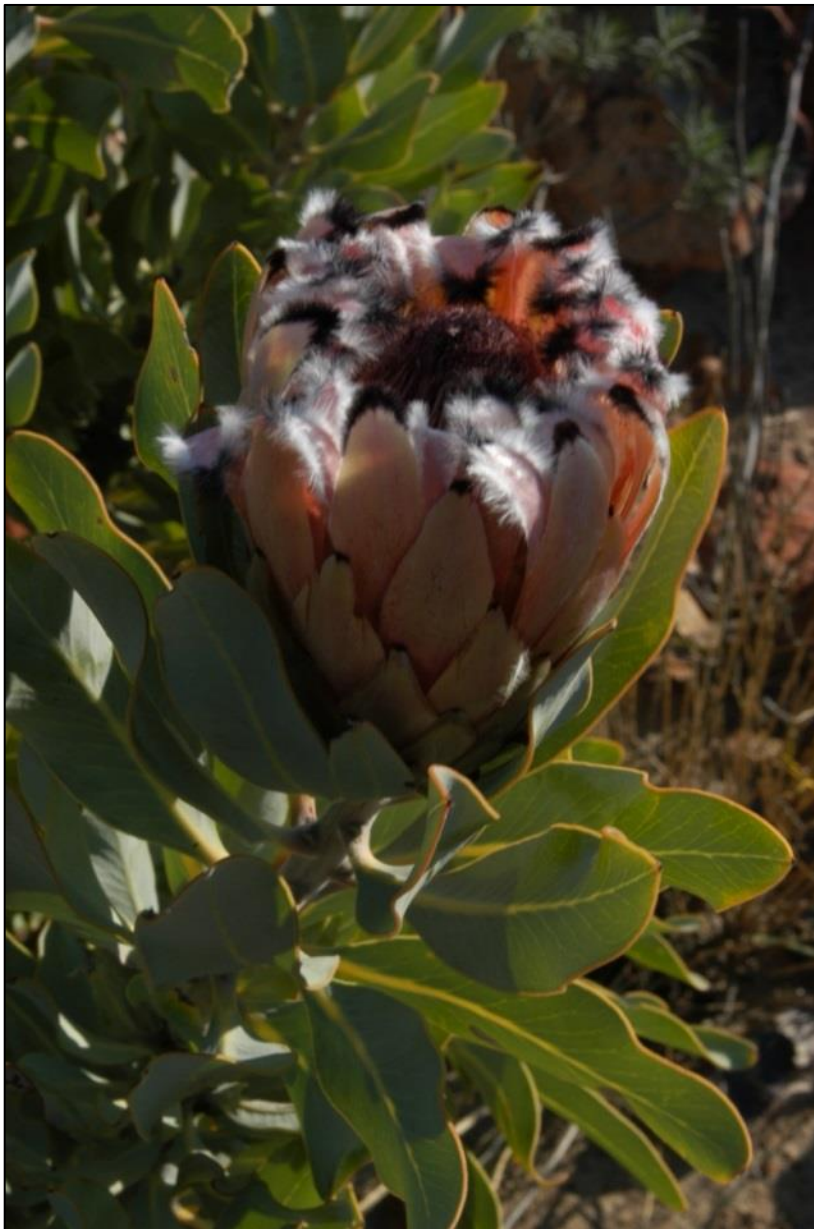


Figure 4.51: *Protea laurifolia* (Laurel Sugarbush, Proteaceae family).

Discussion:

Protea laurifolia (Figure 4.51), *Erica inaequalis* and *Phylica rogersii* that are dominant within this community, are also important in variant iii of sub-community 3.3 as well as in community 10. *Geissorhiza confusa* (41 49.0) is important in this community regarding fidelity (Annexures 1 & 2).

This community comprises of three sub-communities, of which sub-community 9.1 has three variants.

9.1. *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community

The *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community (Figure 4.52) has three variants.



Figure 4.52: The *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community (Sample plot 17) on the hills between the Greater Brandvlei Dam and the Breede River.

Phytosociological Table

Species group V: Important species for the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community:

Important species for Species Group V are *Helichrysum moesianum*, *Aspalathus spicata*, *Geissorhiza confusa*, *Babiana ambigua*, *Chamarea capensis*, *Thesium strictum*, *Lachenalia pustulata*, *Empodium plicatum*, *Cullumia ciliaris*, *Psammotropha* sp. nov., *Agathosma capensis*, *Arctotis acaulis*, *Struthiola ciliata*, *Lapeirousia micrantha*, *Zygophyllum sessilifolium*, *Pelargonium longifolium*, *Manulea cheiranthus*, *Moraea neglecta*, *Indigofera* sp. nov. cf. *angustifolia* (Chapter 5.1.8.4; Figures 5.28 & 5.29) (Annexure 1).

Synoptic Table

Number of relevés: 13

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 77, ***Babiana patula* 92**, *Chrysocoma ciliata* 77, ***Crassula atropurpurea* 92**, *Ehrharta villosa* 77, *Elytropappus gnaphaloides* 77, *Elytropappus rhinocerotis* 77, *Felicia filifolia* ssp. *schaeferi* 85, *Helichrysum hebelepis* 77, *Helichrysum moesianum* 77, *Helichrysum rutilans* 77, *Restio sieberi* 85, ***Oedera squarrosa* 92**, ***Passerina truncata* 92**, ***Searsia dissecta* 92** and ***Ursinia anthemoides* 92** (Annexure 2).

Dominant species: *Aspalathus tuberculata* 8, *Elytropappus gnaphaloides* 8, *Erica inaequalis* 15 (Figure 4.53), *Restio gaudichaudiana* 8, *Passerina truncata* 8, *Phylica constricta* 8, *Phylica rogersii* 8 and *Protea laurifolia* 8 (Annexure 2).

Discussion

Searsia dissecta (92, 24.6), *Psammotropha quadrangularis* (31, 41.6), *Helichrysum hebelepis* (77, 26.0), *Geissorhiza confusa* (69, 59.7), *Lapeirousia micrantha* (31, 39.4), *Aspalathus tuberculata* (62, 29.2) and *Erica inaequalis* (69, 35.4) (Figure 4.53) are significant regarding frequency and fidelity (Annexure 2).



Figure 4.53: *Erica inaequalis* (Ericaceae), is one of two heath (Heide) species that occur on the hills bordering the Greater Brandvlei Dam to the north.

Psammotropha sp. nov. (Figure 4.54) was first collected in 2007 during data collection for this study, and is currently being described by Dr Matt Buys³ who worked on the family while he was stationed at Kirstenbosch Botanical Garden (Collections: A. le Roux, no. 444, 3 September 2007) (Chapter 5.1.10.1; Figures 5.34 & 5.35). Note the differences in growth form and inflorescence between this species and *P. quadrangularis* (Figure 4.57).

³ Dr Matt H. Buys, Curator: National Forestry Herbarium, Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand.



Figure 4.54: The neat, round small shrublet, *Psammotropha* sp. nov. (Molluginaceae) was first collected in 2007 during data collection for this study.

i *Protea laurifolia* Typicum variant

Locality: Hills bordering the Greater Brandvlei Dam to the north (Figure 4.55). An accidental fire burnt the larger part of this area in February 1999, eight years before data gathering.

Sample plots: 22, 36, 42, 38 and 17

Land Type: Fa198a, terrain units 1 and 3 (Table 2.3).

Geology and soil: The Blinkberg (quartzitic sandstone with thin interlaced micaceous siltstone beds) and Swartruggens (siltstone and shale with thin interbedded sandstone) Formations of the Witteberg Group underlie this community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Windblown sand contributes to the soil texture in some areas and a covering of 80% to 100% rock fragments of various sizes (<10 mm to >200 mm) occurs.



Figure 4.55: *Protea laurifolia* Typicum variant of the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community (Sample plot 22).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The *Protea laurifolia* Typicum variant is supported by extremely acidic (pH 3.8) sandy loam soils with stone volume of 24%. The soil here contains less Fe compared to the rest of the soils supporting the major community. The base saturation Ca:Mg ratio of 0.79 indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Tables 4.3 and 4.4).

Aspect: Neutral, N, NW

Gradient: Gentle to steeply sloped

Height above sea-level: 249 - 271 m

Land-cover and use: Vegetation structure is of a medium shrubland (<2 m) with small *Protea laurifolia* trees which can grow higher than 4 m.

The phytosociological table indicates no important species for this variant.

Synoptic table

Number of relevés: 5

Diagnostic species: None

Constant species: ***Albuca flaccida* 100**, *Albuca papyracea* 80, *Anthospermum spathulatum* 80, ***Babiana patula* 100**, *Chrysocoma ciliata* 80, ***Crassula atropurpurea* 100**, *Drosanthemum hallii* 80, *Drosanthemum parvifolium* 80, ***Elytropappus gnaphaloides* 100**, ***Elytropappus rhinocerotis* 100**, ***Felicia filifolia* ssp. *schaeferi* 100**, *Gladiolus floribundus* 80, ***Helichrysum hebelepis* 100**, *Helichrysum moesianum* 80, *Hesperantha acuta* 80, ***Restio sieberi* 100**, *Capeochloa arundinacea* 80, ***Tenaxia stricta* 100**, *Mesembryanthemum longistylum* 80, *Oedera squarrosa* 80, *Othonna lingua* 80, *Passerina truncata* 80, ***Pentameris eriostoma* 100**, *Phyllobolus grossus* 80, *Protea laurifolia* 80, *Searsia dissecta* 80, *Ruschia diversifolia* 80, *Satyrrium erectum* 80 and ***Ursinia anthemoides* 100** (Annexure 2).

Dominant species: *Phylica constricta* 20, *Phylica rogersii* 20 and *Protea laurifolia* 20 (Annexure 2).

Discussion:

The *Protea laurifolia* Typicum variant is characterised by the absence of *Hermannia alnifolia* and *Drosanthemum hispidum*. *Gladiolus guthriei*, *Heliophila scoparia*, *Romulea setifolia* var. *aggregata* and *Tulbaghia dregeana* was only found to be present in this variant (Annexures 1 & 2).

ii *Psammotropha quadrangularis* variant

Locality: The hills bordering the Greater Brandvlei Dam on the northern side and Hammansberg (Figure 4.56).

Sample plots: 171, 33 and 35

Land Type: Fa198a and Fb122a terrain unit 1 (Table 2.3; Table 2.4).

Geology and soil: The Blinkberg (light-grey quartzitic sandstone with thin micaceous siltstone beds) and Floriskraal (yellow-brown-weathering quartzitic sandstone with alternating beds of siltstone and micaceous shale) Formations of the Witteberg Geological Group underlie this variant (Gresse and Theron 1992, Gresse 1997). In this habitat, aeolian sand contributes to the soil texture in some parts, especially around the dam. Rock covering comprises 50 – 90 % and include from gravel to large rock fragments (<10 mm to >200 mm).



Figure 4.56: The *Psammotropha quadrangularis* variant *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community (Sample plot 33).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The *Psammotropha quadrangularis* (Figure 4.57) variant is supported by extremely acidic (pH 3.4) loamy sand with stone volume of 4%. The predominantly fine sand has the lowest proportion of stones and the best water-holding capacity in comparison to the rest of the soils supporting this major community. A high resistance to the flow of an electric current (4580 Ω), shows that the soil here is less saline than most of the soils supporting this major community. The soil here contains especially low amounts of Ca, Mg and Mn,

and has a lower total of exchangeable cations in comparison to the rest of the soils supporting the major community (Tables 4.3 and 4.4).

Aspect: Neutral, E

Gradient: Moderate to steep

Height above sea-level: 238 - 504 m

Land-cover and use: Vegetation structure is that of a medium shrubland (<2 m) with small *Protea laurifolia* trees which can grow higher than 4 m.

Phytosociological table

Species group W: Important species for the *Psammotropha quadrangularis* variant:

Important species for Species Group W are *Hermannia alnifolia*, *Drosanthemum hispidum* and *Psammotropha quadrangularis* (Annexure 1).

Synoptic table

Number of relevés: 3

Diagnostic species: None

Constant species: ***Albuca flaccida* 100, *Chrysocoma ciliata* 100, *Crassula atropurpurea* 100, *Dodonaea viscosa* var. *angustifolia* 100, *Ehrharta villosa* 100, *Restio sieberi* 100, *Capeochloa arundinacea* 100, *Oedera squarrosa* 100, *Ornithogalum hispidum* 100, *Passerina truncata* 100, *Phyllis rogersii* 100 and *Searsia dissecta* 100** (Annexure 2).

Dominant species: *Aspalathus tuberculata* 33 (Annexure 2).

Discussion

Fire can be advantageous to the germination of hard-seeded species such as members of the Fabaceae as scarification facilitated by fire temperature could decrease the water-resistance of the seed coat to enable water uptake for germination (Bond and Van Wilgen 1996). *Aspalathus tuberculata* is an important species in major community 2, but the dominance thereof in this

variant during data collection most probably relates to a fire eight years prior to sampling. Aeolian sand contributes significantly to this habitat. *Psammotropha quadrangularis* (Figure 4.57), a typical psammophilous species (from the ancient Greek, *psámmos* = “sand” + *-phile* = “loving”) (Leistner 2000) has the highest frequency in this habitat (although it also occur in variants i and iii as well as in community 15) and was therefore chosen to name this variant (Annexure 1). The species is absent from the sampling plot on Hammansberg due to the higher degree of rockiness and shallower substrate that characterise some of the sandstone ridges.



Figure 4.57: *Psammotropha quadrangularis* (Molluginaceae) occurs in sandy habitats in the study area.

The presence of *Drosanthemum hispidum* distinguishes this variant from the other two variants in this sub-community. In the study area, *Cliffortia crenata* grows on the hills southeast of the Greater Brandvlei Dam as well as eastwards

on Hammansberg and Ouhangsberg, but *Ruschia lineolata* is only found from Hammansberg and further east in the study area. *Ruschia lineolata*, also important in community 3.1, is important here due to its high cover abundance and resultant dominance. *Cliffortia crenata* was only found to be present within this variant (Annexure 1).

iii *Leucadendron salignum* Variant

Locality: The hills bordering the Greater Brandvlei Dam on the northern side (Figure 4.58).

Sample plots: 50, 7, 21, 23 and 18

Land Type: Fa198a, terrain unit 3 (Table 2.3).



Figure 4.58: The *Leucadendron salignum* variant of the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community (Sample plot 18).

Geology and soil: The Blinkberg (light-grey quartzitic sandstone with thin micaceous siltstone beds) and Swartruggens (siltstone and mudstone alternating with thin grey sandstone beds) Formations of the Witteberg Group underlie this sub-community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Windblown sand contributes to the soil texture in some parts,

especially in Sample plots 18, 21 and 32. A 25 – 90% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The *Leucadendron salignum* variant is supported by extremely acidic (pH 3.9) loamy sand with stone volume of 33.7% (the highest proportion of stones compared to the soils supporting this major community) and the lowest water holding capacity compared to the soils supporting this major community (Tables 4.3 and 4.4).

Aspect: N, NE

Gradient: Gentle to moderately sloped

Height above sea-level: 205 – 255 m

Land-cover and use: Vegetation structure is of a medium shrubland (<2 m) with small *Protea laurifolia* trees which can grow higher than 4 m.

Phytosociological table

Species group X: Important species for the *Leucadendron salignum* variant:

Important species for Species Group X are *Leucadendron salignum* (Figure 4.59), *Selago micradenia*, *Lobelia capillifolia* and *Centella macrocarpa* (Annexure 1).

Synoptic table

Number of relevés: 5

Diagnostic species: None

Constant species: ***Anthospermum spathulatum* 100, *Babiana patula* 100, *Crassula atropurpurea* 80, *Diascia capensis* 80, *Ehrharta villosa* 80, *Elytropappus gnaphaloides* 80, ***Erica species* 100, *Eriocephalus africanus* 100, *Felicia filifolia* ssp. *schaeferi* 80, *Ficinia nigrescens* 80, *Geissorhiza confusa* 80, ***Helichrysum moesianum* 100, *Helichrysum rutilans* 100,******

***Restio capensis* 100, *Oedera squarrosa* 100, *Oxalis pulchella* var. *tomentosa* 100, *Passerina truncata* 100, *Searsia dissecta* 100, *Ursinia anthemoides* 100 and *Willdenowia incurvata* 100** (Annexure 2).

Dominant species: *Elytropappus gnaphaloides* 20, *Erica* species 40, *Restio gaudichaudiana* 20 and *Passerina truncata* 20 (Annexure 2).



Figure 4.59: *Leucadendron salignum* (Proteaceae). This is an example of the female plant.

Discussion

This variant is distinguished from the other variants in this sub-community by the presence of all the important species listed above and their absence in the other two variants. *Lapeirousia micrantha* (60 57.1) and *Agathosma capensis*

(60, 50.1) are significant regarding fidelity (Annexures 1 & 2). Where the sand is thicker lower densities of *Erica inaequalis* occur and psammophytes such as *Cannomois scirpoides*, *Disa flexuosa*, *Helichrysum moesianum*, and *Willdenowia incurvata* occur.

Species only found in this community are *Centella macrocarpa* and *Disa flexuosa* (Annexures 1 & 2).

9.2. *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community

Locality: Sample plots 151 and 158 are located on east to southeast facing slopes of the hills bordering the Greater Brandvlei Dam on the eastern side (Figure 4.60).

Sample plots: 151 and 158

Land Type: Fb123b, terrain unit 1 (Table 2.5).

Geology and soil: Sandstone of the Witpoort (grey quartzitic sandstone with shale interbeds) Formation of the Witteberg Group underlies this plant community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Pebbles and rocks of various sizes (<10 mm to >200 mm) cover up to 95% of the substrate.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

The *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community is supported by extremely acidic (pH 3.9) loamy sand with stone volume of 22.7%. The soil here has the highest proportion of sand in comparison to the rest of the soils supporting this major community. The high resistance to the flow of an electric current (4480 Ω), shows that the soil here is much less saline, and the total of exchangeable cations is lower than most of the soils supporting the major community (T-value 2.22). Compared to the other soils sampled in this study (except the sand supporting major community 5), the soil here has low quantities of Cu and dissolvable S (Tables 4.3 and 4.4).



Figure 4.60: The *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community (Sample plot 151).

Aspect: N, Neutral, SE

Gradient: Steeply sloped

Height above sea-level: 270 – 346 m

Land-cover and use: Vegetation structure is of a medium shrubland (<2 m) with small *Protea laurifolia* trees which can grow higher than 4 m.

Phytosociological table

Species Group Y: Important species for the *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community:

Important species for Species Group Y are *Ehrharta ramosa*, *Asparagus rubicundus*, *Elytropappus intricata*, *Heeria argentea* and *Secamone alpini* (Figure 4.61) (Annexure 1).



Figure 4.61: The perennial climber *Secamone alpini* (Bobbejaantou) (Apocynaceae) grows on the quartzitic outcrops of the Witpoort Formation.

Synoptic table

Number of relevés: 2

Diagnostic species: ***Secamone alpini* 100.0** (Annexure 2).

Constant species: ***Anthospermum spathulatum* 100, *Aspalathus hirta* ssp. *hirta* 100, *Asparagus retrofractus* 100, *Bulbine praemorsa* 100, *Cannomois scirpoides* 100, *Cliffortia ruscifolia* 100, *Dodonaea viscosa* var. *angustifolia* 100, *Ehrharta ramosa* 100, *Ehrharta villosa* 100, *Elytropappus intricata* 100, *Restio sieberi* 100, *Lampranthus leipoldtii* 100, *Lobelia capillifolia* 100, *Maytenus oleoides* 100, *Oxalis convexula* 100, *Oxalis obtusa* 100, *Passerina truncata* 100, *Pelargonium luteolum* 100, *Pentameris airoides* ssp. *airoides* 100, *Satyrium candidum* 100, *Secamone alpini* 100, *Selago triquetra* 100, *Trachyandra revoluta* 100 and *Troglophyton parvulum* 100** (Annexure 2).

Dominant species: None

Discussion:

Secamone alpini, *Sutera decipiens*, *Silene undulata*, *Salvia africana-caerulea*, *Senecio vestitus*, *Conium sphaerocarpum*, *Moraea ochroleuca*, *Senecio paarlensis*, *Senecio repandus* and *Crassula expansa* ssp. *expansa* were only found to be present in this variant (Annexures 1 & 2).

9.3. *Protea laurifolia*–*Passerina truncata*–*Ruschia diversifolia* sub-community

Locality: The hills bordering the greater Brandvlei Dam on the northern and north-eastern side (Figure 4.62).

Sample plots: 81, 43, 46, 59, 48, 71, 72, 70, 86, 85, 58 and 57

Land Type: Fa198a, terrain unit 1 and 3 (Table 2.3).

Geology and soil: The Blinkberg (light-grey quartzitic sandstone with thin micaceous siltstone beds) and Swartruggens (siltstone and shale with thin

interbedded sandstone) Formations of the Witteberg Geological Group underlie this vegetation community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). A 70 – 95% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4) sandy loam with 31% stone volume supports the vegetation of this community. Compared to the rest of the soils supporting the major community, the soil here has more Na, K and Mg. The base saturation Ca:Mg ratio of 0.78, as well as a high Na⁺ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Tables 4.3 and 4.4).



Figure 4.62: The *Protea laurifolia*–*Passerina truncata*–*Ruschia diversifolia* sub-community (Sample plot 48).

Aspect: Neutral, N, NE

Gradient: Gentle to very steeply sloped

Height above sea-level: 177 - 312 m

Land-cover and use: Vegetation structure is of a medium shrubland (<2 m) with small *Protea laurifolia* trees which can grow higher than 4 m.

Phytosociological table

Species group Z: Important species for the *Protea laurifolia*–*Passerina truncata*–*Ruschia diversifolia* (Figure 4.63) sub-community:

Important species for Species Group Z are *Holothrix secunda*, *Oxalis convexula*, *Viscum capense*, *Protea restionifolia*, *Eriospermum nanum*, *Rhynchosidium sessiliflorum*, *Eriospermum bowieanum*, *Phyllica constricta*, *Haemanthus coccineus* and *Drosanthemum bellum* (Annexure 1).



Figure 4.63: *Ruschia diversifolia* (Aizoaceae)

Synoptic table

Number of relevés: 12

Diagnostic species: None

Constant species: *Albuca papyracea* 83, ***Anthospermum spathulatum* 100**, *Bulbine frutescens* 83, *Chrysocoma ciliata* 83, ***Crassula atropurpurea* 100**, *Drosanthemum hallii* 83, ***Elytropappus rhinocerotis* 92**, ***Eriocephalus africanus* 92**, ***Felicia filifolia* ssp. *schaeferi* 100**, *Gladiolus floribundus* 83, ***Hesperantha acuta* 92**, *Restio sieberi* 83, *Lapeirousia pyramidalis* 83, *Capeochloa arundinacea* 83, ***Mesembryanthemum longistylum* 92**, ***Oedera squarrosa* 100**, ***Othonna retrofracta* 100**, ***Passerina truncata* 100**, *Pelargonium radiatum* 83, ***Pentameris eriostoma* 92**, ***Pteronia fasciculata* 92**, *Ruschia caroli* 83, ***Ruschia diversifolia* 100** (Figure 4.63) and ***Satyrium erectum* 92** (Annexure 2).

Dominant species: *Eriocephalus africanus* 8, *Restio sieberi* 8, *Capeochloa arundinacea* 8, *Passerina truncata* 17 and *Pteronia fasciculata* 17 (Annexure 2).

Discussion

Drosanthemum bellum (25 49.2) is significant regarding fidelity. *Ruschia diversifolia* (Figure 4.63) is also important in sub-communities 10.1 and 11.2. *Holothrix secunda* and *Oxalis convexula* are also important in community 8 and in community 11 (Annexure). *Drosanthemum bellum*, *Gomphocarpus cancellatus*, *Gazania krebsiana* ssp. *krebsiana* and *Viscum rotundifolium* were only found within this sub-community (Annexures 1 & 2).

Drosanthemum hallii (Chapter 5.3.1; Figures 5.43 – 5.47) is a constant species in this sub-community, where it occurs together with *D. bellum* (Figure 5.48). While *D. hallii* occurs in major communities 3 and 4 on the hills surrounding the Greater Brandvlei Dam, another closely related species, *D. micans* (Figures 5.52 & 5.53) occurs to the south and southeast of the Greater Brandvlei Dam, on Hammansberg, Droogeriviersberg, Ouhangsberg and Gannaberg. While the filamentous staminodes of *D. bellum* (Figure 5.48) differs morphologically from that of *D. hallii* (Figures 5.42 & 5.44), there are no clear morphological characters by which *D. bellum* occurring at the Greater Brandvlei Dam, and *D. micans* (of which the filamentous staminodes are morphologically similar) (Figure 5.52), occurring in the southern part of the study area, can be distinguished (Hartmann 2008; Hartmann and Le Roux 2011). Further

taxonomic study could provide proof that these two closely related species are indeed separate or possibly representatives of the same species.

These three *Drosanthemum* species has Red List conservation status: Endangered (<http://redlist.sanbi.org>).

Heuweltjies

Plant species occurring on Heuweltjies in major community 2 includes: *Boophone disticha*, *Bulbine frutescens*, *Ehrharta capensis*, *Elytropappus rhinocerotis*, *Eragrostis curvula*, *Eriocephalus africanus*, *Euphorbia burmannii*, *Euryops burmannii*, *Felicia filifolia* ssp. *schaeferi*, *Galenia africana*, *Haemanthus coccineus*, *Lachenalia pustulata*, *Lycium ferocissimum*, *Mesembryanthemum longistylum*, *Metalasia acuta*, *Microloma sagittatum*, *Othonna auriculifolia*, *Othonna lingua*, *Othonna retrofracta*, *Oxalis pes-caprae*, *Pelargonium alternans*, *Pelargonium luteolum*, *Pelargonium rapaceum*, *Pteronia incana*, *Pteronia paniculata*, *Relhania squarrosa*, *Ruschia caroli*, *Searsia incisa* and *Senecio radicans* (Figure 4.64).

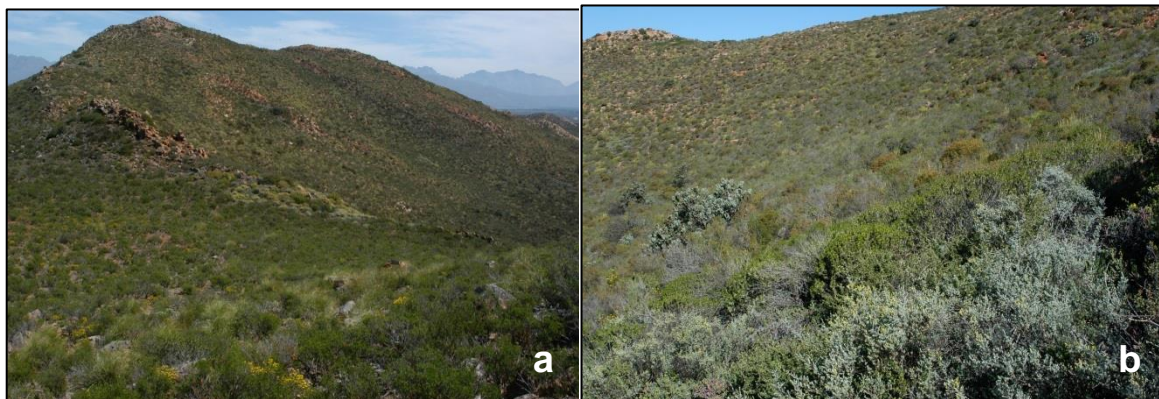


Figure 4.64: *Galenia africana*, *Pteronia incana*, *Pteronia paniculata* and *Searsia incisa* occur on Heuweltjies in major community 2.

Major Plant Community 3: *Capeochloa arundinacea* shrubland

The *Capeochloa arundinacea* major community (Figure 4.65) is a shrubland composed of medium (<2 m) to low (<1 m) shrub vegetation. From the range of hills north, east and southeast of the Greater Brandvlei Dam this major community extends south-eastwards where it occurs on Hammansberg, Ouhangsberg, Gannaberg, Gemsbokkop, and Rooiberg (Gresse 1997). The vegetation dominated by *Capeochloa* [*Merxmuellera*] *arundinacea* (Poaceae) is supported by acidic rocky soils mainly of the sandstone-dominated crests as well as slopes sandwiched between the sandstone formations in the study area (Table 3.1; Figure 3.11).

Major community 3 includes three different land types and comprises three plant communities located predominantly in the following areas:

- The crests of the hills bordering the Greater Brandvlei Dam on the north-western and north-eastern side, the top of Hammansberg and the top, as well as midslopes of Ouhangsberg which include land types Fa198a, Fb122a and Ic116, terrain unit 1 (Tables 2.3, 2.4 and 2.6).
- Midslopes of Ouhangsberg, Droëriviersberg and Gannaberg, as well as sandstone outcrops on Droëriviersberg in the Trappieskraalkloof which include land type Ic116, terrain unit 3 (Table 2.6).
- Some midslopes of the hills east and southeast of the Greater Brandvlei Dam which include land types Fb123a and Fb123b, terrain unit 3 (Table 2.5).



Figure 4.65: The *Capeochloa arundinacea* shrubland on Ouhangsberg.

The Floriskraal (yellow-brown-weathering quartzitic sandstone with alternating beds of siltstone and micaceous shale), Swartruggens (siltstone and shale with thin interbedded sandstone), Witpoort (light-grey quartzitic sandstone), Kweekvlei (dark grey micaceous shale and subordinate siltstone) formations of the Witteberg Group (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982) underlie this major plant community. *Zoophycos* (*Spirophyton*) (Figure 13.12) and *Skolithos* (Figure 3.12; Figure 3.13 e) trace fossils, as well as lycopod stem fossils (Figure 3.14) occur in this major community.

The folded nature of the study area makes it difficult to identify the geological formations in certain areas (Figure 3.16). Although the geological map of Trappieskraalkloof indicates that the Waaipoort Formation (Sample plot 162) underlies slopes on the inside of the semi-circular folds of the Witpoort Formation (Figure 3.11), these slopes are most likely underlain by the Kweekvlei Formation.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). Soil analyses of the A horizon for Major community 3 are given in Tables 4.5 and 4.6. Sand (mostly fine sand) primarily contributes to soil texture (66-84%) of the primarily sandy loam soils supporting this *Capeochloa arundinacea* (Figure 4.66) shrubland, while clay and silt are present in lower quantities (Table 4.6). Rock fragments of various sizes (<10 mm to >200 mm) cover the soil in different proportions.



Figure 4.66: *Capeochloa arundinacea* (Olifantsgras) (Poaceae).

The average soils supporting this major community contains a high proportion of fine sand, is stonier, is less saline and has more nutrients than most of the soils that support the other major communities. The average values for the soils of this major community have a higher base saturation and a higher total of exchangeable cations in comparison with the soils supporting the other major communities (Tables 4.5 and 4.6).

Phytosociological table

Species group AA: Important species for the *Capeochloa arundinacea* shrubland:

Capeochloa arundinacea is important in Species group AA (Annexure 1).

Synoptic Table

Number of relevés: 31

Diagnostic species: None

Constant species: *Restio sieberi* 77, *Oedera squarrosa* 77, *Passerina truncata* 87 and *Pentameris eriostoma* 81 (Annexure 2).

Dominant species: *Agathosma ovata* 6, *Ehrharta capensis* 6, *Elytropappus rhinocerotis* 6, *Oxalis engleriana* 3, *Pteronia fasciculata* 16, *Ruschia caroli* 10, *Scopelogenia verruculata* 3 and *Curio crassulifolius* 3 (Annexure 2).

Discussion:

Capeochloa arundinacea is also important in sub-community 3.3 and in communities 5 and 9 (Annexures 1 & 2).

Table 4.5: Analyses of the soil A horizon for major community 3. T-value = sum of exchangeable Ca, Mg, Na and K.

Plant communities and subunits		pH (KCl)	Electrical resistance (ohm)	H (cmol/kg)	P (Bray II mg/kg)	Exchangeable cations				Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)	C (%)	Dissolvable S (mg/kg)	Base saturation					
						Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)								Na %	K %	Ca %	Mg %	T-value (cmol/kg)	% Acid saturation
10	Sub-com 10.1 Var i	3.6	550	1.52	9	0.39	0.17	0.47	0.77	0.3	0.4	12	0.2	79.41	1.56	23.90	11.66	5.15	14.2	23.2	3.32	45.79
	Sub-com 10.1 Var ii	4.1	1120	1.57	7	0.23	0.21	1.6	1.45	0.5	1.9	36.5	0.42	88.87	2.84	17.87	4.46	4.22	31.63	28.62	5.05	31.08
	Sub-com 10.2	4.4	2660	1.26	7	0.09	0.19	1.57	1.46	0.6	1.2	59.8	0.4	64.32	2.29	12.07	2.05	4.21	34.33	31.88	4.58	27.54
11	Sub-com 11.1	3.9	2920	0.91	6	0.12	0.14	0.57	0.6	0.3	0.5	53.7	0.29	31.76	0.87	9.99	4.98	6.07	24.22	25.71	2.33	39.01
	Sub-com 11.2	3.6	410	2.27	13	0.66	0.19	0.71	1.42	0.5	0.8	22.8	0.53	159.39	1.84	32.78	12.64	3.54	13.55	27.06	5.25	43.21
	Sub-com 11.3	6	360	1.22	203	1.25	1.4	17.27	12.68	1.3	20.4	202.5	2.28	139.76	4.96	82.09	3.69	4.15	51.06	37.49	33.82	3.61
	Sub-com 11.4	3.6	1110	0.61	58	0.21	0.34	1.51	1.44	0.4	1.4	18.7	0.42	188.85	3.38	28.21	5.01	8.31	36.81	35.01	4.11	14.85
Average for major community		4.2	1304	1.34	43.29	0.42	0.38	3.39	2.83	0.56	3.80	58.00	0.65	107.48	2.53	29.56	6.36	5.09	29.40	29.85	8.35	29.30
Average for entire study		4.1	2525	1.18	21	0.2	0.22	1.65	1.39	0.5	1.7	53.8	0.32	77.59	1.48	18.98	4.4	4.95	29.38	26.85	4.64	34.43

Table 4.6: Mechanical analysis of the soil A horizon for major community 3. SaLm = Sandy loam, LmSa = Loamy sand.

Plant communities and subunits		Clay %	Silt %	Sand %	Fine sand %	Med sand %	Coarse sand %	Stoniness %	Texture	Water-holding capacity mm/m
10	Sub-com 10.1 Var 1	15	6	79	65.6	7.2	6	25.9	SaLm	111.84
	Sub-com 10.1 Var 2	11	10	79	67	5.2	6.6	46	SaLm	85.36
	Sub-com 10.2	14	6	80	65.8	6.6	8	23.4	SaLm	116.25
11	Sub-com 11.1	10	6	84	66.3	12.1	6	13.3	LmSa	128.31
	Sub-com 11.2	20	14	66	57.1	4.8	4.4	21.1	SaLm	117.03
	Sub-com 11.3	16	4	80	55.7	14.1	10.6	13.6	SaLm	112.62
	Sub-com 11.4	12	8	80	71.6	4.6	4.2	17.2	SaLm	134.84
Average for major community		14	8	78	64.2	7.8	6.5	22.9		115.18
Average for entire study		13	9	78	59.0	11.0	8.0	19.0		114.00

10. *Metalasia acuta*–*Capeochloa arundinacea* community

The *Metalasia acuta*–*Capeochloa arundinacea* community (Figure 4.67) comprises sub-communities 10.1 and 10.2, where sub-community 10.1 is subdivided in two variants.



Figure 4.67: *Metalasia acuta*–*Capeochloa arundinacea* community (Sample plot 169).

Phytosociological Table

Species group AB: Important species for *Metalasia acuta*–*Capeochloa arundinacea* community:

Metalasia acuta (Figure 4.68) is an important species for Species group AB (Annexure 1).

Synoptic Table

Number of relevés: 11

Diagnostic species: None

Constant species: *Anthospermum spathulatum* 91, *Berkheya armata* 91, *Elytropappus rhinocerotis* 91, *Restio capensis* 91, *Capeochloa arundinacea* 82, *Oedera squarrosa* 91 and *Passerina truncata* 82 (Annexure 2).

Dominant species: *Ehrharta capensis* 9 and *Elytropappus rhinocerotis* 18 (Annexure 2).

Discussion:

Although *Berkheya armata* is a prominent species of Major community 1, it is also important here (Annexure 1).



Figure 4.68: *Metalasia acuta* (Asteraceae).

10.1. *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community

Sub-community 10.1 comprises of two variants.

Phytosociological Table

Species group AC: Important species for the *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community:

Important species for Species Group AC are *Protea humiflora*, *Hypodiscus striatus*, *Erica plukenetii*, *Macrostylis tenuis*, *Erica anguliger* (Figure 4.69) and *Phaenocoma prolifera* (Annexure 1).



Figure 4.69: *Erica anguliger* (Ericaceae) on Hammansberg.

Synoptic table

Number of relevés: 6

Diagnostic species: *Erica anguliger* 81.1 (Annexure 2).

Constant species: *Anthospermum spathulatum* 83, *Berkheya armata* 83, *Drosanthemum micans* 83, *Elytropappus rhinocerotis* 83, *Restio capensis* 83, ***Capeochloa arundinacea* 100**, *Mesembryanthemum longistylum* 83, *Metalasia acuta* 83, ***Oedera squarrosa* 100**, ***Passerina truncata* 100**, *Pentameris eriostoma* 83 and ***Ruschia diversifolia* 100** (Annexure 2).

Dominant species: None

Discussion:

Other significant species regarding fidelity are *Hypodiscus striatus* (67, 72.6), *Osteospermum polygaloides* (67, 68.4), *Syncarpha mucronata* (67, 68.4),

Phylica parviflora (50, 56.2), *Macrostylis tenuis* (50, 64.8), *Agathosma leptospermoides* (50, 70.0), *Hymenolepis speciosa* (50, 70.0) (Annexure 2).

Other species shared by the two variants are *Tetralia nigrovaginata*, *Phylica parviflora*, *Agathosma leptospermoides*, and *Hymenolepis speciosa*. *Protea humiflora* also has a high cover abundance in variant i of sub-community 9.1 and *Carpobrotus mellei* was only found to occur in this sub-community (Annexure 1).

i *Staavia capitella* variant

Locality: The crests of the hills bordering the Greater Brandvlei Dam on the north-western side, the top of Hammansberg and the top of Ouhangsberg (Figure 4.70).

Sample plots: 79, 166 and 168

Land Type: Fa198a, Fb122a and Ic116, terrain unit 1 (Tables 2.3, 2.4 and 2.6).

Geology and soil: Sample plot 79, on the north-western perimeter of the Greater Brandvlei Dam, is underlain by the Swartruggens Formation (siltstone and shale with thin interbedded sandstone) of the Witteberg Group (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Accumulated colluvium of the adjacent Blinkberg Formation forms part of the habitat here. The Witpoort Formation (grey quartzitic sandstone with shale interbeds) of the Witteberg Group underlies sample plots 166 and 168 but because of the folded character of the area, the adjacent Kweekvlei Formation (dark grey micaceous shale and subordinate siltstone) also plays a role in the character of the substrate (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Rock fragments of various sizes (<10 mm to >200 mm) occur.

The substrate is a soil-rock complex with rock, as well as the Mispah soil form (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.70: *Staavia capitella* variant of the *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community (Sample plot 166).

Extremely acidic (pH 3.6) sandy loam with 25.9% stone volume supports the vegetation of this variant. The low resistance to the flow of an electric current (550 Ω) shows that the soils here are more saline compared to the rest of the soils supporting this major community. The soil here contains fewer nutrients (especially less Mn) and a lower total of exchangeable cations compared to most of the soils supporting the major community. The base saturation Ca:Mg ratio of 0.61, as well as a high Na^+ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Tables 4.5 and 4.6).

Aspect: SE, N

Gradient: Steeply sloped

Height above sea-level: 272 - 702 m

Land-cover and use: Vegetation structure is a medium shrubland (<2 m).

Phytosociological Table

Species Group AD: Important species for the *Staavia capitella* variant:

Important species for Species Group AD are *Tetraria nigrovaginata*, *Cannomois spicata*, *Thamnochortus lucens*, *Leucospermum calligerum*, *Phylica parviflora*, *Tritoniopsis antholyza*, *Aspalathus pachyloba*, *Searsia lucida*, *Agathosma leptospermoides*, *Pelargonium crispum*, *Hymenolepis speciosa*, *Staavia capitella* and *Wahlenbergia neorigida* (Annexure 1).

Synoptic Table

Number of relevés: 3

Diagnostic species: *Staavia capitella* 81.2 (Figure 4.71) and *Wahlenbergia neorigida* 81.2 (Annexure 2).



Figure 4.71: *Staavia capitella* (Bruniaceae).

Constant species: *Anthospermum spathulatum* ssp. *spathulatum* 100, *Restio sieberi* 100, *Capeochloa arundinacea* 100, *Oedera squarrosa* 100, *Passerina truncata* 100, *Pentameris eriostoma* 100 and *Ruschia diversifolia* 100 (Annexure 2).

Dominant species: None

Discussion:

Staavia capitella (Figure 4.71) variant can be distinguished from the *Syncarpha mucronata* variant by the presence of *Staavia capitella*, *Wahlenbergia neorigida*, *Cannomois spicata*, *Thamnochortus lucens*, *Leucospermum calligerum*, *Tritoniopsis antholyza*, *Aspalathus pachyloba*, *Searsia lucida* and *Pelargonium crispum*. Species only found in this variant during this study are *Aspalathus linearis*, *Sutera uncinata*, *Selago venosa*, *Clutia alaternoides* var. *alaternoides*, *Anaxeton asperum* and *Pelargonium setulosum* (Annexures 1 & 2).

The analysis sorted Sample plot 79 with major community 3, sub-community 10.1 due to the dominance of *Capeochloa arundinacea* and *Protea humiflora*, however none of the important species for this variant were present (Annexure 1). Due to the dominance of *Drosanthemum hallii* and *Ruschia diversifolia*, Sample plot 79 shows a strong affinity with community 9. While *Erica inaequalis* is dominant in community 9, *E. anguliger* is dominant in sub-community 10.1. *Cannomois spicata* also has high cover abundance in sub-community 9.2 (Annexures 1 & 2).

ii *Syncarpha mucronata* variant

Locality: Ouhangsberg (Figure 4.72)

Sample plots: 181, 180, 169

Land Type: lc116, terrain unit 3 (Table 2.6).

Geology and soil: The Floriskraal Formation of the Witteberg Group (yellow-brown-weathering quartzitic sandstone with alternating beds of siltstone and

micaceous shale) underlie this habitat on Ouhangsberg. Due to the folded character of the area, the adjacent Kweekvlei Formation (dark grey micaceous shale and subordinate siltstone) also plays a role in the character of the substrate (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). A 90% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.1) sandy loam with a high (46%) stone volume and a lower water-holding capacity compared to the rest of the soils supporting the major community supports the vegetation of this variant (Table 4.6).



Figure 4.72: *Syncarpha mucronata* variant of the *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community (Sample plot 181).

Aspect: Neutral, NE

Gradient: Gentle, moderate to steeply sloped

Height above sea-level: 570 - 580 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

Phytosociological Table

Species group AE: Important species for the *Syncarpha mucronata* variant:

Important species for Species Group AE are *Cymbopappus adenosolen*, *Helichrysum excisum*, *Relhania relhanioides*, *Agathosma* sp. nov. 1, *Osteospermum polygaloides*, *Syncarpha mucronata* (Figure 4.73), *Agathosma parva*, *Serruria acrocarpa* and *Erica pilosiflora* ssp. *purpurea* (Annexure 1).

Synoptic Table

Number of relevés: 3

Diagnostic species: *Osteospermum polygaloides* 78.7 and *Syncarpha mucronata* 78.7 (Annexure 2).

Constant species: ***Berkheya armata* 100, *Drosanthemum micans* 100, *Elytropappus rhinocerotis* 100, *Erica boucheri* 100, *Eriocephalus africanus* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Ficinia nigrescens* 100, *Helichrysum excisum* 100, *Helichrysum hebelepis* 100, *Hypodiscus striatus* 100, *Restio capensis* 100, *Capeochloa arundinacea* 100, *Mesembryanthemum longistylum* 100, *Metalasia acuta* 100, *Oedera squarrosa* 100, *Osteospermum polygaloides* 100, *Passerina truncata* 100, *Phyllica rogersii* 100, *Relhania relhanioides* 100, *Ruschia diversifolia* 100, *Syncarpha mucronata* 100 and *Thesium imbricatum* 100** (Annexure 2).

Dominant species: None



Figure 4.73: *Syncarpha mucronata* (Asteraceae).

Discussion:

Erica pilosiflora ssp. *pilosiflora* (67 60.3) is significant here regarding frequency and fidelity. The conservation status of this species is Vulnerable (<http://redlist.sanbi.org>).

Helichrysum excisum, *Agathosma parva* and *Agathosma* sp. nov. 1 (first collected during the data collection for this study) (Figure 4.74; Chapter 5.1.12.1; Figure 5.37) also has a high cover abundance in sub-community 11.1. *Relhania relhanioides* also has a high cover abundance in variant ii of sub-community 3.1 and *Cymbopappus adenosolen* has a high cover abundance also in community 5. Species only found in this variant are *Zygophyllum lichtensteinianum*, *Helichrysum saxicola*, *Drimia dregei*, *Erica coarctata*, *Struthiola* species and *Moraea bellendenii*. A unique character of this habitat is the occurrence of five different boegoe species (Rutaceae) namely *Agathosma leptospermoides*, *A. ovata*, *A. parva*, *A. sp. nov. 1* (Figure 4.74) as well as *Macrostylis tenuis* (Annexures 1 & 2).



Figure 4.74: *Agathosma* sp. nov. 1 at the type locality on Gannaberg.

10.2. *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community

Locality: The hills east and southeast of the Greater Brandvlei Dam (Figure 4.75)

Sample plots: 146, 97, 159, 145 and 96

Land Type: Fb123a and Fb123b (Table 2.5)

Geology and soil: The Floriskraal (yellow-brown-weathering quartzitic sandstone with alternating beds of siltstone and micaceous shale) and Swartruggens (siltstone and shale with thin interbedded sandstone) Formations

underlie this sub-community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). A 90% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.



Figure 4.75: The *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community with small *Protea nitida* trees in the background (Sample plot 97).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.4) sandy loam with 23.4% stone volume supports the vegetation of this sub-community. Fine sand make out most of the sand proportion. Apart from Cu and Mn, the soil here has fewer nutrients compared to the rest of the soil supporting the major community (Tables 4.5 and 4.6).

Aspect: S, SW

Gradient: Moderate to steeply sloped

Height above sea-level: 218 – 292 m

Land-cover and use: Vegetation structure is a medium shrubland (<2 m) with small *Protea nitida* trees that can grow higher than 4 m.

Phytosociological Table

Species Group AF: Important species for the *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community:

Important species for Species Group AF are *Searsia rosmarinifolia*, *Arctopus echinatus*, *Oxalis livida*, *Corymbium glabrum*, *Dimorphotheca nudicaulis*, *Protea nitida*, *Clusia polifolia*, *Senecio erosus*, *Moraea tripetala*, *Senecio pinifolius*, *Festuca scabra*, *Geissorhiza inflexa*, *Oxalis polyphylla*, *Erepsia anceps*, *Aspalathus spicata* ssp. *spicata*, *Arctotis undulata*, *Crassula capensis*, *Geissorhiza scillaris*, *Phyllica excelsa*, *Erica totta*, *Pauridia minuta*, *Watsonia* sp., *Aspalathus cephalotes* ssp. *violaceae*, *Corymbium africanum*, *Centella villosa* and *Watsonia spectabilis* (Annexure 1).

Synoptic Table

Number of relevés: 5

Diagnostic species: *Erepsia anceps* 84.9 (Figure 4.76; Annexure 2)

Constant species: ***Anthospermum spathulatum* 100**, *Arctopus echinatus* 80, ***Berkheya armata* 100**, *Corymbium glabrum* 80, *Crassula subulata* var. *subulata* 80, ***Cyphia volubilis* 100**, *Dimorphotheca nudicaulis* 80, ***Ehrharta capensis* 100**, *Elytropappus gnaphaloides* 80, ***Elytropappus rhinocerotis* 100**, *Erepsia anceps* 80, *Ficinia nigrescens* 80, ***Restio capensis* 100**, *Mohria caffrorum* 80, *Oedera capensis* 80, *Oedera squarrosa* 80, *Oxalis livida* 80, *Oxalis polyphylla* 80, *Pelargonium radiatum* 80, ***Searsia rosmarinifolia* 100**, ***Senecio pinifolius* 100**, *Syncarpha canescens* 80 and ***Tribolium utriculosum* 100** (Annexure 2).

Dominant species: *Ehrharta capensis* 20 and *Elytropappus rhinocerotis* 40 (Annexure 2).



Figure 4.76: *Erepsia anceps* (Aizoaceae).

Discussion:

Other significant species regarding fidelity are *Arctotis undulata* (60, 63.8) and *Crassula capensis* (60, 70.2). *Protea nitida* (Waboom) has the highest frequency in this sub-community (Annexure 2).

Arctopus echinatus also has a high cover abundance in community 6. Species only found in this community during the study are *Ballota africana*, *Bolandia pedunculosa*, *Cliffortia sericea*, *Cliffortia species*, *Coleonema juniperinum*, *Corymbium africanum*, *Corymbium villosum*, *Cyphia linarioides*, *Lachenalia moniliformis*, *Micranthus tubulosus*, *Moraea barnardiella*, *Osteospermum bidens*, *Restio distichus*, *Romulea minutiflora*, *Senecio incertus* and *Drimia fragrans* (Annexures 1 & 2).

Moraea barnardiella is considered to be Endangered and *Lachenalia moniliformis* Critically Endangered (<http://redlist.sanbi.org>).

11. *Ruschia caroli*–*Capeochloa arundinacea* community

Plant Community 11 comprises of four sub-communities.

Phytosociological Table

Species Group AG: Important species for the *Ruschia caroli*–*Capeochloa arundinacea* community:

Important species for Species Group AG are *Ruschia caroli* (Figure 4.77), *Pteronia fasciculata*, *Adromischus filicaulis* ssp. *marlothii*, *Bulbine mesembryanthemoides*, *Crassula rupestris* and *Agathosma ovata* (Annexure 1).



Figure 4.77: *Ruschia caroli* (Aizoaceae).

Synoptic Table

Number of relevés: 20

Diagnostic species: None

Constant species: *Adromischus filicaulis* ssp. *marlothii* 80, *Crassula atropurpurea* 90, *Restio sieberi* 85, *Mesembryanthemum longistylum* 85, *Passerina truncata* 90, *Pentameris eriostoma* 85 and *Ruschia caroli* 85 (Annexure 2).

Dominant species: *Agathosma ovata* 10, *Ehrharta capensis* 5, *Oxalis engleriana* 5, *Pteronia fasciculata* 25, *Ruschia caroli* 15, *Scopelogena verruculata* 5 and *Curio crassulifolius* 5 (Annexure 2).

Discussion:

Haworthia maculata (40, 51.8) *Crassula rupestris* 75 47.4, *Pollichia campestris* (30 47.1), *Maytenus oleoides* (50 45.9), *Bulbine mesembryanthemoides* (55 44.3) and *Albuca aurea* (30 36.1), are significant here regarding fidelity (Table). *Ruschia caroli* and *Pteronia fasciculata* are important here but also has a high cover abundance in community 3 and in community 9 (especially in sub-community 9.3). *Agathosma ovata* has high cover abundance in variant iii of sub-community 3.3, and *Crassula rupestris* has high cover abundance in community 12 (Annexures 1 & 2).

11.1. *Ruschia caroli*–*Capeochloa arundinacea*–*Tritonia flabellifolia* sub-community

Locality: Droëriviersberg and Gannaberg (Figure 4.78).

Sample plots: 162, 179, 161 and 164

Land Type: lc116, terrain unit 3 (Table 2.6).

Geology and soil: The Kweekvlei Formation (dark grey micaceous shale and subordinate siltstone) as well as the youngest Waaipoort (shale, mudstone, siltstone and thin immature sandstone beds) of the Witteberg Geological Group

(Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982) underlie this plant community. The occurrence of rock fragments of various sizes (<10 mm to >200 mm) can be up to 95% in this area.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).



Figure 4.78: The *Agathosma ovata*–*Ruschia caroli*–*Tritonia flabellifolia* sub-community (Sample plot 162).

Extremely acidic (pH 3.9) loamy sand with 13.3% stone volume supports the vegetation of this sub-community. The high resistance to the flow of an electric current (2920 Ω) indicates that the soil here is less saline than the other soils supporting this major community. The base saturation Ca:Mg ratio of 0.94 indicates a tendency towards clay dispersion and poor soil structure. Compared to the rest of the soils supporting this major community, the soil here has the lowest capacity to attract, retain and exchange cations T-(value 2.33) (Tables 4.5 and 4.6).

Aspect: Neutral, S, E

Gradient: Gentle, moderate to steeply sloped

Height above sea-level: 255 – 508 m

Land-cover and use: Vegetation structure is a medium shrubland (<2 m)

Phytosociological Table

Species group AH: Important species for the *Ruschia caroli*–*Capeochloa arundinacea*–*Tritonia flabellifolia* sub-community:

Important species for Species Group AH are *Tritonia flabellifolia* (Figure 4.79) and *Pteronia flexicaulis* (Annexure 1).



Figure 4.79: *Tritonia flabellifolia* (Iridaceae) on the slopes of Droëriviersberg.

Synoptic Table

Number of relevés: 4

Diagnostic species: None

Constant species: *Drosanthemum speciosum* 100, *Elytropappus rhinocerotis* 100, *Euryops rehmannii* 100, *Felicia filifolia* ssp. *schaeferi* 100, *Capeochloa arundinacea* 100, *Oedera squarrosa* 100, *Passerina truncata* 100, *Pharnaceum aurantium* 100, *Pteronia fasciculata* 100, *Ruschia caroli* 100 (Annexure 1).

Dominant species: *Ehrharta capensis* 25 (Annexure 1).

Discussion

Drosanthemum speciosum (100, 50.6) is also significant here regarding fidelity (Annexure 2). Species only found in this sub-community during the study are *Eriocephalus grandiflorus*, *Helichrysum simulans*, *Hermannia filifolia*, *Isolepis* species, *Lachnospermum neglectum*, *Olea europaea* ssp. *africana* (Olienhout) and *Trichodiadema* species (Annexures 1 & 2).

Lachnospermum neglectum has Red List conservation status: Near Threatened (<http://redlist.sanbi.org>).

11.2. *Ruschia caroli*–*Capeochloa arundinacea*–*Othonna arbuscula* sub-community

Locality: Hills bordering the Greater Brandvlei Dam to the northeast (Figure 4.80).

Sample plots: 65, 67, 80, 69 and 51

Land Type: Fa198a, terrain unit 3 (Table 2.3).

Geology and soil: Transitional areas of folded Swartruggens (siltstone and shale with thin interbedded sandstone) and Witpoort Formations (light-grey quartzitic sandstone) of the Witteberg Geological Group underlie this plant community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Up to 95% rock fragments of various sizes (<10 mm to >200 mm) occur.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991). Extremely acidic (pH 3.6) sandy loam with 21.1% stone volume supports the vegetation of

this sub-community. Compared to the other soils supporting the major community, the soil here has the highest proportions of clay and silt and is close to being regarded as saline (resistance to the flow of an electric current 410Ω) (Tables 4.5 and 4.6). According to the Bemlab guidelines, soil with resistance $<300 \Omega$ is regarded as saline (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>).



Figure 4.80: The *Agathosma ovata*–*Ruschia caroli*–*Othonna arbuscula* sub-community (Sample plot 65).

Apart from Na, Fe and dissolvable S, the soil here has fewer nutrients compared to most of the soils supporting the major community. The base saturation Ca:Mg ratio of 0.50, as well as a high Na^+ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Table 4.5).

Aspect: N, NE, NW

Gradient: Moderate to very steeply sloped

Height above sea-level: 214 – 293 m

Land-cover and use: Vegetation structure is a low karroid shrubland (<1 m).

Phytosociological Table

Species Group AI: Important species for the *Ruschia caroli*–*Capeochloa arundinacea*–*Othonna arbuscula* sub-community:

Important species for Species Group AI are *Senecio sarcooides*, *Haworthia maculata*, *Othonna arbuscula* (Figure 4.81), *Albuca aurea*, *Senecio bulbinifolius*, *Anacampseros retusa*, *Convolvulus capensis* and *Drimia intricata* (Annexure 1).



Figure 4.81: The deciduous succulent shrub, *Othonna arbuscula* (Asteraceae) flowering in summer.

Synoptic Table

Number of relevés: 5

Diagnostic species: None

Constant species: ***Adromischus filicaulis* ssp. *marlothii* 100**, *Albuca aurea* 80, ***Bulbine mesembryanthemoides* 100**, *Bulbine praemorsa* 80, ***Crassula atropurpurea* 100**, *Crassula rupestris* 80, ***Drosanthemum hallii* 100**, ***Felicia filifolia* ssp. *schaeferi* 100**, *Holothrix villosa* 80, ***Restio sieberi* 100**, ***Mesembryanthemum longistylum* 100**, *Oedera squarrosa* 80, *Ornithogalum dubium* 80, ***Othonna arbuscula* 100**, ***Passerina truncata* 100**, ***Pentameris eriostoma* 100**, ***Pteronia fasciculata* 100**, *Pteronia paniculata* 80, *Ruschia caroli* 80, *Ruschia diversifolia* 80, *Curio crassulifolius* 80, ***Senecio sarcoides* 100** (Annexure 2).

Dominant species: *Pteronia fasciculata* 100 and *Ruschia caroli* 20 (Annexure 2).

Discussion:

Haworthia maculata also occurs in sub-communities 9.3 as well as in 11.2 and 11.3 (Annexures 1 & 2).

11.3. *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogena verruculata* sub-community

Number of relevés: 4

Locality: Sandstone outcrops on Droëriviersberg in the Trappieskraalkloof as well as outcrops on the hills bordering the Greater Brandvlei Dam to the northeast (Figure 4.82).

Sample plots: 163, 68, 82 and 83

Geology and soil: Sandstone of the Blinkberg Formation (light-grey quartzitic sandstone with thin micaceous siltstone beds) and largely the Witpoort Formation (light-grey quartzitic sandstone) of the Witteberg Group underlie this habitat (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). The rocky soil consists of 95 - 99% covering of rock fragments of various sizes (<10 mm to >200 mm).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Moderately acidic (pH 6) sandy loam with 13.6% stone volume supports the vegetation of this sub-community. Compared to the other soils supporting the major community, the soil here has a higher pH and is particularly rich in nutrients and is close to being regarded as saline (the lowest measure of resistance to the flow of an electric current for the major community, 360 Ω) (Tables 4.5 and 4.6). According to the Bemlab guidelines, soil with resistance <300 Ω is regarded as saline (Bemlab: <http://www.bemlab.co.za/quickref.php?id=21>).



Figure 4.82: *Agathosma ovata*–*Ruschia caroli*–*Scopelogenia verruculata* sub-community (Sample plot 82).

The soil here has a markedly higher capacity to attract, retain and exchange cations (T-value 33.82) compared to the rest of the soil supporting this major community (Table 4.5).

Aspect: Neutral, E, SE

Gradient: Very steeply sloped

Height above sea-level: 216 – 297 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

Phytosociological Table

Species Group AJ: Important species for the *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogenia verruculata* sub-community:

Important species for Species Group AJ are *Maytenus oleoides*, *Scopelogenia verruculata* (Figure 4.83), *Lycium oxycarpum*, *Pteronia divaricata* and *Stayneria neilii* (Annexure 1).



Figure 4.83: In the study area, *Scopelogenia verruculata* (Aizoaceae) prefers the quartzitic outcrops and rock faces of the Witpoort Formation.

Synoptic Table

Number of relevés: 4

Diagnostic species: ***Scopelogenia verruculata* 96.2** (Annexure 2).

Constant species: ***Agathosma ovata* 100, *Crassula atropurpurea* 100, *Crassula rupestris* 100, *Maytenus oleoides* 100, *Ruschia caroli* 100, *Scopelogenia verruculata* 100 and *Tylecodon paniculatus* 100** (Annexure 2).

Dominant species: *Ruschia caroli* 25 and *Scopelogenia verruculata* 25 (Annexure 2).

Discussion

Lycium oxycarpum (75, 72.7) is significant regarding frequency and fidelity. *Maytenus oleoides* also has high cover abundance in sub-community 9.2 and occurs in nearly all the samples of sub-community 11.4. *Aloe mitriformis* and *Pelargonium plurisectum* were only found in this sub-community during this study (Annexures 1 & 2).

Rock hyrax and rock rabbit colonies defecate and urinate in latrines (middens), which can be large through continuous use (Figure 4.84; Collins 2005; Gaylard 2005). The accumulation and consequent decomposition of organic material contribute to the soil texture and nutrient status, creating a microhabitat within the rocky outcrop habitat. Urine and decomposition of such middens can contribute to soil fertility as precipitation facilitates leaching and distribution of nutrients.



Figure 4.84: Rock rabbit colonies defecate and urinate in latrines (middens), where urine and decomposition of such middens can contribute to soil fertility, as evident from the fungi growing on the latrine in the picture.

The more alkaline, especially mineral rich soil of the sub-community is most likely a consequence of the high accumulation of organic material between the rocks in this habitat (Figures 4.85 and 4.86). Small mammals living in these rocky outcrops, such as dormice and rock mice, make nests of grass and sticks (Leon and Belonje 1979; Skinner and Chimimba 2005; Carr *et al.* 2016).



Figure 4.85: Small mammals living in rocky outcrops, such as dormice and rock mice, make nests of grass and sticks. Decomposition of this organic material contributes to soil fertility and texture.



Figure 4.86: A high accumulation of organic material (a) such as termite frass (b) contributes to the humus-rich soil (c) of the *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogenia verruculata* sub-community.

Harvester ants and harvester termites also contribute to this microhabitat (Figure 4.87). The high pH and high nutrient status of the soil here most probably relate to the effect of accumulated organic material through the

activities of ecological engineers such as small mammals and insects that live in these rocky outcrops.



Figure 4.87: Harvester ants and termites carrying plant material to their nests (a and b).

The continuing collection of plant material, reworking of the soil and as well as frass (excrement) (Figure 4.86) changes the soil to be finer in texture, more alkaline, more saline, and with higher concentrations of macro- and micro-elements (Midgley and Musil 1990; Dean 1995; Booij 2011; Kunz *et al.* 2012).

11.4. *Ruschia caroli*–*Capeochloa arundinacea*–*Curio crassulifolius* sub-community

Locality: Crests of the hills that border the Greater Brandvlei Dam to the north (Figure 4.88).



Figure 4.88: The rocky habitat of the *Agathosma ovata*–*Ruschia caroli*–*Senecio crassulaefolius* sub-community (Sample plot 73).

Sample plots: 73, 40, 47, 63, 41, 37 and 39

Land Type: Fa198a, terrain units 1 and 3 (Table 2.3).

Geology and soil: The Blinkberg- (light-grey quartzitic sandstone with thin micaceous siltstone beds) and Witpoort (grey quartzitic sandstone with shale interbeds) Formations of the Witteberg Group underlie this plant community

(Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). A 90 - 95% covering of rock fragments of various sizes (<10 mm to >200 mm) occurs.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 3.6) sandy loam with 17.2% stone volume supports the vegetation of this sub-community. Compared to the rest of the soils supporting the major community, the soil here has highest proportion of fine sand, the highest water-holding capacity and high amounts of organic C as well as Fe (Tables 4.5 and 4.6).

Aspect: Neutral, N, SE, SW

Gradient: Moderate to very steeply sloped,

Height above sea-level: 246 – 310 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m).

Phytosociological Table

Species Group AK: Important species for the *Ruschia caroli*–*Capeochloa arundinacea*–*Curio crassulifolius* sub-community:

Important species for Species Group AK are *Curio crassulifolius* (Figure 4.89) and *Manochlamys albicans* (Annexure 1).

Synoptic Table

Number of relevés: 7

Diagnostic species: None

Constant species: ***Adromischus filicaulis* ssp. *marlothii* 100**, ***Agathosma ovata* 100**, *Crassula atropurpurea* 86, *Euryops rehmannii* 86, *Restio sieberi* 86, *Maytenus oleoides* 86, ***Mesembryanthemum longistylum* 100**, *Oxalis fergusonae* 86, *Passerina truncata* 86 and ***Pentameris eriostoma* 100** (Annexure 2).

Dominant species: *Agathosma ovata* 29, *Oxalis engleriana* 14, *Ruschia caroli* 14 and *Curio crassulifolius* 14 (Annexure 2).

Discussion:

Manochlamys albicans (71 43.7) and *Maytenus oleoides* (86 42.2) are also significant here regarding frequency and fidelity. *Curio crassulifolius* also has high cover abundance in sub-community 11.2. During this study, *Helichrysum revolutum* was only noted in this habitat (Annexures 1 & 2).



Figure 4.89: *Curio crassulifolius* (Asteraceae).

Heuweltjies

Plant species occurring on Heuweltjies in major community 3 includes: *Aloe microstigma* (Figure 4.90), *Diospyros glabra*, *Drosanthemum parvifolium*, *Euclea undulata*, *Lycium oxycarpum*, *Maytenus oleoides*, *Pteronia incana* (Figure 4.90), *Ruschia multiflora*, *Searsia undulata* and *Tylecodon paniculatus*.

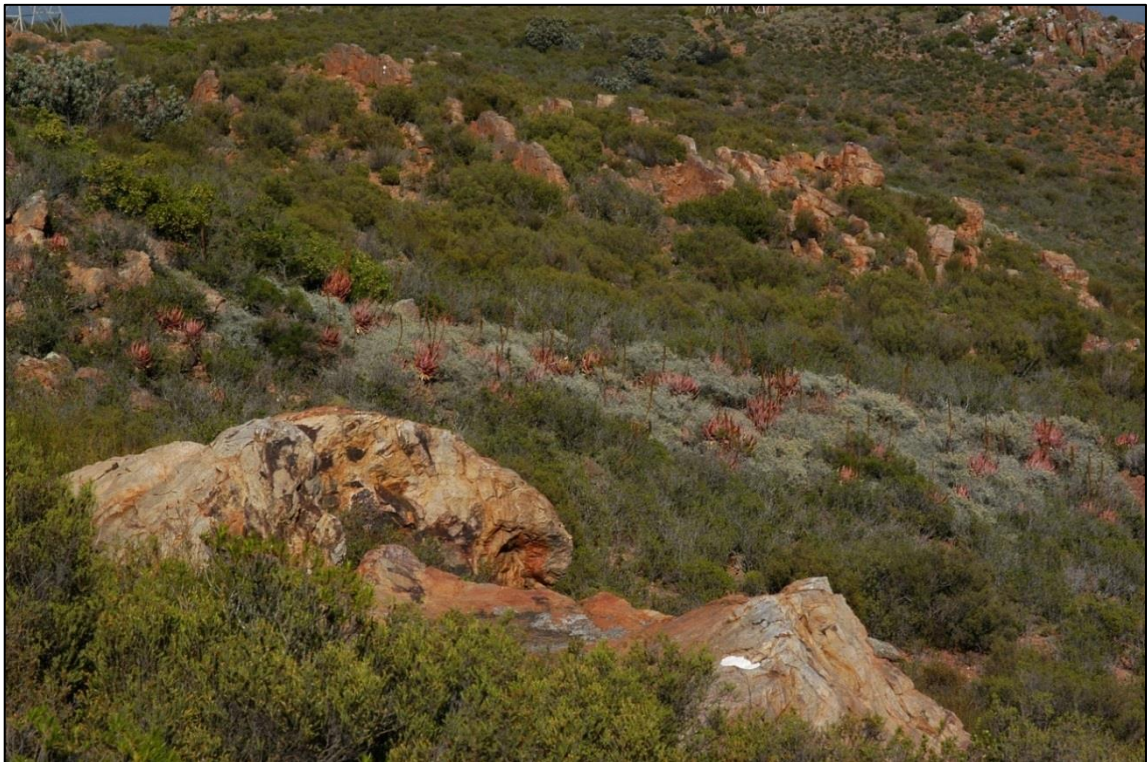


Figure 4.90: *Aloe microstigma* and *Pteronia incana* dominate the Heuweltjies in major community 3.

Major Plant Community 4: *Hirpicium integrifolium* shrubland

The *Hirpicium integrifolium* Major community (Figure 4.91) is a shrubland composed of low (<1 m) karroid shrub vegetation that occurs on Sandberg, Droëriviersberg and Hammansberg.



Figure 4.91: The *Hirpicium integrifolium* shrubland on Dwyka tillite.

The *Hirpicium integrifolium* shrubland includes two different land types and comprises two plant communities located predominantly in the following areas:

- Mid- and footslopes of Hammansberg and Droëriviersberg on Dwyka tillite. Land types Fb122a and Ic116, terrain unit 3 (Tables 2.4 and 2.6).

Dwyka tillite (dark grey-green tillite which weathers yellowish brown) (Figure 3.15; Figure 4.91) of the Karoo Supergroup underlies this plant community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982).

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms) (Figure 3.17; Soil Classification Working Group 1991). Rock fragments of various sizes (<10 mm to >200 mm) cover the soil in different

proportions. Soil analyses of the A horizon for Major community 4 are given in Tables 4.7 and 4.8.

Compared to most of the soils supporting the other major communities (with the exception of major community 5 which is supported by aeolian sand), the sandy loam soils supporting the *Hirpicium integrifolium* (Figure 4.92) shrubland has a higher proportion of clay, less silt, higher proportions of medium and coarse sand and a lower water-holding capacity (Table 4.8). The soils sampled in this major community are furthermore less acidic and more saline compared to most of the soils supporting the other major communities (Table 4.7).



Figure 4.92: *Hirpicium integrifolium* (Haarbossie) (Asteraceae).

Table 4.7: Analyses of the soil A horizon for major community 4. T-value = sum of exchangeable Ca, Mg, Na and K.

Plant communities and subunits		pH (KCl)	Electrical resistance (ohm)	H (cmol/kg)	P (Bray II mg/kg)	Exchangeable cations				Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)	C (%)	Dissolvable S (mg/kg)	Base saturation					
						Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)								Na %	K %	Ca %	Mg %	T-value (cmol/kg)	% Acid saturation
12	Community 12	4.2	1310	0.88	13	0.21	0.22	1.17	1.60	0.5	0.5	42.2	0.43	37.23	0.59	13.69	5.18	5.44	28.66	39.14	4.08	21.58
13	Community 13	4.3	770	1.11	15	0.22	0.25	3.77	1.10	0.7	5.4	123.2	0.62	81.96	1.90	20.2	3.46	3.92	58.43	17.00	6.46	17.19
Average for major community		4.3	1040	1.00	14	0.22	0.24	2.47	1.35	0.6	3	82.7	0.53	59.60	1.25	16.95	4.32	4.68	43.55	28.07	5.27	19.39
Average for entire study		4.1	2525	1.18	21	0.20	0.22	1.65	1.39	0.5	1.7	53.8	0.32	77.59	1.48	18.98	4.40	4.95	29.38	26.85	4.64	34.43

Table 4.8: Mechanical analysis of the soil A horizon for major community 4. SaLm = Sandy loam.

Plant communities and subunits		Clay %	Silt %	Sand %	Fine sand %	Med sand %	Coarse sand %	Stoniness %	Texture	Water-holding capacity mm/m
12	Community 12	16	4	80	46.8	19	14.6	23.1	SaLm	87.8
13	Community 13	16	10	74	45.6	15.2	13.6	16.4	SaLm	100.98
Average for major community		16	7	77	46.2	17.1	14.1	19.75		94.39
Average for entire study		13	9	78	59.0	11.0	8.0	19.0		114.00

Phytosociological Table

Species group AL: Important species for the *Hirpicium integrifolium* shrubland:

Important species for Species group AL are *Tylecodon paniculatus*, *Pelargonium alternans*, *Searsia incisa*, *Crassula muscosa*, *Tetragonia fruticosa*, *Galenia africana*, *Hirpicium integrifolium*, *Euclea undulata*, *Cotyledon orbiculata* var. *orbiculata*, *Cissampelos capensis*, *Selago eckloniana*, *Crassula divaricata*, *Euphorbia mauritanica*, *Haworthia herbacea*, *Carissa bispinosa*, *Crassula subaphylla* and *Sutherlandia frutescens* (Annexure 1).

Synoptic Table

Number of relevés: 7

Diagnostic species: *Anginon swellendamensis* 83.5, *Crassula divaricata* 76.8, *Euphorbia mauritanica* 89.8, *Haworthia herbacea* 80.3 and *Hirpicium integrifolium* 83.3 (Annexure 2).

Constant species: *Adromischus filicaulis* ssp. *marlothii* 86, *Anginon swellendamensis* 86, *Chrysocoma ciliata* 86, ***Crassula atropurpurea* 100**, ***Euphorbia burmannii* 100**, *Euphorbia mauritanica* 86, *Hirpicium integrifolium* 86, *Pelargonium alternans* 86, ***Pteronia paniculata* 100**, *Searsia incisa* 86, *Ruschia caroli* 86 and ***Tylecodon paniculatus* 100** (Annexure 2).

Dominant species: *Hirpicium integrifolium* 14, *Pteronia fasciculata* 14 and *Pteronia paniculata* 14 (Annexure 2).

Discussion:

Species significant regarding frequency and fidelity are *Euclea undulata* (71 72.6), *Duvalia caespitosa* (57 71.8), *Euphorbia hamata* (57 71.8), *Crassula subaphylla* (57 71.8), *Mesembryanthemum varians* (57 71.8), *Leipoldtia schultzei* (57 70.3), *Cotyledon orbiculata* var. *orbiculata* (57 61.0), *Selago scabrida* (57 69.2), *Selago eckloniana* (57 63.5), *Drosanthemum speciosum* (71 63.2), *Pelargonium tetragonum* (43 61.2), *Cissampelos capensis* (57 60.6), *Carissa bispinosa* (43 59.5), *Eriocephalus ericoides* (43 58.1) and *Crassula muscosa* (71 56.2) (Annexure 2).

Regarding cover abundance, *Pelargonium alternans* is also important in sub-community 9.3 as well as in 11.1 and 11.2; *Tylecodon paniculatus* is also important in community 7 and in sub-community 11.3; *Searsia incisa* in sub-community 9.3 and *Cotyledon orbiculata* in variant 1 of sub-community 3.1 (Annexure 1).

12. *Euphorbia hamata*–*Hirpicium integrifolium* community

The *Euphorbia hamata*–*Hirpicium integrifolium* community occurs on the rocky slopes and outcrops of Dwyka tillite in the study area (Figure 4.93).

Locality: Hammansberg and Droëriviersberg.

Sample plots: 175, 178 and 174

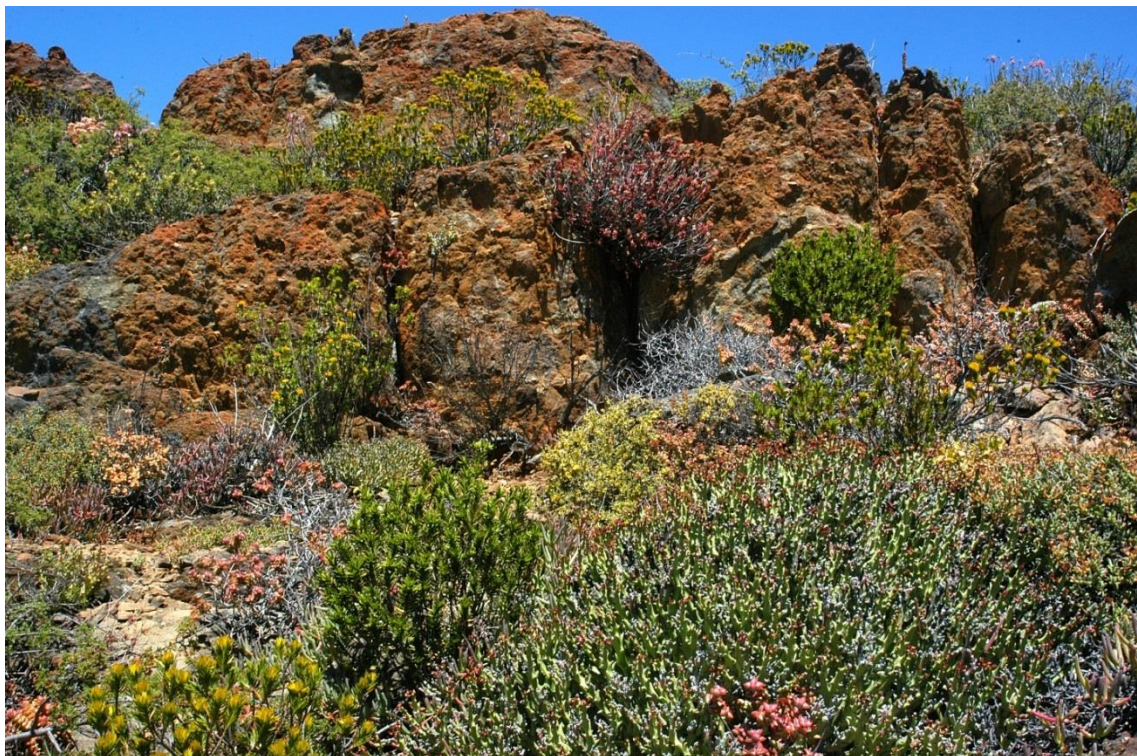


Figure 4.93: The *Euphorbia hamata*–*Hirpicium integrifolium* community (Sample plot 174) on Hammansberg with *Euphorbia hamata* in the foreground.

Land Type: Fb122a and Ic116, terrain unit 3 (Tables 2.4 and 2.6).

Geology and soil: Dwyka tillite (dark grey-green tillite which weathers yellowish brown) of the Karoo Supergroup underlies this plant community (Gresse and

Theron 1992; Gresse 1997; Tankard *et al.* 1982). Rock fragments are abundant (up to 98% covering) and determine the depth of the loam soil.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.2) sandy loam with 23.1% stone volume supports the vegetation of this community. The resistance to the flow of an electric current (1310 Ω), shows that the soil here is less saline compared to the other soils supporting this major community. In comparison to other soils supporting the major community, the soil here has less silt, a higher proportion of medium sand as well as stoniness, and a lower water-holding capacity. With the exception of Mg, the soil here is poorer in nutrients compared to the other soils supporting the major community. The Ca:Mg ratio of 0.73, together with a relatively high Na⁺ saturation, indicates a tendency towards clay dispersion and poor soil structure which can cause the soil to be prone to erosion (Tables 4.7 and 4.8).

Aspect: N, NE

Gradient: Moderate to steeply sloped

Height above sea-level: 287 – 447 m

Land-cover and use: Vegetation structure is of a low karroid shrubland (<1 m).

Phytosociological Table

Species group AM: Important species for the *Euphorbia hamata*–*Hirpicium integrifolium* community:

Important species for Species Group AM are *Asparagus retrofractus*, *Senecio radicans*, *Leipoldtia schultzei*, *Selago scabrida*, *Adromischus maculatus*, *Eriocephalus ericoides*, *Euphorbia hamata* (Figure 4.94), *Conophytum ficiforme*, *Lotononis leptoloba*, *Gasteria disticha* and *Sarcostemma viminale* (Annexure 1).

Synoptic Table

Number of relevés: 3

Diagnostic species: *Cotyledon orbiculata* var. *orbiculata* 80.5, ***Eriocephalus ericoides* 97.4**, *Euphorbia hamata* 88.6, *Haworthia herbacea* 79.2, *Leipoldtia schultzei* 87.3, *Lotononis leptoloba* 80.7, *Sarcostemma viminale* 80.7, *Selago scabrida* 85.3, *Senecio radicans* 81.8 (Annexure 2).

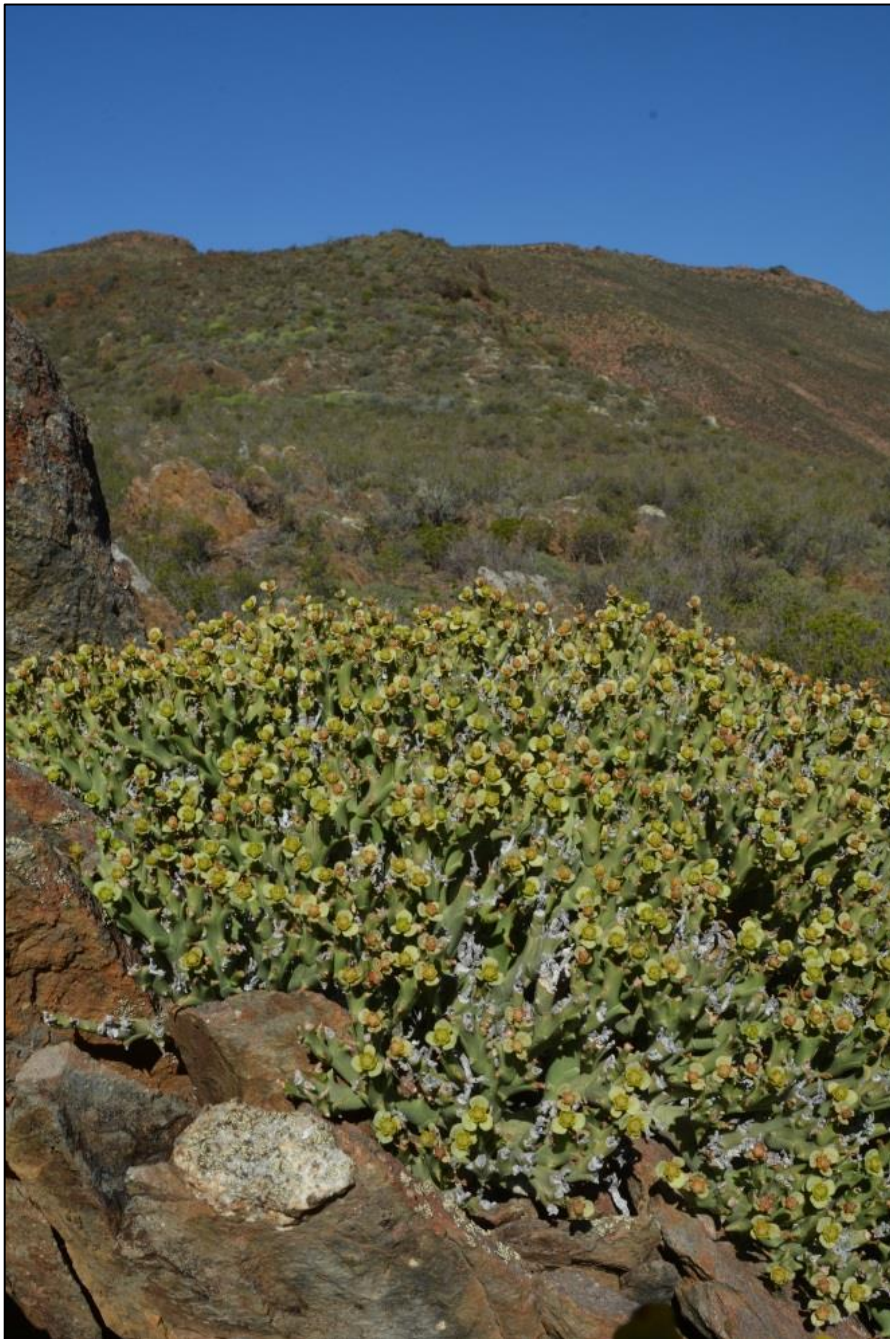


Figure 4.94: *Euphorbia hamata* (Beesmelkbos, Olifantmelkbos) (Euphorbiaceae) on the Dwyka tillite in the study area.

Constant species: *Adromischus filicaulis* ssp. *marlothii* 100, *Cotyledon orbiculata* var. *orbiculata* 100, *Crassula atropurpurea* 100, *Crassula muscosa* 100, *Crassula rupestris* 100, *Ehrharta calycina* 100, *Eriosephalus ericoides* 100, *Euclea undulata* 100, *Euphorbia burmannii* 100, *Euphorbia hamata* 100, *Euphorbia mauritanica* 100, *Galenia africana* 100, *Haworthia herbacea* 100, *Hirpicium integrifolium* 100, *Leipoldtia schultzei* 100, *Pelargonium alternans* 100, *Pteronia fasciculata* 100, *Pteronia paniculata* 100, *Searsia incisa* 100, *Selago scabrida* 100, *Senecio radicans* 100, *Tylecodon paniculatus* 100 (Annexure 2).

Dominant species: *Pteronia fasciculata* 33 (Annexure 2).

Discussion:

Although *Eriosephalus ericoides* is the diagnostic species with the highest fidelity, it was not used to name this community due to the fact that it also occurs on the Bokkeveld Geological Group which was not included in this study. *Euphorbia nesemannii*, *Gasteria disticha*, *Lebeckia leptophylla* and *Limeum aethiopicum* were only found in this community during the study (Annexures 1 & 2).

The conservation status of *Euphorbia nesemannii*, which is known from Worcester to Robertson to Swellendam, is considered Near Threatened (<http://redlist.sanbi.org>).

13. *Pelargonium karoicum*–*Hirpicium integrifolium* community

The *Pelargonium karoicum*–*Hirpicium integrifolium* community occurs on plateaus and lower slopes underlain by Dwyka tillite in the study area (Figure 4.95).

Locality: Droëriviersberg and Hammansberg.

Land Type: Fb122a and Ic116, terrain unit 3 and 4 (Tables 2.4 and 2.6).

Sample plots: 177, 173, 176 and 172

Geology and soil: Dwyka tillite (dark grey-green tillite which weathers yellowish brown) of the Karoo Supergroup underlies this plant community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). Rock fragments cover between 20 - 80% of the surface area.

The substrate is a soil-rock complex with rock, as well as Mispah and Glenrosa soil forms (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.3) sandy loam with 16.4% stone volume supports the vegetation of this community. The relatively low resistance to the flow of an electric current (770 Ω), shows that the soil here is considerably more saline compared to the other soil supporting this major community. In comparison with other soils supporting the major community, the soil here has a higher proportion of silt, less stones and a higher water-holding capacity. With the exception of Mg, the soil here contains a higher amount of nutrients and a higher total of exchangeable cations compared to the other soils supporting this major community (Tables 4.7 and 4.8).



Figure 4.95: The *Pelargonium karoicum*–*Hirpicium integrifolium* community on the lower western slope of Hammansberg with *Haworthia herbacea* in flower (Sample plot 172).

Aspect: Neutral, S

Gradient: Gentle to moderately sloped

Height above sea-level: 336 – 439 m

Land-cover and use: Vegetation structure is a low shrubland (<1 m)

Phytosociological Table

Species Group AN: Important species for the *Pelargonium karooicum*–*Hirpicium integrifolium* community:

Important species for Species Group AN are *Drimia capensis*, *Ornithogalum graminifolium*, *Anginon swellendamensis*, *Ornithogalum pilosum*, *Pelargonium karooicum* (Figure 4.96), *Duvalia caespitosa*, *Quaqua mammillaris*, *Mesembryanthemum varians*, *Pelargonium tetragonum*, *Mesembryanthemum splendens* and *Ixia latifolia* (Annexure 1).

Synoptic Table

Number of relevés: 4

Diagnostic species: *Crassula divaricata* 75.6 and *Pelargonium karooicum* 84.9 (Annexure 2).

Constant species: ***Albuca papyraceae* 100, *Anginon swellendamensis* 100, *Chrysocoma ciliata* 100, *Crassula atropurpurea* 100, *Crassula divaricata* 100, *Euphorbia burmannii* 100, *Mohria caffrorum* 100, *Ornithogalum dubium* 100, *Pelargonium karooicum* 100, *Pentameris airoides* ssp. *airoides* 100, *Pteronia paniculata* 100, *Ruschia caroli* 100 and *Tylecodon paniculatus* 100** (Annexure 2).

Dominant species: *Hirpicium integrifolium* 25 and *Pteronia paniculata* 25 (Annexure 2).



Figure 4.96: The deciduous *Pelargonium karooicum* (Geraniaceae) flowering in autumn.

Discussion:

Duvalia caespitosa (75 70.0), *Ixia latifolia* (50 69.5) and *Euphorbia mauritanica* (75 52.1) are also significant here regarding frequency and fidelity (Annexure 2).

Athanasia humilis, *Berkheya rigida*, *Cineraria lobata*, *Cotyledon orbiculata* var. *spuria*, *Crassula orbicularis*, *Helichrysum* species, *Ixia latifolia*, *Ixia vanzyliae*, *Nemesia pageae*, *Pelargonium heterophyllum* and *Pelargonium ternatum* were

only found in this community during the study. Though *Disa triloba* was only sampled in this community, the species also grows in community 1 (Annexures 1 & 2).

The conservation status of two localised species known from Worcester to Robertson, *Ixia vanzilliae* and *Mesembryanthemum varians* is considered Vulnerable (<http://redlist.sanbi.org>).

Infrequent populations of *Pelargonium conradiae* (Geraniaceae) (Figure 4.97), a recently described species first collected during the data collection for this study, occurs in this community (Manning and Le Roux 2016; Annexure 11; Chapter 5.1.9.2; Figure 5.31).



Figure 4.97: The small deciduous shrub, *Pelargonium conradiae* (Geraniaceae).

Heuweltjies

The density of Heuweltjies on soils derived from Dwyka Tillite in major community 4 is usually high. The patches are quite distinctive compared to the rest of the vegetation due to the yellow-green colour of dominant *Euphorbia mauritanica* shrubs (Figure 4.98).



Figure 4.98: A high density of Heuweltjies occur in soils derived from Dwyka tillite in the study area. As *Euphorbia mauritanica* dominates the Heuweltjies here, the patches are clearly distinct due to the yellow green colour of the *Euphorbia* shrubs.

Plant species occurring on Heuweltjies in major community 4 includes: *Aloe microstigma*, *Asparagus retrofracta*, *Carissa bispinosa* (Figure 4.99), *Cissampelos capensis*, *Cotyledon orbiculata* var. *orbiculata*, *Crassula atropurpurea*, *Crassula expansa* ssp. *expansa*, *Crassula rupestris*, *Crassula tetragona* ssp. *tetragona*, *Drimia capensis*, *Drosanthemum hispidum*, *Eriocephalus ericoides* (Figure 4.100), *Euclea undulata* (Figures 4.98 & 4.99), *Euphorbia hamata*, *Euphorbia mauritanica* (Figure 4.99), *Galenia africana*, *Helichrysum rutilans*, *Hermannia cuneifolia* var. *cuneifolia*, *Leipoldtia schultzei*, *Lycium oxycarpum*, *Mesembryanthemum junceum*, *M. splendens*, *Pteronia incana*, *Pelargonium tetragonum*, *Pentzia incana*, *Pharnaceum*

aurantium, *Sarcostemma viminale* ssp. *viminale*, *Tetragonia spicata*, *Tylecodon paniculatus* (Figure 4.100) and *Zygophyllum foetidum*.



Figure 4.99: Heuweltjies on Dwyka tillite is often dominated by *Carissa bispinosa*, *Euclea undulata* and *Euphorbia mauritanica*.



Figure 4.100: Heuweltjies on Dwyka tillite can also be dominated by *Eriocephalus ericoides* and *Tylecodon paniculatus*.

Major Plant Community 5: *Thamnochortus bachmannii* sandveld

The *Thamnochortus bachmannii* Sandveld (Figure 4.101) is characterised by the dominance of certain members of the Restionaceae family. This shrubland consists of medium tall (<2 m) shrub vegetation and occurs on aeolian sand deposits which were transported by strong winds from alluvium deposits during dry spells. From the range of hills north, east and southeast of the Greater Brandvlei Dam this major community occurs south-eastwards towards Robertson in habitats where aeolian sands were deposited (Figure 3.11; Gresse 1997).



Figure 4.101: The *Thamnochortus bachmannii* Sandveld in the foreground. The dominance of certain members of the Restionaceae indicates the presence of deep aeolian sand deposits.

Number of relevés: 8

The *Thamnochortus bachmannii* (Figure 4.102) Sandveld includes three different land types and includes two plant communities located in the following areas:

- Aeolian sand deposits on the mid- and footslopes of hills bordering the Greater Brandvlei Dam on the north-western side. Land type Fa198a, terrain unit 3 (Table 2.3).
- The lower west-facing slope of hills bordering the Greater Brandvlei Dam to the east, as well as the lower southern side (north-facing slope) of a small kloof east of the dam, between the dam and the Villiersdorp road. Land type Bb41a and Fb123b, terrain unit 3 (Tables 2.2 and 2.4).



Figure 4.102: *Thamnochortus bachmannii* (Restionaceae) is a typical species of deep sand deposits in the study area.

The Fernwood soil form (Figure 3.17; Soil Classification Working Group 1991) dominates. Soil analyses of the A horizon of the *Thamnochortus bachmannii* Sandveld are shown in Tables 4.9 and 4.10. Sand (mostly fine and medium grained sand) primarily contributes to soil texture with lower percentages of clay and silt than the averages for the entire study. Less than 20 % covering of gravel to medium (<200 mm) rock fragments occurs in parts (Table 4.10).

Table 4.9: Analyses of the soil A horizon for major community 5. T-value = sum of exchangeable Ca, Mg, Na and K.

Plant communities and subunits		pH (KCl)	Electrical resistance (ohm)	H (cmol/kg)	P (Bray II mg/kg)	Exchangeable cations				Cu (mg/kg)	Zn (mg/kg)	Mn (mg/kg)	B (mg/kg)	Fe (mg/kg)	C (%)	Dissolvable S (mg/kg)	Base saturation					
						Na (cmol/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)								Na %	K %	Ca %	Mg %	T-value (cmol/kg)	% Acid saturation
14	Community 14	4.3	8980	0.44	4	0.03	0.04	0.44	0.18	0.1	0.3	6.1	0.19	13.31	0.22	7.61	2.56	3.62	38.98	16.2	1.14	38.64
15	Community 15	4.3	6190	0.29	3	0.04	0.04	0.22	0.16	0.1	0.2	1.5	0.13	16.52	0.15	9.21	4.72	5.83	29.43	21.33	0.75	38.68
Average for major community		4.3	7585	0.37	3.5	0.04	0.04	0.33	0.17	0.1	0.25	3.8	0.16	14.92	0.19	8.41	3.64	4.73	34.21	18.77	0.95	38.66
Average for entire study		4.1	2525	1.18	21	0.20	0.22	1.65	1.39	0.5	1.7	53.8	0.32	77.59	1.48	18.98	4.40	4.95	29.38	26.85	4.64	34.43

Table 4.10: Mechanical analysis of the soil A horizon for major community 5. Sa = Sand.

Plant communities and subunits		Clay %	Silt %	Sand %	Fine sand %	Med sand %	Coarse sand %	Stoniness %	Texture	Water-holding capacity mm/m
15	Community 15	4	0	96	38	44.4	14.0	0	Sa	77.95
Average for major community		4	2	94	37.1	40.6	16.7	0.5		81.24
Average for entire study		13	9	78	59.0	11.0	8.0	19.0		114.00

Phytosociological Table

Species Group AO: Important species for the *Thamnochortus bachmannii* Sandveld:

Important species for Species Group AO are *Thamnochortus bachmannii*, *Gladiolus carinatus*, *Gymnodiscus capillaris*, *Stipagrostis zeyheri* ssp. *zeyheri*, *Aristida diffusa* ssp. *diffusa*, *Rafnia angulata* and *Brunsvigia orientalis* (Annexure 1).

Synoptic Table

Number of relevés: 8

Diagnostic species: ***Gymnodiscus capillaris* 95.6**, *Polpoda capensis* 75.6, *Thamnochortus bachmannii* 80.3 and *Willdenowia incurvata* 75.4 (Annexure 2).

Constant species: *Ehrharta villosa* 88, ***Gymnodiscus capillaris* 100**, *Thamnochortus bachmannii* 88, *Ursinia anthemoides* 88 and *Willdenowia incurvata* 88 (Annexure 2).

Dominant species: *Ehrharta calycina* 25, *Erica plumosa* 12, *Thamnochortus bachmannii* 38 and *Willdenowia incurvata* 38 (Annexure 2).

Discussion:

In terms of frequency and fidelity, the following species are also significant in this major community: *Gladiolus carinatus* (75 73.3), *Limeum africanum* (50 61.2), *Heliophila coronopifolia* (62 60.9), *Euphorbia tuberosa* (62 68.8), *Pelargonium radulifolium* (50 66.7), *Restio gaudichaudiana* (75 65.8), *Trachyandra chlamydophylla* (50 65.1), *Aristida diffusa* ssp. *diffusa* (50 64.2), *Babiana ambigua* (62 62.4), *Lyperia tristis* (50 62.3), *Hermannia cuneifolia* var. *cuneifolia* (50 62.0), *Euchaetis pungens* (50 61.9), *Adenogramma glomerata* (75 59.4), *Aspalathus heterophylla* (50 59.1), *Ornithoglossum viride* (50 57.5), *Diospyros glabra* (62 57.4), *Trachyandra revoluta* (50 57.7), *Brunsvigia orientalis* (38 56.9), *Leucospermum rodolentum* (38 56.9), *Phyllica stipularis* (38 56.9), *Rafnia angulata* (38 56.9), *Senecio burchellii* (38 56.9), *Leucadendron salignum* (50 56.8), *Stipagrostis zeyheri* ssp. *zeyheri* (50 56.4), *Trichogyne*

repens (50 65.1), *Aristea dichotoma* (38 55.1), *Babiana ringens* (38 55.1), *Centella capensis* (38 54.1), *Wiborgia obcordata* (38 54.1) and *Eragrostis curvula* (50 51.5) (Annexures 1 & 2).

14. *Leucospermum rodolentum*–*Thamnochortus bachmannii* community

Locality: The lower west-facing slope of hills bordering the Greater Brandvlei Dam to the east, as well as the lower southern side (north-facing slope) of a small kloof east of the dam between the dam and the Villiersdorp road (Figure 4.103).

Sample plots: 143, 95 and 94



Figure 4.103: The *Leucospermum rodolentum*–*Thamnochortus bachmannii* Sandveld (Sample plot 143) east for the Greater Brandvlei Dam.

Land Type: Bb41a and Fb123b, terrain unit 3 (Table). The area east of the dam lies within a transition of Bb41a into Fb123a, these sample plots are on the footslope and have the character of Bb41a (terrain unit 3) rather than that of Fb123a (Tables 2.2 and 2.5).

Geology and soil: Although colluvium and shallow soils cover most of the slopes around the Greater Brandvlei Dam build by the Witteberg Group, aeolian sands blown up from the alluvium during the dry spells, blanket some of these deposits (Le Roux *et al.* in prep; Annexure 13). The Swartruggens Formation (siltstone and shale with thin interbedded sandstone) underlies the deep yellow-brown aeolian sand at sample plot 143 (Gresse and Theron 1992; Gresse 1997). Rock fragments are scarce and the Fernwood soil form dominates (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.3) sand with 1% stone volume, a small proportion of silt, a larger proportion of coarse sand and a higher water-holding capacity in comparison with the sand supporting the rest of the major community support the vegetation of this community. A high resistance to the flow of an electric current (8980 Ω), shows that the sand here is less saline compared to the other sands supporting this major community. Although the sand here contains less Fe, it is somewhat richer in nutrients (especially in Mn) and has a higher total of exchangeable cations compared to the rest of the sand supporting the major community (Tables 4.9 and 4.10).

Aspect: E

Gradient: Gently sloped

Height above sea-level: 211 – 242 m

Land-cover and use: Vegetation structure is of a medium tall shrubland (<2 m) with large *Leucospermum rodolentum* shrubs (Figure 4.104) that can grow taller than 3 m.

Phytosociological Table

Species group AP: Important species for *Leucospermum rodolentum*–*Thamnochortus bachmannii* Sandveld:

Important species for Species Group AP are *Stoebe cinerea*, *Diospyros glabra*, *Trachyandra revoluta*, *Euchaetis pungens*, *Polpoda capensis*, *Trichogyne repens*, *Acrosanthes teretifolia*, *Trachyandra chlamydophylla*, *Aristea dichotoma*, *Babiana ringens*, *Pelargonium radulifolium*, *Leucospermum*

rodolentum, *Phylica stipularis*, *Oxalis commutata*, *Lotononis involucrata*, *Elytropappus glandulosus*, *Cyphia bulbosa*, *Rumex cordatus*, *Arctotis incisa*, *Chenopodiopsis hirta*, *Erica plumosa*, *Nenax hirta* ssp. *hirta* and *Stoebe nervigera* (Annexure 1).

Synoptic Table

Number of relevés: 3



Figure 4.104: *Leucospermum rodolentum* grows in deep sand east of the Greater Brandvlei Dam.

Diagnostic species: *Aristea dichotoma* 88.6, *Chenopodiopsis hirta* 80.7, *Elytropappus glandulosus* 75.2, *Euchaetis pungens* 87.7, *Erica plumosa* 80.7, ***Leucospermum rodolentum* 100.0**, *Nenax hirta* ssp. *hirta* 80.7, ***Phylica stipularis* 100.0**, *Polpoda capensis* 83.3, *Stoebe nervigera* 80.7 and *Trichogyne repens* 81.7 (Annexure 2).

Constant species: *Aristea dichotoma* 100, *Diospyros glabra* 100, *Elytropappus gnaphaloides* 100, *Euchaetis pungens* 100, *Gymnodiscus capillaris* 100, *Restio gaudichaudiana* 100, *Leucospermum rodolentum* 100, *Oxalis obtusa* 100, *Phylica stipularis* 100, *Polpoda capensis* 100, *Thamnochortus bachmannii* 100 and *Trichogyne repens* 100 (Annexure 2).

Dominant species: *Erica plumosa* 33 and *Thamnochortus bachmannii* 100 (Annexure 2).

Discussion:

The population growing in deep sand east of the Greater Brandvlei Dam contains the most eastern inland distribution of *Leucospermum rodolentum* (Sandveld Pincushion / Sandveldluisiesbos) (Figure 4.104). The major distribution area of the species lies in the Sandveld (northwest of the study area) that occurs from Hondeklip Bay to Hopefield to the Cape Flats (Rebelo 2001).

Arctotis incisa (67 67.6) *Cyphia bulbosa* (67 67.6) *Rumex cordatus* (67 67.6), *Erica plumosa* (67 80.7), *Oxalis commutata* (67 67.6) and *Lotononis involucrata* (67 67.6) are also significant here regarding frequency and fidelity (Annexure 2).

Aspalathus quinquefolia ssp. *virgata*, *Babiana arenicola*, *Chenopodiopsis hirta*, *Cliffortia polygonifolia*, *Diosma acmaeophylla*, *Erica mammosa*, *Erica plumosa*, *Ficinia secunda*, *Indigofera procumbens*, *Metalasia adunca*, *Lachnospermum fasciculatum*, *Lebeckia contaminata*, *Leucadendron chamelaea*, *Leucospermum hypophyllocarpodendron* ssp. *canaliculatum*, *Leucospermum rodolentum*, *Lobostemon fruticosus*, *Manulea leiostachys*, *Metalasia agathosmoides*, *Metalasia erubescens*, *Nenax hirta* ssp. *hirta*, *Othonna ciliata*, *Oxalis hirta*, *Phylica stipularis*, *Scabiosa columbaria*, *Staberoha distachyos*, *Stoebe nervigera*, *Sutera caerulea*, *Tetragonia portulacoides* and *Watsonia meriana* were only found to be present in this community (Annexure 1).

Species with Red List conservation status that occur in this community are *Babiana arenicola* (Endangered), *Leucadendron chamelaea* (Critically

endangered) and *Leucospermum rodolentum* (Vulnerable) (<http://redlist.sanbi.org>).

An undescribed geophytic *Pelargonium* species (Figure 4.105), belonging to the section Hoarea, was found in this community on the southern perimeter of the Greater Brandvlei Dam in October 2017 (Chapter 5.1.9.4; Figure 5.33) The species is currently investigated by Dr E.M. Marais⁴.



Figure 4.105: *Pelargonium* sp. nov. 2.

⁴ Department Forest and Wood Science, University of Stellenbosch, Stellenbosch, Private Bag X1, Matieland 7602, South Africa

15. *Willdenowia incurvata*–*Thamnochortus bachmannii* community

Locality: Windblown sand accumulations on the mid- and footslopes of hills bordering the Greater Brandvlei Dam on the north-western side (Figure 4.106).

Sample plots: 19, 20, 34, 55 and 54

Land Type: Fa198a, terrain unit 3 (Table 2.3).



Figure 4.106: The *Willdenowia incurvata*–*Thamnochortus bachmannii* Sandveld occurs on the deep sand deposits north of the Greater Brandvlei Dam (Sample plot 20).

Geology and soil: Although covered with windblown sand, the Blinkberg (light-grey quartzitic sandstone with thin micaceous siltstone beds), Swartuggens (siltstone and shale with thin interbedded sandstone) and Witpoort (grey quartzitic sandstone with shale interbeds) Formations of the Witteberg Group underlie this community (Gresse and Theron 1992; Gresse 1997; Tankard *et al.* 1982). The substrate is deep sand and rock fragments are mostly absent. The Fernwood soil form dominates (Figure 3.17; Soil Classification Working Group 1991).

Extremely acidic (pH 4.3) sand with no stones supports the vegetation of this community. Although the sand here contains slightly more Fe and dissolvable

S, it is somewhat poorer in nutrients (especially in Mn) and has a low total of exchangeable cations in comparison with the rest of the sand supporting the major community (Tables 4.9 and 4.10).

Aspect: N, S, W

Gradient: Moderately sloped

Height above sea-level: 181 – 245 m

Land-cover and use: Vegetation structure is a medium shrubland (<2 m)

Phytosociological Table

Species Group AQ: Important species for the *Willdenowia incurvata*–*Thamnochortus bachmannii* Sandveld:

Important species for the *Willdenowia incurvata*–*Thamnochortus bachmannii* Sandveld are *Willdenowia incurvata* (Figure 4.107), *Moraea fugax*, *Ficinia bulbosa*, *Ferraria variabilis*, *Ornithoglossum viride*, *Eragrostis curvula*, *Aspalathus heterophylla*, *Lapeirousia anceps*, *Hermannia cuneifolia* v. *cuneifolia*, *Albuca cooperi*, *Silene clandestina*, *Wahlenbergia capensis*, *Lyperia tristis*, *Ursinia nana*, *Tripteris clandestina*, *Microcodon glomeratum*, *Annesorhiza laticostata* and *Caesia contorta* (Annexure 1).

Synoptic Table

Number of relevés: 5

Diagnostic species: *Lyperia tristis* 80.3.

Constant species: ***Adenogramma glomerata* 100**, *Anthospermum spathulatum* 80, *Cliffortia ruscifolia* 80, *Crassula bergioides* 80, *Crassula strigosa* 80, *Cyanella hyacinthoides* 80, *Dodonaea viscosa* var. *angustifolia* 80, *Ehrharta calycina* 80, ***Ehrharta villosa* 100**, *Ferraria variabilis* 80, *Gladiolus carinatus* 80, ***Gymnodiscus capillaris* 100**, *Helichrysum asperum* 80, ***Helichrysum incarnatum* 100**, ***Helichrysum moesianum* 100**, *Helichrysum rutilans* 80, ***Heliophila coronopifolia* 100**, *Indigofera heterophylla* 80, *Lyperia tristis* 80, ***Microloma sagittatum* 100**, *Moraea fugax* 80, *Nylandtia spinosa* 80,

Ornithoglossum viride 80, *Pharnaceum aurantium* 100, *Ruschia species* 80, *Senecio arenarius* 100, *Taraxacum officinale* 100, *Thamnochortus bachmannii* 80, *Ursinia anthemoides* 100, *Wiborgia mucronata* 80 and *Willdenowia incurvata* 100 (Annexure 2).

Dominant species: *Ehrharta calycina* 40 and *Willdenowia incurvata* 60 (Figure 4.107; Annexure 2).



Figure 4.107: *Willdenowia incurvata* (Sonkwasriet) (Restionaceae), female plant (a), male plant (b) and in its sandy habitat (c).

Dicussion:

Although a higher cover abundance was measured for *Leucadendron salignum* in Variant iii of Sub-community 9.1, the species has a higher frequency in this community (Annexure). *Silene clandestina* (60 69.5), *Tripteris clandestina* (60 67.5), *Lapeirousia anceps* (60 60.9), and *Ursinia nana* (60 58.5) are also significant regarding frequency and fidelity (Annexures 1 & 2). Community 15 shows similarities with Sub-community 2.2 and with variant iii of sub-community 9.1 where *Willdenowia incurvata* is also an important component of the vegetation (Annexures 1 & 2).

Aristea africana, *Bromus diandrus*, *Chaetobromus involucreatus* ssp. *dregeana*, *Crassula thunbergiana*, *Oncosiphon grandiflorum*, *Dimorphotheca sinuata*, *Hermannia trifurca*, *Lachenalia juncifolia*, *Lapeirousia jacquinii*, *Leysera gnaphalodes*, *Moraea macrocarpa*, *Pelargonium chamaedryfolium*, *Trichogyne paronychioides*, *Tripteris clandestina* and *Wahlenbergia rubens* were only recorded in this community (Annexures 1 & 2).

The conservation status of *Annesorhiza laticostata* (Figure 4.108), a recently described species first collected during the course of this study, is considered to be Critically Endangered (CR) (<http://redlist.sanbi.org>). *A. laticostata* is only known from the type locality where it grows in windblown alluvial sands near the Breede River (Magee *et al.* 2011; Chapter 5.1.4.1; Figure 5.14 – 5.16).

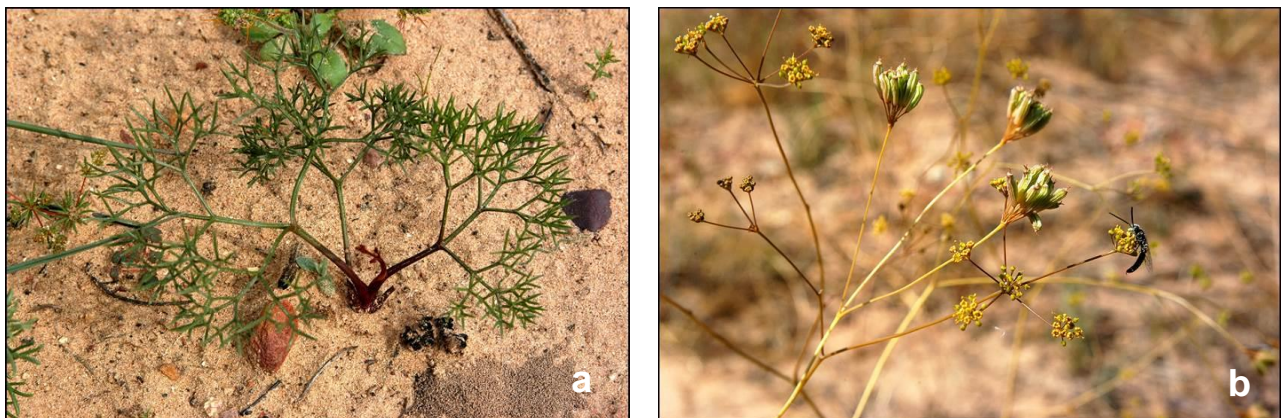


Figure 4.108: The deciduous geophyte *Annesorhiza laticostata* (Apiaceae) at the type locality north of the Greater Brandvlei Dam. Leaves appear in winter (a) and are dead or dying at time of flowering. Flowering time is from January to February with prominent to narrowly winged mature fruits present from March to May (b).

4.3 ORDINATION

Ordination of the second and third axes complemented the Braun Blanquet analysis in the most realistic way, where topography and rock cover were the strongest environmental characters influencing associations and discontinuities between the vegetation units (Figure 4.109).

In an ordination of genus data from the GCFR, Bergh *et al.* (2014) show similarities between renosterveld units and other vegetation types such as fynbos and subtropical thicket, and also that most of the inland mountain renosterveld units has a strong correlation with succulent karoo.

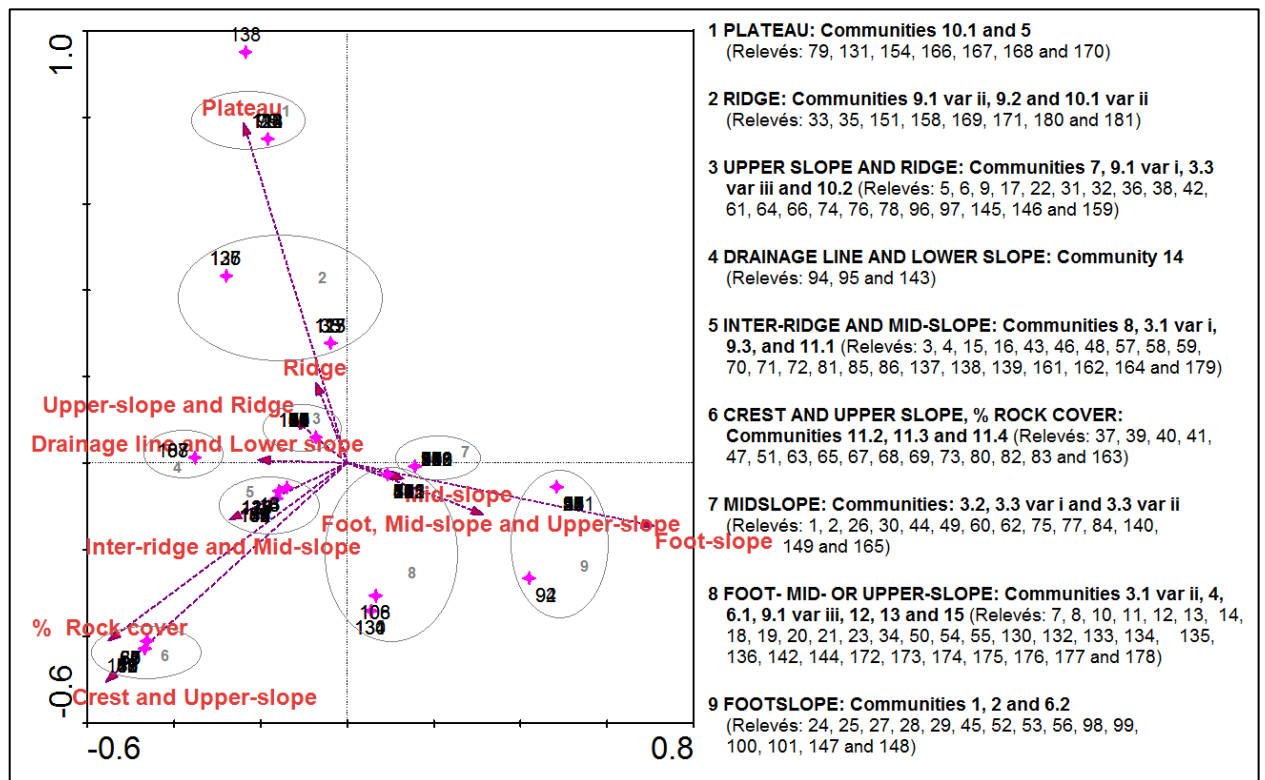


Figure 4.109: Topography and rock cover were the strongest environmental characters influencing associations between the vegetation units.

Bergh *et al.* (2014) reported on the complexity of classifying of floristic communities of the Greater Cape Floristic Region into distinct and meaningful units.

In this study, the end result of an ordination of floristic and environmental (habitat and soil) data reflect the complexity of this system. Folding of the sandstone- and mudrock-dominated layers creates a multifaceted topography

(Figures 1.1, 1.2 & 3.16), where transitions between plant communities are often as subtle as the transitions between the geological layers. Although definite associations between habitat characteristics and the floristic classification is not always possible in this study area, some of the vegetation units were found to be restricted to specific habitats.

Figure 4.110 indicates the physical characteristics of the different topographical features of the habitat that were associated with specific plant communities.

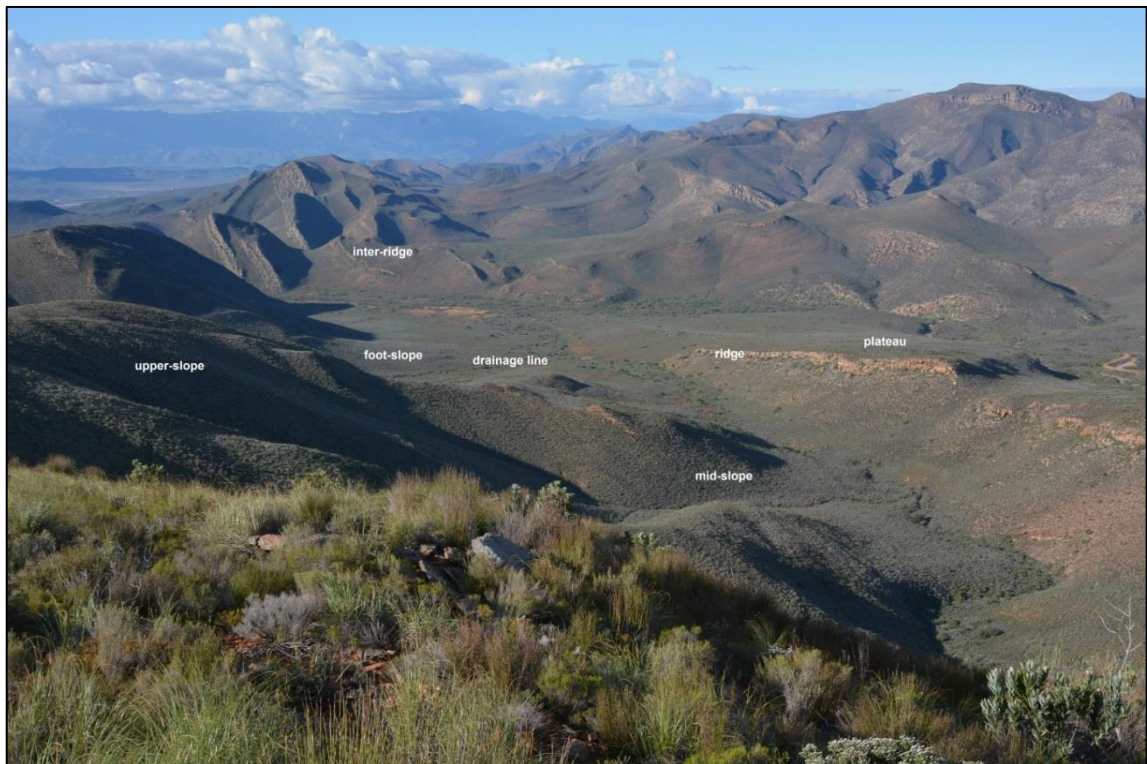


Figure 4.110: An indication of the location of the different topographical units often associated with vegetation units.

Within the folded mountain-environment of the study area, habitats sustaining the *Elytropappus rhinocerotis shrubland* (major community 1) occur mostly on (Figure 4.109);

- the footslopes (the *Tylecodon ventricosus–Elytropappus rhinocerotis* and *Selago triquetra–Elytropappus rhinocerotis* communities as well as the *Struthiola confusa–Elytropappus rhinocerotis–Senecio anthemifolius* sub-community)

- the midslopes (the *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Pelargonium pillansii* sub-community as well as the *Drosanthemum striatum*-and the *Crassula saxifraga* Typicum variants of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community)
- foot-, mid- or upper-slopes (the *Pelargonium carneum* variant of the *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community, the *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community and the *Struthiola confusa*–*Elytropappus rhinocerotis* Typicum sub-community)
- upper slopes (*Nerine humilis* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community)
- inter-ridges (the *Cineraria platycarpa* variant of the *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community)
- plateaus (*Erica boucheri*–*Elytropappus rhinocerotis* community).

Habitats sustaining the *Passerina truncata* shrubland (major community 2) comprise areas on;

- the upper slopes (the *Pentameris eriostoma*–*Passerina truncata* community and the *Protea laurifolia* Typicum variant of the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community)
- the ridges (the *Psammotropha quadrangularis* variant of the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community and the *Protea laurifolia*–*Passerina truncata*–*Secamone alpini* sub-community)
- foot-, mid- or upper-slopes (the *Leucadendron salignum* variant of the *Protea laurifolia*–*Passerina truncata*–*Erica inaequalis* sub-community)

- inter-ridges (the *Drosanthemum hallii*–*Passerina truncata* community as well as the *Protea laurifolia*–*Passerina truncata*–*Phyllica constricta* sub-community).

Habitats sustaining the *Capeochloa arundinacea* shrubland (major community 3) comprise areas on:

- the plateaus (the *Staavia capitella* variant of the *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community)
- the upper slopes (the *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community)
- the ridges (the *Syncarpha mucronata* variant *Metalasia acuta*–*Capeochloa arundinacea*–*Erica anguliger* sub-community)
- inter-ridges (the *Ruschia caroli*–*Capeochloa arundinacea*–*Tritonia flabellifolia* sub-community)
- the crests (the *Ruschia caroli*–*Capeochloa arundinacea*–*Othonna arbuscula*-, *Ruschia caroli*–*Capeochloa arundinacea*–*Scopelogena verruculata*- and *Ruschia caroli*–*Capeochloa arundinacea*–*Curio crassulifolius* sub-communities).

Community 11 is noticeably associated with a high percentage rock cover as is communities 3.1 var i, 8 and 9.3 (Figure 4.109).

Habitats in the study area sustaining the *Hirpicium integrifolium* shrubland (major community 4), as well as the *Thamnochortus bachmannii* Sandveld (major community 5) mainly comprise areas on the mid- and footslopes, however the *Leucospermum rodolentum*–*Thamnochortus bachmannii* community occurs in the valleys where windblown sand deposits.

Where the alternating sandstone- and shale dominated geological layers are extremely folded in the study area, the different plant communities are distributed in a mosaic, primarily determined by soil type, rock cover and

moisture availability. The vegetation growing on the lower-, mid-, upper slopes, ridges, inter-ridges and drainage lines show the most continuity, while the greatest differences occur in the vegetation on the footslopes, plateaus and the crests (Figure 4.110).

4.4 CONCLUSION

The vegetation of the study area includes 15 different plant communities which are characterised by different plant species compositions. These communities are organised within five major communities that are associated with geology, topography, soil characteristics as well as soil depth and moisture availability. Major structural differences in the soil of the major communities include the following (Tables 4.2, 4.4, 4.6, 4.8 & 4.10):

- Soil supporting major community 1 generally contains more silt and less sand compared to that of the other major communities. Except for major community 5, the soils supporting major community 1 are generally less saline and have a lower percentage of stones compared to the soils supporting major communities 2, 3 and 4.
- Soil supporting major communities 2 and 3 contain the largest proportion of stones and the largest proportions of fine sand.
- Soil supporting major community 4 contains the largest proportion of clay and the smallest proportion of fine sand.
- Soil supporting major community 5 contains the smallest proportions of clay and silt, the largest proportion of sand (mostly medium-grained sand), the lowest proportion of stones, and has the lowest water-holding capacity.

Being derived from mudrock-dominated formations, the Mn-rich soils that support the *Elytropappus rhinocerotis* shrubland (Major community 1) are finer grained and have more silt, but are slightly less saline and mostly have a somewhat lower ability to retain and exchange cations compared to the soils

supporting the other major communities (Tables 4.1 and 4.2). Major community 1 (Figure 4.1) is dominated by renosterbos (*Elytropappus rhinocerotis*) as well as other shrubs such as *Eriocephalus africanus*, *Oedera genistifolia* and *O. squarrosa*, *Pteronia* species such as *P. paniculata* and *P. fasciculata*, *Helichrysum* species such as *H. incarnatum* and *H. rutilans*, various restios, grasses, annuals and perennials, several succulents as well as numerous geophyte species. The plant community diversity of major community 1 is reflected in 6 different communities, 7 sub-communities and 5 variants (Annexure 1).

Mucina *et al.* (2005) mapped this vegetation unit as Breede Shale Renosterveld (Figure 3.18). Rebelo *et al.* (2006) consider this vegetation in need of detailed study, as little is known about it. Although the *Elytropappus rhinocerotis* shrubland in some measure compares with *Breede Shale Renosterveld* (Mucina and Rutherford 2006), there are incongruities regarding important taxa listed in Rebelo *et al.* (2006). In fine scale vegetation mapping in the upper Breede River valley Helme (2007) described several renosterveld-mosaic vegetation units, of which most of them contain species that were found to be important, dominant and constant in major community 1. Major community 1 could therefore relate to the broader habitat type scale Helme (2007) described as *Arid Renosterveld on shale*. Several endemic species as well as species of conservation concern such as, *Colchicum hughocymbion*, *Sparaxis maculosa*, *Moraea vuvuzela*, *Ixia atrandra*, *I. collina*, *Romulea tortilis* var. *dissecta*, *Crassula bergioides*, *Brianhuntleya intrusa*, *Antimima microphylla*, *Drosanthemum hallii* and *Senecio anthemifolius* occur in this shrubland (Annexures 1 & 5).

The *Passerina truncata* shrubland (major community 2) (Figure 4.45) occurs on the rocky sandstone dominated slopes and ridges and comprises 3 communities and 3 variants (Annexure 1). Compared to most of the soils supporting the other major communities (except for the aeolian sand of major community 5), the soils supporting major community 2 have lower pH, are poorer in nutrients (with the exception of hydrogen and phosphorus), have a lower base saturation and a lower total of exchangeable cations (Tables 4.1, 4.3, 4.5, 4.7 & 4.9). Dominant species in this shrubland include the shrubs

Passerina truncata, *Elytropappus rhinocerotis*, *Phylica constricta*, *P. rogersii*, *Erica inaequalis*, *Pteronia fasciculata*, the large shrub *Protea laurifolia* as well as restios, grasses such as *Pentameris eriostoma*, various annuals, perennials, succulents as well as geophytes. Endangered species in the *Passerina truncata* shrubland comprise several endemic species (Annexure 4) while *Drosanthemum bellum*, *D. hallii* and *D. micans* are considered endangered (Annexures 1 & 5).

Although the *Passerina truncata* shrubland in some measure compares with *Breede Quartzite Fynbos* (Figure 3.18), a poorly studied vegetation unit according to Mucina and Rutherford (2006), there are incongruities regarding important taxa listed in Rebelo *et al.* (2006). The *Passerina truncata* shrubland in some measure compares with the *Brandvlei Arid Fynbos* vegetation unit in the *Arid Fynbos* habitat type described by Helme (2007).

The *Capeochloa arundinacea* shrubland (major community 3) occurs on sandstone dominated crests and slopes and comprises 2 communities, 6 sub-communities and 2 variants (Annexure 1). Dominant species include the grass *Capeochloa arundinacea*, the aromatic shrub *Agathosma ovata* as well as succulents *Scopelogena verruculata* and *Ruschia caroli* (Annexure 2). The relatively high nutrient status of the soil supporting this major community most probably relate to the effect of accumulated organic material through the activities of ecological engineers such as small mammals and insects that live in these rocky outcrops (Midgley and Musil 1990; Dean 1995; Booij 2011; Kunz *et al.* 2012). Species of conservation concern occurring in the *Capeochloa arundinacea* shrubland are *Erica pilosiflora* ssp. *pilosiflora*, *Moraea barnardiella*, *Lachenalia moniliformis* and *Lachnospermum neglectum* (Annexures 1 & 5).

Mucina and Rutherford (2006) mapped *Breede Quartzite Fynbos* (Figure 3.18) as the vegetation type occurring on soils derived from Witteberg quartzites in the mountains of the study area. Regarding important taxa listed by (Rebelo *et al.* 2006), there is little comparison with *Capeochloa arundinacea* shrubland (Annexure 1). Similarly is *Brandvlei Arid Fynbos* in the *Arid Fynbos* habitat type

described by Helme (2007) the closest vegetation unit that can be compared with major community 3.

The *Hirpicium integrifolium* shrubland (major community 4, comprising 2 communities) primarily occurs on relatively shallow soils derived from Dwyka tillite in the study area. Compared to most of the soils supporting the other major communities (with the exception of major community 5 which is supported by aeolian sand), the sandy loam soils supporting the *Hirpicium integrifolium* shrubland has a higher proportion of clay, less silt, higher proportions of medium and coarse sand and a lower water-holding capacity (Table 4.8). The soils sampled in major community 4 are furthermore less acidic and more saline compared to most of the soils supporting the other major communities (Tables 4.1, 4.3, 4.5 & 4.7). Small shrubs such as *Hirpicium integrifolium*, *Pteronia fasciculata*, *P. paniculata*, *Euphorbia mauritanica*, *E. burmannii* and succulents such as *Crassula atropurpurea* and *Leipoldtia schultzei* dominate the *Hirpicium integrifolium* shrubland. Larger shrubs occurring in major community 4 include *Carissa bispinosa* and *Euclea undulata*. Species of conservation concern include *Euphorbia nesemannii*, *Ixia vanzijliae* and *Mesembryanthemum varians* (Annexures 1 & 5).

The *Hirpicium integrifolium* shrubland generally corresponds to the *Robertson Karoo* vegetation unit mapped by Mucina and Rutherford (2006) (Rebelo *et al.* 2006). Species composition of the *Hirpicium integrifolium* shrubland furthermore shows some similarities with the *Moordkuil Tillite Succulent Karoo* vegetation unit of *the Karoo on Tillite flats* habitat type, as well as with the *Houmoed Renosterveld Karoo* vegetation unit in the *Karoo Renosterveld Gannabos Mosaic* habitat type described by Helme (2007).

The *Thamnochortus bachmannii* sandveld (major community 5, comprising two communities) occurs on deep aeolian sand deposits and supports a unique vegetation unit dominated by restios such as *Thamnochortus bachmannii* and *Willdenowia incurvata* however, shrubs, annuals, perennials and geophytes occur (Figure 4.101). Species with Red List conservation status occurring in this community are *Babiana arenicola*, *Leucadendron chamelaea*, *Leucospermum rodolentum* and *Annesorhiza laticostata* (Annexures 1 & 5).

The soils sampled in major community 5 have a much higher proportion of sand and are more leached compared to the rest of the soils supporting the other major communities (Tables 4.9 & 4.10). Although the pH is similar, the sands of communities 14 and 15 are different regarding texture and nutrient content. The soil of community 14 include almost similar quantities of fine and medium sands and a higher percentage of coarse sand than that of community 15 where medium-grained sand dominates the sand proportion. The sands of community 14 are less saline, especially richer in Mn, while Fe is somewhat less. Regarding base saturation, the percentage of Ca^{2+} is higher than that of community 15 where the percentages of Mg^{2+} and Na^+ are higher (Tables 4.9 & 4.10).

As climate conditions are similar, the differences in soil and low rock cover most likely provide a basis for the variation in plant species occurring in communities 14 and 15. Although the water-holding capacity of community 14 is only slightly better than that of community 15, the presence of *Leucospermum rodolentum* may be an indicator of areas with a greater amount of groundwater as the species is known to survive in arid areas by tapping deep water (<http://redlist.sanbi.org>). The *Willdenowia incurvata*–*Thamnochortus bachmannii* sandveld also occurs in sandy areas the study area east of the Greater Brandvlei Dam.

The *Thamnochortus bachmannii* sandveld agrees with “Breede Sand Fynbos” mapped by Mucina *et al.* (2005) (Figure 3.18) as well as by Helme (2007), and considered as a vulnerable, and poorly studied vegetation unit (Rebelo *et al.* 2006).

CHAPTER 5

SPECIES NEW TO SCIENCE AND TAXONOMIC PROBLEMATIC TAXA

‘Facts are only the materials of science. To give them a suitable form and to combine them by analogy is to prepare them for building; by uniting them we raise the edifice’.

From: Observations from the structure of fruits and seeds by Louis-Claude Marie Richard, 1819.



Pelargonium sp. nov 2

TABLE OF CONTENTS

5.1 SECTION A: SPECIES NEW TO SCIENCE	315
5.1.1 ASPHODELACEAE	316
5.1.1.1 <i>Bulbine</i> sp. nov.	316
5.1.1.2 <i>Trachyandra</i> sp. nov.	317
5.1.2 HYACINTHACEAE	317
5.1.2.1 <i>Ledebouria</i> sp. nov.	317
5.1.3 IRIDACEAE	319
5.1.3.1 <i>Moraea helicoidea</i> Goldblatt & J.C.Manning, sp. nov.	319
5.1.3.2 <i>Moraea vuvuzela</i> Goldblatt & J.C.Manning sp. nov.	320
5.1.3.3 <i>Watsonia</i> sp. nov. sp.1	324
5.1.3.4 <i>Watsonia</i> sp. nov. sp.2	325
5.1.4 APIACEAE	326
5.1.4.1 <i>Annesorhiza laticostata</i> Magee	326
5.1.5 ASTERACEAE	327
5.1.5.1 <i>Athanasia</i> aff <i>filiformis</i> sp. nov.	327
5.1.5.2 <i>Dimorphotheca</i> sp. nov.	328
5.1.5.3 <i>Ursinia</i> sp. nov.	329
5.1.6 CHENOPODIACEAE	330
5.1.6.1 <i>Chenolea convallis</i> Snijman & J.C.Manning, sp. nov.	330
5.1.7 CRASSULACEAE	332
5.1.7.1 <i>Crassula</i> sp. nov. 1	332
5.1.7.2 <i>Crassula</i> sp. nov. 2	333
5.1.8 FABACEAE	334
5.1.8.1 <i>Amphithalea ornata</i> Boatwr. & J.C.Manning sp. nov.	334
5.1.8.2 <i>Aspalathus</i> sp. nov. 1	335
	307

5.1.8.3 <i>Aspalathus</i> sp. nov. 2	336
5.1.8.4 <i>Indigofera</i> sp. nov. cf. <i>angustifolia</i>	337
5.1.9 GERANIACEAE	338
5.1.9.1 <i>Pelargonium flabelliforme</i> E.M.Marais, sp. nov.....	338
5.1.9.2 <i>Pelargonium conradiae</i> J.C. Manning & A.le Roux, sp. nov.	339
5.1.9.3 <i>Pelargonium</i> sp. nov. 1	340
5.1.9.4 <i>Pelargonium</i> sp. nov. 2	341
5.1.10 MOLLUGINACEAE	342
5.1.10.1 <i>Psammotropha</i> sp. nov.....	342
5.1.11 OXALIDACEAE	344
5.1.11.1 <i>Oxalis</i> sp. nov	344
5.1.12 RUTACEAE.....	345
5.1.12.1 <i>Agathosma</i> sp. nov 1	345
5.1.12.2 <i>Agathosma</i> sp. nov. 2	346
5.2 SECTION B: INDETERMINATE TAXA	347
5.2.1 <i>Drosanthemum</i> sp. cf. nov. (Aizoaceae)	347
5.2.2 <i>Othonna</i> sp. cf. nov. (Asteraceae).....	348
5.2.3 A representative of the Asteraceae family	349
5.2.4 <i>Coleonema</i> sp. nov. cf. <i>album</i> (Rutaceae)	350
5.3 SECTION C: TAXONOMIC PROBLEMATIC TAXA.....	351
5.3.1 <i>Drosanthemum</i> subgenus <i>Speciosa</i>	351
5.3.2 <i>Mesembryanthemum caudatum</i> L.Bolus (<i>Phyllobolus caudatus</i> (L.Bolus) Gerbault).....	360
5.3.3 <i>Adromischus</i> species	364
5.3.4 A smaller cliff dwelling <i>Crassula</i> species and <i>C. rupestris</i>	366
5.3.5 A possible <i>Crassula saxifraga</i> species complex.....	366
5.3.6 <i>Wiborgia</i> cf. <i>sericea</i>	366

5.3.7 <i>Oxalis</i> species	368
5.4 CONCLUSION.....	373

LIST OF FIGURES

Figure 5.1: An undescribed <i>Bulbine</i> species flowering in August.....	316
Figure 5.2: An undescribed <i>Trachyandra</i> species growing in gravelly soil of the Waaipoort Formation.	317
Figure 5.3: An interesting <i>Ledebouria</i> species flowering in February (a) as the spotted leaves start to emerge (c). The leaves are out during the growing season (picture in August), die back during autumn (b). 318	
Figure 5.4: <i>Moraea helicoidea</i> at the type locality.	319
Figure 5.5: The type locality of <i>Moraea helicoidea</i> , a transition zone between the Witteberg- and Dwyka geological Groups.....	320
Figure 5.6: The large attractive flowers of <i>Moraea vuvuzela</i> (flowering early in August) only last one day.....	321
Figure 5.7: A large and healthy population of <i>Moraea vuvuzela</i> grows on Hammansberg south of Worcester.	322
Figure 5.8: A population of <i>Moraea vuvuzela</i> on sandy loam soil blanketing from Dwyka tillite on the farm Sandberg (325 m.a.s.l.).	322
Figure 5.9: A population of <i>Moraea vuvuzela</i> on a plateau on Ouhangsberg (600 m.a.s.l.).....	322
Figure 5.10: The colour intensity of the flower markings may differ as shown here: flowering populations on Sandberg (a) and on Ouhangsberg (b).	323
Figure 5.11: Fruits of <i>Moraea vuvuzela</i> (a) (between the black remains of <i>Pterygodium alatum</i> plants) following prolific flowering of the species in 2010 after a controlled fire in 2009. A profuse amount of seeds (b) was produced in that season.	323
Figure 5.12: An undescribed <i>Watsonia</i> species with salmon-pink flowers (a) growing on the steep south-facing slopes Ouhangsberg (b).....	324

- Figure 5.13: An apparently undescribed *Watsonia* species found on the hills east of the Greater Brandvlei Dam flowers in spring (a) with fruits in summer (b). 325
- Figure 5.14: *Annesorhiza laticostata* at the type locality. The leaves dying at time of flowering in January/February. 326
- Figure 5.15: *Annesorhiza laticostata* at the type locality just after flowering. . 326
- Figure 5.16: *Annesorhiza laticostata* at the type locality with winged fruit in March. 326
- Figure 5.17: Further study is required to confirm if this *Athanasia* species collected of the farm Droogeriviersberg in 2015 is new. 327
- Figure 5.18: An undescribed *Dimorphotheca* species from south of Worcester with its large, bright yellow flowers in August 2014. 328
- Figure 5.19: Flowers (a) and fruits (b) of an undescribed *Ursinia* species. The small shrub (c) flowers in Spring. 329
- Figure 5.20: *Chenolea convallis* flowering at the type locality. 330
- Figure 5.21: Another population was found to the east of the type locality. ... 331
- Figure 5.22: The small branching shrubs have succulent pale glaucous green leaves and resprout from a deeply rooted woody base. 331
- Figure 5.23: This small geophytic *Crassula* species flowers in summer (a) and has its leaves in winter (b). 332
- Figure 5.24: A scabrid-leaved (a & b) *Crassula* sp. nov. 2 growing in soil derived from Dwyka tillite on the farm Droogeriviersberg (c & d). 333
- Figure 5.25: *Amphithalea ornata* flowering in October (a) and with fruits a month later (b). The type locality is currently the only known population (c). 334
- Figure 5.26: *Aspalathus* sp. nov. 1 (a & b) from the farm Sandberg flowers in October. 335
- Figure 5.27: The summer flowering *Aspalathus* sp. nov. 2 (a, b) in habitat on Ouhangsberg (c). 336
- Figure 5.28: The bright mauve flowers of *Indigofera* sp. nov. cf. *angustifolia* in August 2010. 337
- Figure 5.29: The flowers of *Indigofera* sp. nov. cf. *angustifolia* are followed by fruits in September. 337

Figure 5.30: <i>Pelargonium flabelliforme</i> flowering at the type locality in late summer.....	338
Figure 5.31: <i>Pelargonium conradiae</i> flowering at the type locality (a & b). The stems at the end of dry season with emergent new growth (c). ...	339
Figure 5.32: The leaves of this undescribed geophytic <i>Pelargonium</i> appear during the rainy season in winter (a) and are followed by the flowers in October (b) after the leaves have died.....	340
Figure 5.33: <i>Pelargonium</i> sp. nov. 2 flowering prolifically in the midst of severe drought conditions in October 2017 (a). Flower colour varies from white to soft pink (b, c & d).....	341
Figure 5.34: The small spring flowering <i>Psammotropha</i> sp. nov. in habitat. ...	342
Figure 5.35: <i>Psammotropha</i> sp. nov. was found to grow more abundant and flowered prolifically after a controlled fire in 2009.	343
Figure 5.36: A suspected undescribed <i>Oxalis</i> species (a & b) in the sub-section Pardales growing on the hills east of the Greater Brandvlei Dam.	344
Figure 5.37: <i>Agathosma</i> sp. nov 1 flowering at the type location on Gannaberg in September 2014 (a) and with fruits in March the following year (b & c).	345
Figure 5.38: <i>Agathosma</i> sp. nov. 2 at the type locality east of the Greater Brandvlei Dam.	346
Figure 5.39: An interesting small <i>Drosanthemum</i> shrub found on sandstone ledges in the study area is monitored for flowers to shed light on the taxonomy of the species.	347
Figure 5.40: Flowers (a) and seeds (b) of an interesting <i>Othonna</i> species that is further studied to determine its taxonomy.	348
Figure 5.41: An interesting succulent representative of the Asteraceae on Ouhangsberg.	349
Figure 5.42: <i>Coleonema</i> sp. nov. cf. <i>album</i> on Ouhangsberg.....	350
Figure 5.43: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain from a yellow flower of <i>Drosanthemum hallii</i> . Scale bar: 10 μ m.....	352

- Figure 5.44: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain from a yellow with red petal tips coloured flower of *Drosanthemum hallii*. Scale bar: 10 μm 352
- Figure 5.45: White (a), orange (b) and red (c) flower colour variations in the *Drosanthemum hallii* (Aizoaceae) population at the type locality north of the Greater Brandvlei Dam. 353
- Figure 5.46: Polar- (a) and side (b) view of a pollen grain from an orange flower of *Drosanthemum hallii*. Scale bar: 10 μm 353
- Figure 5.47: Polar- (a) and side (b) view of a pollen grain from a red flower of *Drosanthemum hallii*. Scale bar: 10 μm 353
- Figure 5.48: *Drosanthemum pulchrum* on a hill bordering the Greater Brandvlei Dam to the north. Although Hartmann (2008) and Hartmann & le Roux (2001) treat this as a distinct species, Bayer (2006¹; pers. com.) understands this as *Drosanthemum speciosum*. 355
- Figure 5.49: Bright pink (a), pale pink (b) pale yellow (c) and pale yellow with pink (d) colour forms of the flowers of *Drosanthemum bellum* (Aizoaceae) on the hills north of the Greater Brandvlei Dam, the filamentous staminodes covering the stamens in young flowers. 356
- Figure 5.50: These flower forms, orange (a) and red (b) occur on the range of hills bordering the Greater Brandvlei Dam to the north. Until further study provide clarity, concerning habitat and the morphology of the staminodes, this study treats these plants as *Drosanthemum bellum*. 356
- Figure 5.51: Polar- (a) and side (b) view of a pollen grain from a pale pink coloured flower of *Drosanthemum bellum*. Scale bar: 10 μm 357
- Figure 5.52: Polar- (a) and side (b) view of a pollen grain from a pale yellow coloured flower of *Drosanthemum bellum*. Scale bar: 10 μm 357
- Figure 5.53: *Drosanthemum micans* (Aizoaceae) from Gannaberg in the southern part of the study area. 358
- Figure 5.54: Polar- (a) and side (b) view of a pollen grain from a red coloured flower of *Drosanthemum micans* from Gannaberg. Scale bar: 10 μm 359

- Figure 5.55: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain of *Drosanthemum speciosum* from Gannaberg. Scale bar: 10 μm 359
- Figure 5.56: *Mesembryanthemum grossum* with small salmon coloured flowers and short leaves with fairly large idioblasts..... 360
- Figure 5.57: *Mesembryanthemum caudatum* (Mopkop vygie) with large bright yellow flowers and distinct long cylindrical leaves..... 360
- Figure 5.58: Dr M.B. Buys and Dr L.R. Tiedt in the habitat (a) of *Mesembryanthemum caudatum* (b) on the northern perimeter of the Greater Brandvlei Dam in the study area..... 362
- Figure 5.59: The near Nieuwoudtville habitat (a) of *Mesembryanthemum caudatum* (b)..... 362
- Figure 5.60: An 8000 x enlargement of the side view (a) and exine sculpture (b) of a pollen grain (*Mesembryanthemum caudatum*, Worcester). . 363
- Figure 5.61: An 8000 x enlargement of the side view (a) and exine sculpture (b) of a pollen grain (*Mesembryanthemum caudatum*, Nieuwoudtville). 363
- Figure 5.62: A 70 x enlargement of the abaxial leaf surface of *Mesembryanthemum caudatum* (Worcester population). 363
- Figure 5.63: A 70 x enlargement of the abaxial leaf surface of *Mesembryanthemum caudatum* (Nieuwoudtville population)..... 363
- Figure 5.64: The view from the side (a) and from the top (b) of a seed of *Mesembryanthemum caudatum* from the Worcester population. 364
- Figure 5.65: The view from the side (a) and from the top (b) of a seed of *Mesembryanthemum caudatum* from the Nieuwoudtville population. 364
- Figure 5.66: *Adromischus maculatus* (a) flowering (b) in the study area (picture b: H. de Wet)..... 365
- Figure 5.67: A possible hybrid between *Adromischus maculatus* and *A. hemisphaericus* (a) was found on Hammansberg in February 2015. The flowers differ from that of *Adromischus maculatus* (b). 365
- Figure 5.68: The difference between a smaller cliff dwelling *Crassula* species (a) and *Crassula rupestris* (b). 366

- Figure 5.69: The difference between the flowers of a small geophytic *Crassula* species (a) and *Crassula saxifraga* (b).....366
- Figure 5.70: An indeterminate *Wiborgia* species growing on the farm Sandberg in the south of the study area..... 367
- Figure 5.71: *Oxalis pardalis* in the study area around the Greater Brandvlei Dam. 368
- Figure 5.72: This *Oxalis* species (a) (A. le Roux no 1121), occurring in the southeast of the study area, is identified as *Oxalis confertifolia* (Dr K.C. Oberlander). The bulbs with old tunics (b) are typical of the sub-subsection Pardales. Bayer (1992) combined *Oxalis confertifolia* in the species group *Oxalis pardalis*. 369
- Figure 5.73: An *Oxalis* species (A. le Roux nr 1344) occurring on a hill bordering the Greater Brandvlei Dam (a & b) on the eastern side could be what Salter (1944) described as *Oxalis camelopardalis*, but what Bayer (1992) combined in the group-species *Oxalis pardalis*. 369
- Figure 5.74: This *Oxalis* species (A. le Roux nr 572) occurring in sandy soil on the hills bordering the Greater Brandvlei Dam to the north, was identified by the Compton herbarium as *Oxalis capillaceae*, but combined by Bayer (1992) in the group-species *Oxalis pardalis*.370
- Figure 5.75: This *Oxalis* species (A. le Roux nr 1117) occurring in the southeastern part of the study area, was identified by Dr K.C. Oberlander as what Salter (1944) described as *Oxalis leptogramma*, but what Bayer (1992) combined in the group-species *Oxalis pardalis*. 370
- Figure 5.76: An indeterminate *Oxalis* species (possibly undescribed and likely to belong in the subsection Pardales) (A. le Roux no. 818) growing on the hills east of the Greater Brandvlei Dam (a & b)..... 371
- Figure 5.77: Although identified by the Compton herbarium as *Oxalis cf. annae* (A. le Roux nr 541), the identity of this species, growing in sandy soil on the hills bordering the Greater Brandvlei Dam on the northern side, is uncertain..... 372

- Figure 5.78: Other indeterminate *Oxalis* species growing in the study area: a from the older formations, and b & c from the within Witpoort rocks of the Witteberg Group in the southeast of the study area..... 372
- Figure 5.79: This *Oxalis* species (A. le Roux nr 918) occurring in sandy soil on the perimeter of the Greater Brandvlei Dam on the eastern side (a & b), was identified by the Compton herbarium as *Oxalis commutata*, but Dr K.C. Oberlander considers this to be *Oxalis eckloniana*..... 373

5.1 SECTION A: SPECIES NEW TO SCIENCE

Several species new to science were collected in the study area. Some are still awaiting formal descriptions. All recently described species as well as those awaiting formal description are considered endemic to the Core Cape Subregion. The following species new to science were documented during data collection for this study:

5.1.1 ASPHODELACEAE

5.1.1.1 *Bulbine* sp. nov.

Collection: A. le Roux & E. van Jaarsveld nr. 1464

This interesting *Bulbine* species (Figure 5.1) was found during data collection for this study and was brought to the attention of Dr E.J. van Jaarsveld¹ who considered it to be yet undescribed.

The plants grow in deep aeolian sand deposits (major plant community 5) on the farm Sandberg. The succulent leaves are flattened. Flowers, with a sweet fragrance appear in August (Figure 5.1). The species is currently being investigated by Dr van Jaarsveld.



Figure 5.1: An undescribed *Bulbine* species flowering in August.

¹ Extraordinary senior lecturer and researcher, Department of Biodiversity and Conservation, University of the W. Cape. Bellville, South Africa.

5.1.1.2 *Trachyandra* sp. nov.

Collection: A. le Roux & E. Haumann nr. 1465

This interesting *Trachyandra* species (Figure 5.2) with hairy, curled leaves, was found during data collection for this study and was brought to the attention of Dr E.J. van Jaarsveld who considered it to be yet undescribed.

The plants grow on the farm Sandberg in a transition zone between the Witteberg- and Dwyka geological Groups, where they grow in gravelly loam soil derived from the Waaipoort Formation of the Witteberg Group (Gresse 1997; Gresse and Theron 1992). The species is currently being investigated in collaboration with Dr van Jaarsveld.



Figure 5.2: An undescribed *Trachyandra* species growing in gravelly soil of the Waaipoort Formation.

5.1.2 HYACINTHACEAE

5.1.2.1 *Ledebouria* sp. nov.

This interesting *Ledebouria* species (Figure 5.3) was first observed in February 2015 during data collection for this study. A healthy population occurs in sandy soil derived from Dwyka tillite on the farm Sandberg. The plant was brought to

the attention of Dr John Manning at the Compton herbarium and the species was identified as *L. undulata*. Later investigation brought the plant to the attention of Dr Fanie Venter who recently revised the genus. According to Dr Venter, this *Ledebouria* sp. is not *L. undulata*, but a species not yet described, and the second hysteroanthous *Ledebouria* species (Dr Venter pers. com.).



Figure 5.3: An interesting *Ledebouria* species flowering in February (a) as the spotted leaves start to emerge (c). The leaves are out during the growing season (picture in August), die back during autumn (b).

5.1.3 IRIDACEAE

5.1.3.1 *Moraea helicoidea* Goldblatt & J.C.Manning, sp. nov.

A recently described localized endemic known only from the Farm Droogeriviersberg, ±30 km SE of Worcester in Western Cape (Figures 5.4 & 5.5) where it occurs in the *Pelargonium carneum* variant of the *Oedera genistifolia*–*Elytropappus rhinocerotis*–*Wiborgia tenuifolia* sub-community (Sub-community 3.1, Variant ii). The species was described in Goldblatt *et al.* (2015) (Annexure 10).

The plants were found on 10 September 2014 during data collection for this study in a transition zone between the Witteberg- and Dwyka geological Groups, where they grow in strongly acidic (pH 4.6), and gravelly loam soil derived from the Waaipoort Formation of the Witteberg Group (Gresse, 1997; Gresse and Theron, 1992). Three healthy densely populated stands of the plants are currently known on the same farm (Figures 5.4 and 5.5).



Figure 5.4: *Moraea helicoidea* at the type locality.



Figure 5.5: The type locality of *Moraea helicoidea*, a transition zone between the Witteberg- and Dwyka geological Groups.

5.1.3.2 *Moraea vuvuzela* Goldblatt & J.C.Manning sp. nov.

This recently described *Moraea* was initially found on the footslopes of the hills bordering the Greater Brandvlei Dam to the north during data collection in this study in August of 2006. The plants were found after a controlled burn in 2009. They appeared in bountiful numbers a collection was made (Le Roux 2011). Although this species flowers abundantly after fire, fire is not essential for flowering. The species was described in Goldblatt and Manning (2010).

Several years before the description of this species was to commemorate the 2010 Soccer World Cup, Mrs Hettie Conradie had already noticed the pretty yellow *Moraea* flowers on their family farm Droogeriviersberg (H. Conradie pers. com.). During this study, the recently described *Moraea* was initially found on the footslopes of the hills bordering the Greater Brandvlei Dam to the north during data collection in this study in August of 2006 (Figure 5.5). Only after a controlled burn in 2009 were the plants found in profuse numbers and was a collection thereof made (Le Roux 2011).

Field work and monitoring in the course of this study found several other populations in the years following its description in 2010 and healthy populations are known to occur on Hammansberg, Ouhangsberg and Gannaberg (Figures 5.6 – 5.11). The species is associated with major community 1 and frequently found in the *Struthiola confusa*–*Elytropappus rhinocerotis* plant community (community 6), as well as in the *Metalasia acuta*–*Capeochloa arundinacea*–*Erepsia anceps* sub-community (sub-community 10.2.). The bulbs grow in open damp extremely acidic loamy sand and sandy loam soils derived from the mudstone-dominated layers of the Witteberg Geological Group (Table 3.1), but this species also occurs in two localities in soil derived from weathered Dwyka tillite (Figures 5.7 & 5.9).



Figure 5.6: The large attractive flowers of *Moraea vuvuzela* (flowering early in August) only last one day.



Figure 5.7: A large and healthy population of *Moraea vuvuzela* grows on Hammansberg south of Worcester.



Figure 5.8: A population of *Moraea vuvuzela* on sandy loam soil blanketing from Dwyka tillite on the farm Sandberg (325 m.a.s.l.).

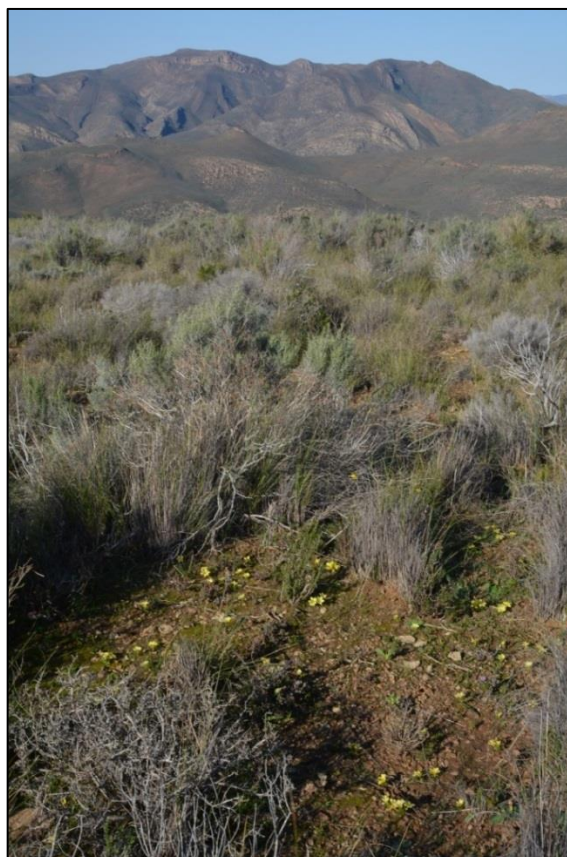


Figure 5.9: A population of *Moraea vuvuzela* on a plateau on Ouhangsberg (600 m.a.s.l.).

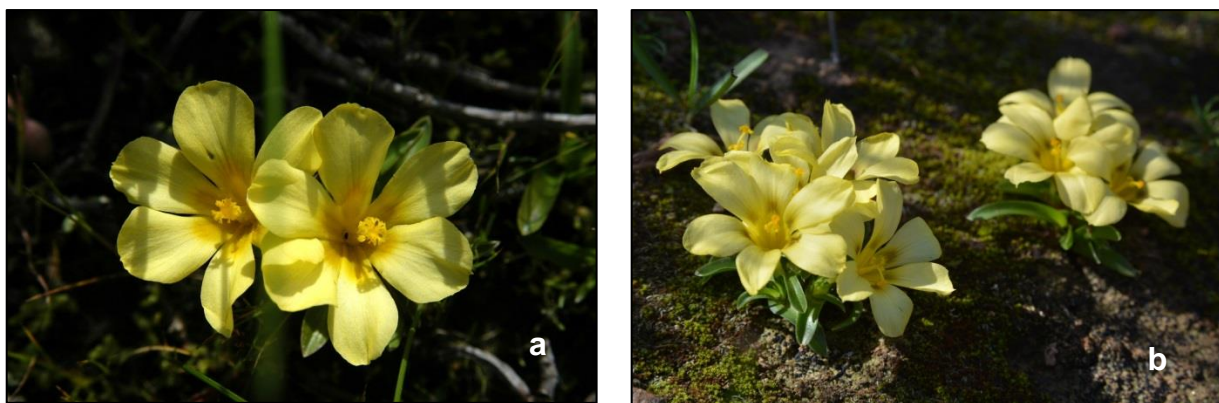


Figure 5.10: The colour intensity of the flower markings may differ as shown here: flowering populations on Sandberg (a) and on Ouhangsberg (b).

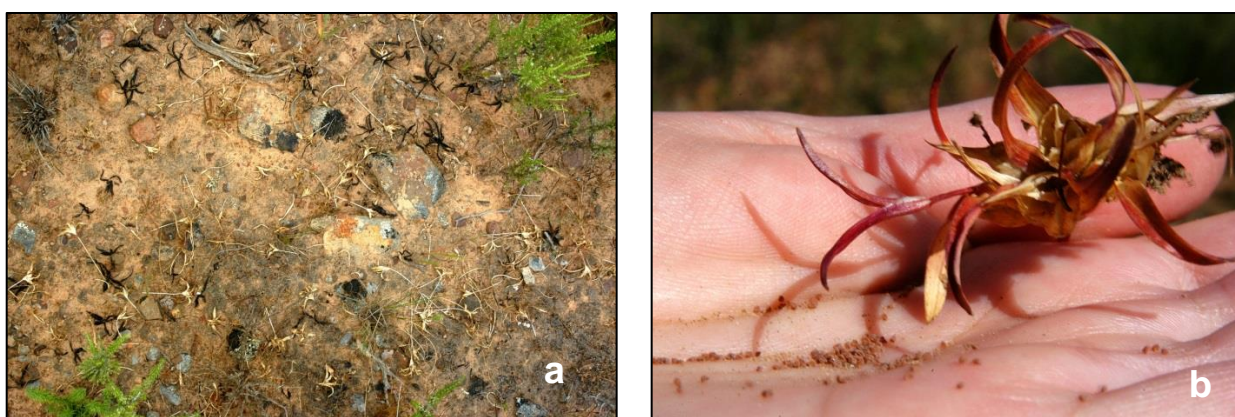


Figure 5.11: Fruits of *Moraea vuvuzela* (a) (between the black remains of *Pterygodium alatum* plants) following prolific flowering of the species in 2010 after a controlled fire in 2009. A profuse amount of seeds (b) was produced in that season.

5.1.3.3 *Watsonia* sp. nov. sp.1

Collection: A. le Roux, H. de Wet & E. van Jaarsveld nr. 1410

A large population of an apparently undescribed *Watsonia* species (Figure 5.12) was found in October 2016 on a south-facing slope of the Ouhangsberg south of Worcester. The species is currently being investigated and described by Dr E.J. van Jaarsveld.



Figure 5.12: An undescribed *Watsonia* species with salmon-pink flowers (a) growing on the steep south-facing slopes Ouhangsberg (b).

5.1.3.4 *Watsonia* sp. nov. sp.2

Collection: A. le Roux nr. 1156

Various stands of a population of this *Watsonia* species (Figure 5.13) were found on the hills east of the Greater Brandvlei Dam in September 2016. According to Dr J.C. Manning this could be a (probably old) hybrid *W. aletroides* x *W. laccata* (Dr Manning pers. com.). The species is currently being investigated and described by Dr E.J. van Jaarsveld.



Figure 5.13: An apparently undescribed *Watsonia* species found on the hills east of the Greater Brandvlei Dam flowers in spring (a) with fruits in summer (b).

5.1.4 APIACEAE

5.1.4.1 *Annesorhiza laticostata* Magee

Collections in NBG: A. le Roux, nr. 714, 1 February 2010; A. Magee and A. le Roux nr. 188, 15 February 2010

A. laticostata is endemic to the Western Cape Breede River Valley between Worcester and Rawsonville. The species was described in Magee *et al.* (2011).

This deciduous geophyte was only noted after fire, described from a locality on the northern perimeter of the Greater Brandvlei Dam in 2011. Leaves appear in winter and are dead or dying at time of flowering (Figure 5.14). Flowering time is from January to February (Figures 5.13 – 5.16), and the fruits present from March to May (Figure 5.16). The species is only known from this area where it grows in windblown alluvial sands near the Breede River.



Figure 5.14: *Annesorhiza laticostata* at the type locality. The leaves dying at time of flowering in January/February.



Figure 5.15: *Annesorhiza laticostata* at the type locality just after flowering.

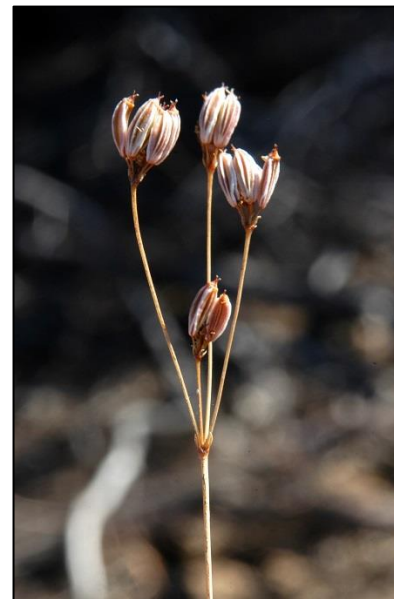


Figure 5.16: *Annesorhiza laticostata* at the type locality with winged fruit in March.

5.1.5 ASTERACEAE

5.1.5.1 *Athanasia* aff *filiformis* sp. nov.

Collection: A. le Roux nr. 1450

This *Athanasia* species (Figure 5.17) was collected of the farm Droogeriviersberg 2015 during data collection for this study. A specimen was sent to the Compton herbarium where it was studied by Dr A. Magee. Dr Magee² commented: “further study required to confirm if it is a new species.”



Figure 5.17: Further study is required to confirm if this *Athanasia* species collected of the farm Droogeriviersberg in 2015 is new.

² South African National Biodiversity Institute, Compton Herbarium, Private Bag X7, Claremont 7735, South Africa

5.1.5.2 *Dimorphotheca* sp. nov.

Collections: A. le Roux nr. 1045 and nr. 1239

This *Dimorphotheca* species (Figure 5.18) was documented during the data collection for this study. Dr J.C. Manning³ of Kirstenbosch recognised the species as undescribed. Two populations are known, one from the farm Keurfontein, and the other one from Haumanskloof, both localities are south of Worcester.



Figure 5.18: An undescribed *Dimorphotheca* species from south of Worcester with its large, bright yellow flowers in August 2014.

³ Compton Herbarium, South African National Biodiversity Institute, Private Bag X7, Claremont 7735, South Africa

5.1.5.3 *Ursinia* sp. nov.**Collection: A. le Roux nr. 1173**

This *Ursinia* species (Figure 5.19) was documented during the data collection for this study. Dr J.C. Manning of Kirstenbosch recognised the species as undescribed. Several populations occur on Ouhangsberg and one population is known from Hammansberg south of Worcester.



Figure 5.19: Flowers (a) and fruits (b) of an undescribed *Ursinia* species. The small shrub (c) flowers in Spring.

5.1.6 CHENOPODIACEAE

5.1.6.1 *Chenolea convallis* Snijman & J.C.Manning, sp. nov.

Chenolea convallis (Figures 5.20 – 5.22) was recorded during data collection for this study and is currently known from two populations, one on the eastern banks of the Greater Brandvlei Dam and the other part of a former floodplain to the east of the type location (Figure 5.20 & 5.21). The species was described in Snijman and Manning (2013).



Figure 5.20: *Chenolea convallis* flowering at the type locality.

The species is characterised by a very deep root system which may relate to the historical floodplain habitat prior to the construction of the Quaggaskloof Dam wall. Deep and extensive root systems are traits of plants in Mediterranean ecosystems and often develop in habitats with fine-textured soils with good infiltration and a sharp water gradient as well as where a seasonal surplus of water can accumulate during the wet season and be accessed during the dry season. Deep roots protect the soil against erosion and anchor plants well in the substrate of dynamic ecosystems (Dr E.J. van Jaarsveld pers. com.; Schenk and Jackson 2005; Sardans and Peñuelas 2013; Lindha *et al.* 2014).



Figure 5.21: Another population was found to the east of the type locality.



Figure 5.22: The small branching shrubs have succulent pale glaucous green leaves and resprout from a deeply rooted woody base.

5.1.7 CRASSULACEAE

5.1.7.1 *Crassula* sp. nov. 1

Collections: A. le Roux, nr. 1106, 14 May 2014; A. le Roux, H. Conradie and H. de Wet, nr. 1395, 31 March 2015

According to Dr Peter Bruyns⁴, this unnamed geophyte has been known around McGregor since the early 1980's (pers. com.). Several populations of this small geophytic *Crassula* species were found growing in rock crevices on Hammansberg, as well as on Ouhangsberg south of Worcester (Figure 5.23). The species is currently being investigated and described by Dr Bruyns.



Figure 5.23: This small geophytic *Crassula* species flowers in summer (a) and has its leaves in winter (b).

⁴ Bolus Herbarium, Department of Biological Sciences, University of Cape Town, 7701 Rondebosch, South Africa.

5.1.7.2 *Crassula* sp. nov. 2

Collections: A. le Roux & E. Haumann nr. 1466

This scabrid-leaved *Crassula* species (Figure 5.24) was found between Worcester and Robertson in 2016. It occurs on the rocky Dwyka tillite hills in the study area and is currently being describes by Dr E.J. van Jaarsveld.



Figure 5.24: A scabrid-leaved (a & b) *Crassula* sp. nov. 2 growing in soil derived from Dwyka tillite on the farm Droogeriviersberg (c & d).

5.1.8 FABACEAE

5.1.8.1 *Amphithalea ornata* Boatwr. & J.C.Manning sp. nov.

This previously undescribed species was discovered in 2013 in the Trappieskraalkloof area between Worcester and Robertson during field surveys for this study (Figure 5.25). The species was described in Boatwright *et al.* (2016) (Annexure 12).



Figure 5.25: *Amphithalea ornata* flowering in October (a) and with fruits a month later (b). The type locality is currently the only known population (c).

5.1.8.2 *Aspalathus* sp. nov. 1

Collection: A. le Roux & H. Conradie nr. 1297

This *Aspalathus* species was collected earlier by Ms H. Conradie and a specimen sent to the Compton herbarium where it was considered to be an undescribed species (Figure 5.26). It was again collected in October 2012 and is currently investigated by Prof Charles Stirton⁵.

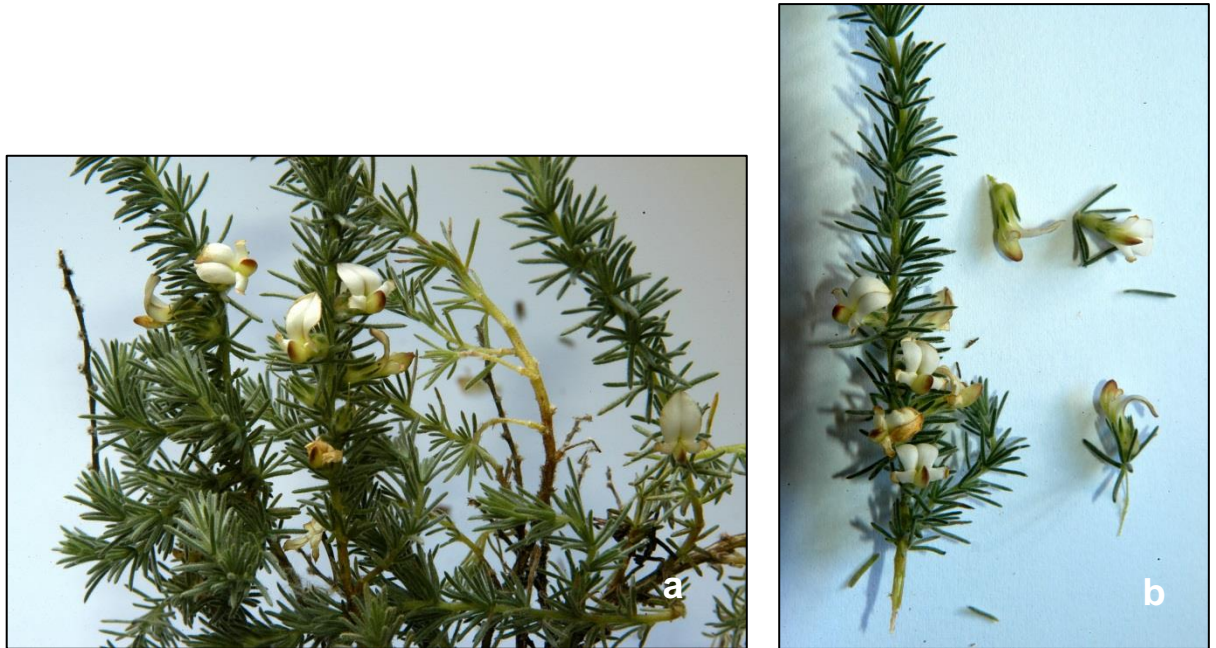


Figure 5.26: *Aspalathus* sp. nov. 1 (a & b) from the farm Sandberg flowers in October.

⁵ Bath, United Kingdom. Honorary Research Associate, Department of Biological Sciences, University of Cape Town, Rondebosch, South Africa

5.1.8.3 *Aspalathus* sp. nov. 2

Collection: A. le Roux nr. 1346, December 2014

A few populations of this summer flowering low growing undescribed *Aspalathus* shrub is found on certain plateaus of Ouhangsberg and Hammansberg south of Worcester (Figure 5.27). It was first collected in December 2014.



Figure 5.27: The summer flowering *Aspalathus* sp. nov. 2 (a, b) in habitat on Ouhangsberg (c).

5.1.8.4 *Indigofera* sp. nov. cf. *angustifolia*

Collection: A. le Roux nr. 439

Fabaceae taxonomic specialist, Prof C.H. Stirton and Brian Schrire⁶ examined this *Indigofera* species (which was identified as *Indigofera* cf. *brachystachya*) and concluded that it could be an undescribed species associated with *I. angustifolia* (Figures 5.28 & 5.29). This species is only known to occur in sandstone derived soil of a hill on the north-eastern perimeter of the Greater Brandvlei Dam. The plants were more abundant and flowered more prolifically after a controlled fire in 2009.



Figure 5.28: The bright mauve flowers of *Indigofera* sp. nov. cf. *angustifolia* in August 2010.



Figure 5.29: The flowers of *Indigofera* sp. nov. cf. *angustifolia* are followed by fruits in September.

⁶ Herbarium, Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, U.K.

5.1.9 GERANIACEAE

5.1.9.1 *Pelargonium flabelliforme* E.M.Marais, sp. nov

The geophytic *P. flabelliforme* is known only from the type collection north of the Greater Brandvlei Dam where it was firstly collected in 2009 (Figure 5.30). The species was described in Marais (2016).



Figure 5.30: *Pelargonium flabelliforme* flowering at the type locality in late summer.

5.1.9.2 *Pelargonium conradiae* J.C. Manning & A. le Roux, sp. nov.

Collections in NBG: A. le Roux, nr. 1150, September 2014; A. le Roux and H. Conradie, nr. 1405, 17 August 2015; A. le Roux, nr. 1406, 15 August 2015).

Dr D. Snijman first collected this small shrub *Pelargonium* to the northeast of the study area in 1983 (Manning and Le Roux 2016). Additional populations have recently been found on the farms Droogeriviersberg and Sandberg during fieldwork for this study (Figure 5.31). This led to description of the species in 2016 (Manning and Le Roux 2016). The species is endemic to the Breede River Valley. Conservation status assessment is pending.



Figure 5.31: *Pelargonium conradiae* flowering at the type locality (a & b). The stems at the end of dry season with emergent new growth (c).

5.1.9.3 *Pelargonium* sp. nov. 1

Collections: A. le Roux and H. de Wet, nr. 1305, October 2014; E.M. Marais and A. le Roux nr. 1408, September 2015)

The first known collection of this geophyte was made in October 1979 by G.J. Rossouw (E. M. Marais pers. com.). It was again collected in 2014 during data collection for this study and is presently being described by Dr E.M. Marais⁷. The species is a narrow endemic of the Breede River Valley and is known from several populations in the Moddergat area southeast of Worcester (Figure 5.32). It grows in loam soils derived from glacial tillite of the Dwyka geological Group (Karoo Supergroup) (Gresse 1997; Gresse and Theron 1992) in a Breede Shale Renosterveld - Robertson Karroo (Mucina *et al.* 2005; Mucina *et al.* 2006; Rebelo *et al.*, 2006) ecotonal shrubland (Figure 5.32).



Figure 5.32: The leaves of this undescribed geophytic *Pelargonium* appear during the rainy season in winter (a) and are followed by the flowers in October (b) after the leaves have died.

⁷ Department Forest and Wood Science, University of Stellenbosch, Stellenbosch, Private Bag X1, Matieland 7602, South Africa

5.1.9.4 *Pelargonium* sp. nov. 2

Collections: A. le Roux, G. Groenewald & E.M. Marais nr. 1464

This beautiful geophytic *Pelargonium* species (Figure 5.33) was collected on 13 October 2017. A large population was found growing in deep sand near the Greater Brandvlei Dam. The species is currently investigated by Dr E.M. Marais.



Figure 5.33: *Pelargonium* sp. nov. 2 flowering prolifically in the midst of severe drought conditions in October 2017 (a). Flower colour varies from white to soft pink (b, c & d).

5.1.10 MOLLUGINACEAE

5.1.10.1 *Psammotropha* sp. nov.

Collection: A. le Roux, nr. 444, 3 September 2007

An apparently undescribed *Psammotropha* species was discovered in 2007 during data collection. Populations were found on the hills north and east of the Greater Brandvlei Dam as well as on Hammansberg. The species is currently being investigated by Dr M. Buys⁸. This small round shrub differs from *P. quadrangularis* which also occurs in the study area. Where the latter grows in deep windblown sand deposits, the undescribed species grows mostly in rocky loam soil sometimes with thin aeolian sand covering (Figures 5.34 & 5.35). The plants were more abundant and flowered more prolifically after a controlled fire in 2009.



Figure 5.34: The small spring flowering *Psammotropha* sp. nov. in habitat.

⁸ Dr Matt H. Buys, Curator: National Forestry Herbarium, Scion, 49 Sala Street, Private Bag 3020, Rotorua 3046, New Zealand.



Figure 5.35: : *Psammotropha* sp. nov. was found to grow more abundant and flowered prolifically after a controlled fire in 2009.

5.1.11 OXALIDACEAE

5.1.11.1 *Oxalis* sp. nov

A. le Roux nr. 818

During the data collection for this study, this interesting *Oxalis* species was found on the hills bordering the Greater Brandvlei Dam to the east (Figure 5.36). Although Mr M.B. Bayer⁹ trusts this species to belong to the species-group *Oxalis pardalis*, it is yet uncertain because the leaflets are not streaked with pellucid lines that turn black in the dry state, the leaflets can be up to 5 and apart from being somewhat sticky, the bulb tunics are not clothed with retrorse hairs.



Figure 5.36: A suspected undescribed *Oxalis* species (a & b) in the sub-section Pardales growing on the hills east of the Greater Brandvlei Dam.

⁹ Entomologist formerly with the South African Department of Agriculture as well as with other research institutions, former curator of the Karoo Botanic Garden in Worcester (1969-1987) and later at the Worcester Veld Reserve. Retired at Fisherhaven, Hermanus.

5.1.12 RUTACEAE

5.1.12.1 *Agathosma* sp. nov 1

Collections: A. le Roux, no. 1003, 13 September 2013; A. le Roux, no. 1153, September 2014; A. le Roux, no. 1341, October 2014

A. le Roux nr. 1153 and nr. 1397

This *Agathosma* species was collected in September 2013 during data collection for this study and confirmed by Terry H. Trinder-Smith (Curator, Bolus Herbarium, University of Cape Town) as yet undescribed. Since found at the type locality on a south facing slope of Gannaberg, several other populations were found on Gannaberg as well as on Ouhangsberg southeast of Worcester (Figure 5.37). The species is presently described by Terry Trinder-Smith¹⁰.



Figure 5.37: *Agathosma* sp. nov 1 flowering at the type location on Gannaberg in September 2014 (a) and with fruits in March the following year (b & c).

¹⁰ Bolus Herbarium Curator, University of Cape Town.

5.1.12.2 *Agathosma* sp. nov. 2**Collection: A. le Roux nr. 1268**

This *Agathosma* species (Figure 5.38) was collected in September 2014 during data collection for this study. The Rutaceae specialist taxonomist, Terry H. Trinder-Smith considers the species likely to be an undescribed one. It occurs on the range of hills east of the Greater Brandvlei Dam and was firstly collected in November 2014 (Figure 5.38).



Figure 5.38: *Agathosma* sp. nov. 2 at the type locality east of the Greater Brandvlei Dam.

5.2 SECTION B: INDETERMINATE TAXA

5.2.1 *Drosanthemum* sp. cf. nov. (Aizoaceae)

Collection: A. le Roux & H. de Wet nr. 1407

An interesting small *Drosanthemum* shrub was found on a sandstone ridge on the southern slope of Hammansberg in 2015. The shrub was also found in similar habitat in the southeastern part of the study area in 2016 (Figure 5.39). It is being studied in collaboration with Dr E.J. van Jaarsveld and is monitored for flowers to verify the species.



Figure 5.39: An interesting small *Drosanthemum* shrub found on sandstone ledges in the study area is monitored for flowers to shed light on the taxonomy of the species.

5.2.2 *Othonna* sp. cf. nov. (Asteraceae)

Collection: A. le Roux, E.J. van Jaarsveld, A. Stander & H. de Wet 1173

An interesting indeterminate *Othonna* species (Figure 5.40) was found on a sandstone ridge on Droogeriviersberg. The species is studied in collaboration with Dr E.J. van Jaarsveld.



Figure 5.40: Flowers (a) and seeds (b) of an interesting *Othonna* species that is further studied to determine its taxonomy.

5.2.3 A representative of the Asteraceae family

A population of this interesting, succulent plant (possibly *Senecio* or *Othonna* species) occurs on Ouhangsberg in the study area (Figure 5.41). Although the population has been monitored for several years, no flowers have yet been observed to determine its taxonomy. The species is monitored and studied in collaboration with Dr E.J. van Jaarsveld.



Figure 5.41: An interesting succulent representative of the Asteraceae on Ouhangsberg.

5.2.4 *Coleonema* sp. nov. cf. *album* (Rutaceae)

A. le Roux no. 1313

Rutaceae specialist taxonomist, Terry H. Trinder-Smith considers this *Coleonema* species unusual. According to Terry, dissecting and keying it out brought him to *C. album*, and although this species is morphologically very similar to *C. album*, the locality (not coastal), substrate (loam, not Table Mountain Sandstone rocks or sand) and stem colour (red, not grey) would possibly qualify it as a new subspecies of *C. album*. Populations of the species were found on rocky sandstone ridges of Ouhangsberg and Gannaberg, as well as in Haumanskloof (Figure 5.42).



Figure 5.42: *Coleonema* sp. nov. cf. *album* on Ouhangsberg.

5.3 SECTION C: TAXONOMIC PROBLEMATIC TAXA

5.3.1 *Drosanthemum* subgenus *Speciosa*

Hartmann (2008) and Hartman & le Roux (2011) divided the *Drosanthemum* species with black staminodes (*Drosanthemum* subgenus *Speciosa*) as follows:

- into two main groups regarding the number bladder-cells on the leaf surface:
 - smooth leaf surfaces
 - rough leaf surfaces
- into three groups regarding leaf shape:
 - leaves with a sharp permanent hook at the end
 - leaves thickest in their middle, narrowing to base and tip
 - leaves with parallel sides, tapering only moderately into a rounded tip
- into two groups regarding the staminodes:
 - flowers with many narrow acute filamentous staminodes covering the stamens in the early states;
 - flowers with relatively few broader apically rounded filamentous staminodes at most as long as the stamens

The hills around the Greater Brandvlei Dam are the type locality of *Drosanthemum hallii* (Figure 5.43) where Harry Hall, at that time the senior horticulturist in charge of the succulent plant section of the Kirstenbosch National Botanic Garden (Glen and Germishuizen 2010), first collected the species in October 1960. According to Hartmann 2008, it was for many years believed that each *Drosanthemum* species had its own petal colour, but recent studies show that petal colour can differ in populations (Figures 5.43 – 5.45). Because description of *D. hallii* was based on a sample with yellow flowers, flowers with red-tipped petals was in the past confused with, and identified as *D. micans* (Hartmann 2008; Hartmann and Le Roux 2011). In the study area, other colour forms of *D. hallii* include white, orange and red (Figure 5.45). Although different flower colours occur, scanning electron microscopic images show that the pollen grains are morphologically similar (Figures 5.43 – 5.47).

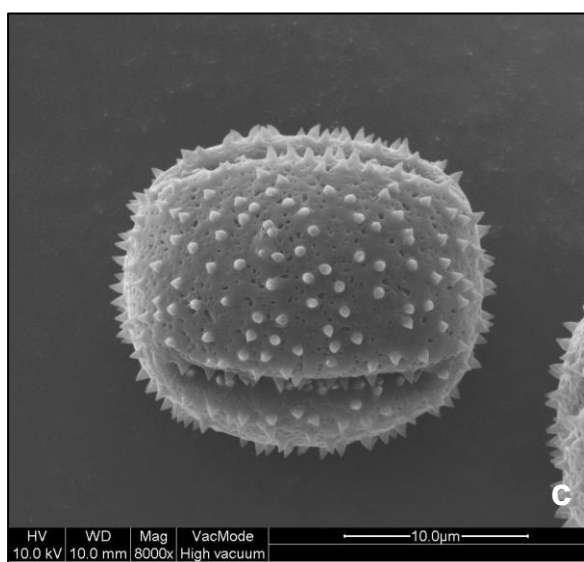
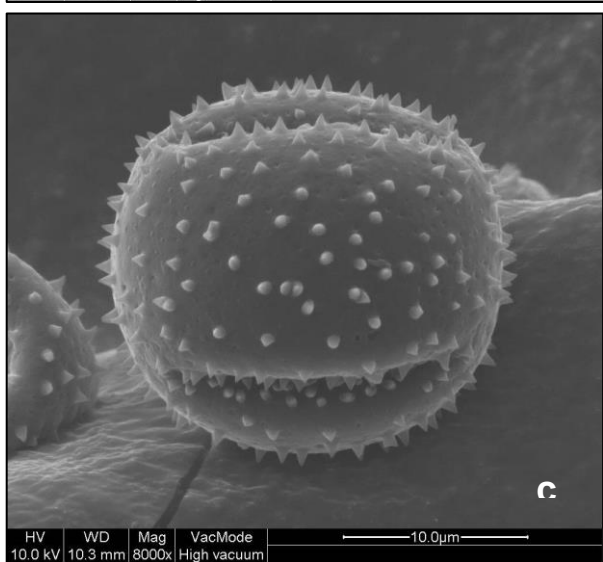
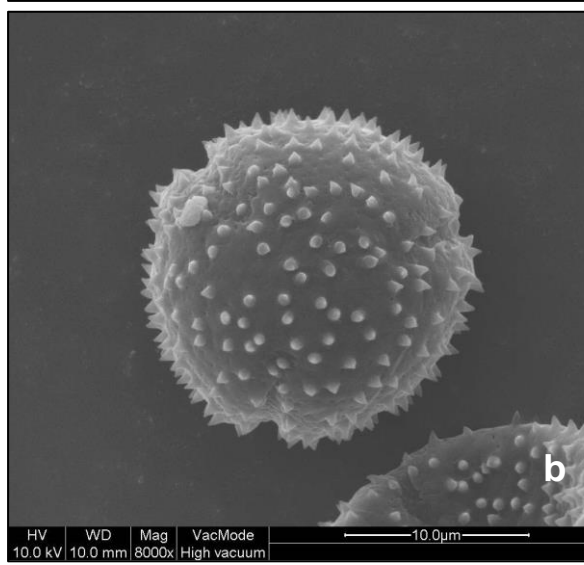
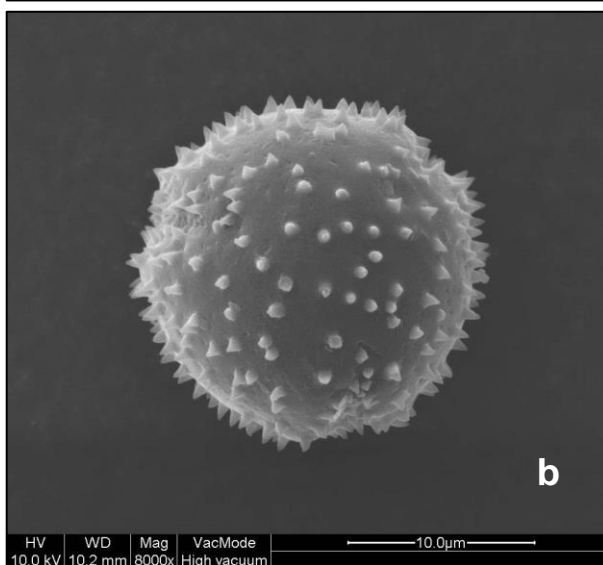


Figure 5.43: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain from a yellow flower of *Drosanthemum hallii*. Scale bar: 10 µm.

Figure 5.44: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain from a yellow with red petal tips coloured flower of *Drosanthemum hallii*. Scale bar: 10 µm.

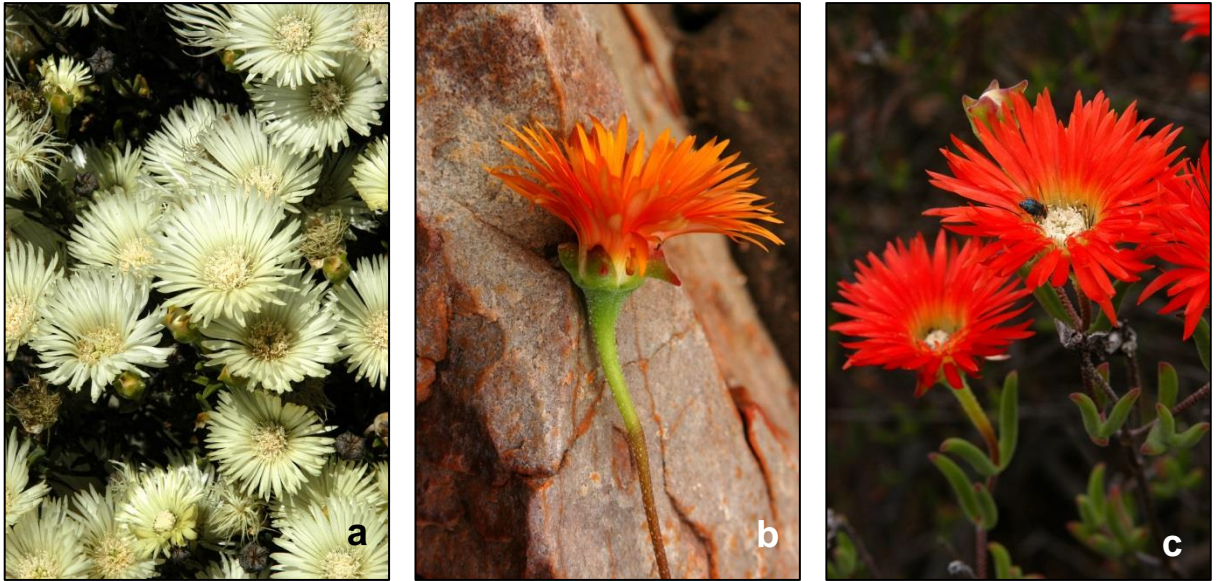


Figure 5.45: White (a), orange (b) and red (c) flower colour variations in the *Drosanthemum hallii* (Aizoaceae) population at the type locality north of the Greater Brandvlei Dam.

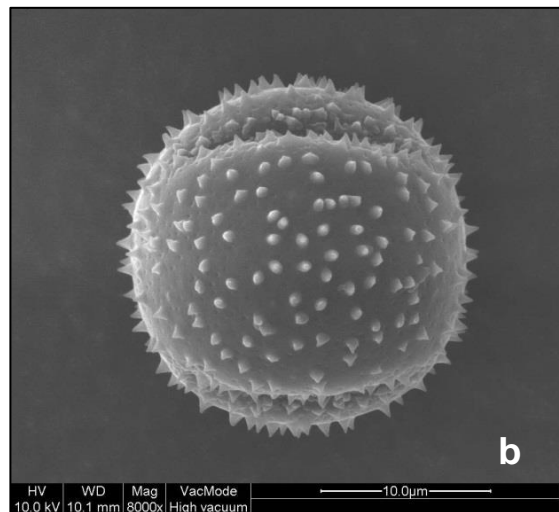
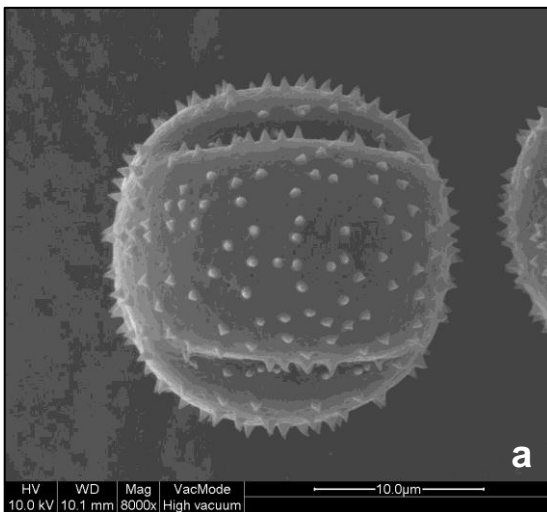
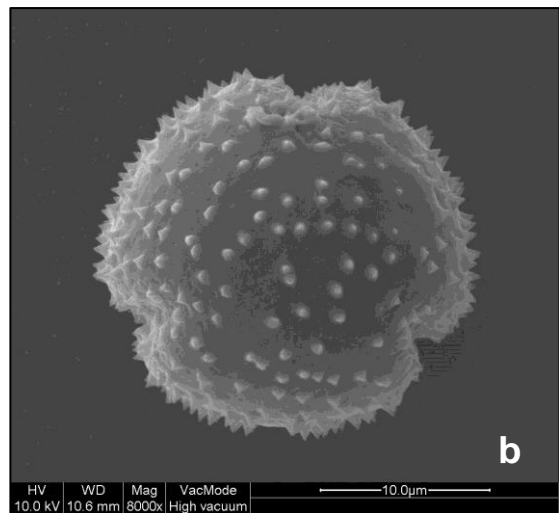
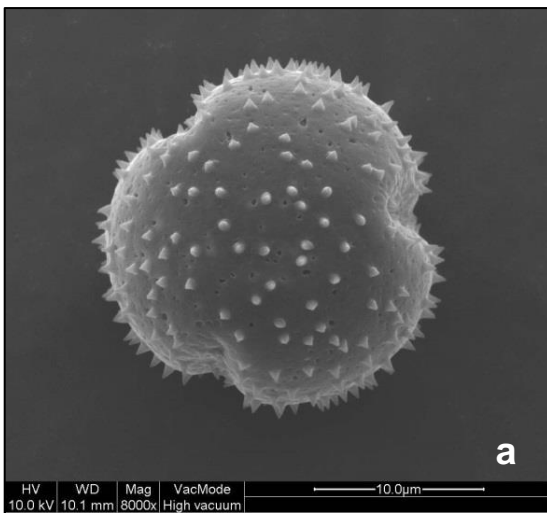


Figure 5.46: Polar- (a) and side (b) view of a pollen grain from an orange flower of *Drosanthemum hallii*. Scale bar: 10 μm.

Figure 5.47: Polar- (a) and side (b) view of a pollen grain from a red flower of *Drosanthemum hallii*. Scale bar: 10 μm.

Drosanthemum hallii has Red List conservation status: Endangered (<http://redlist.sanbi.org>).

In the study area, the *Drosanthemum* species of this subgenus differ in distribution area as well as in morphologically as follows:

Drosanthemum pulchrum, *D. hallii* and *D. bellum* were only found to occur on the hills bordering the Greater Brandvlei Dam to the north and to the east, while *D. speciosum* and *D. micans* was only found to occur to the southeast of the dam. Regarding their distribution in the study area, populations of *D. speciosum* and *D. micans* occur together (sympatric) on Hammansberg, Droogeriviersberg and Gannaberg.

Drosanthemum bellum, *D. hallii* and *D. micans* have leaves with rough leaf surfaces and a sharp permanent hook at the end. While *D. hallii* is mostly characterised by fewer wiry filamentous staminodes, usually as long as the stamens and merging into the stamens as the flower ages, the narrow staminodes of *D. bellum* and *D. micans* cover the stamens in the young flower (Hartmann & Le Roux 2011).

Drosanthemum speciosum and *D. pulchrum* have smooth leave surfaces, but in *D. pulchrum* the leaves have mostly parallel sides, tapering only moderately into a rounded tip, where in *D. speciosum* the leaves are thickest in their middle, narrowing to base and tip (Hartmann 2008; Hartmann and Le Roux 2011).

Drosanthemum pulchrum was only found in the *Nerine humilis* variant of the *Euryops rehmannii*–*Elytropappus rhinocerotis*–*Crassula saxifraga* sub-community (sub-community 3.3 variant iii) on the hills bordering the Greater Brandvlei Dam to the north (where *D. speciosum* does not occur). Although Hartmann (2008) and Hartmann & le Roux (2001) treat this as a distinct species, Bayer (pers. com.; 2006¹) considers the species nothing less than *D. speciosum* (Figure 5.48).



Figure 5.48: *Drosanthemum pulchrum* on a hill bordering the Greater Brandvlei Dam to the north. Although Hartmann (2008) and Hartmann & le Roux (2001) treat this as a distinct species, Bayer (2006¹; pers. com.) understands this as *D. speciosum*.

Hartmann & Le Roux (2011) developed a key to the species of *Drosanthemum* subgenus *Speciosa* that describes the flowers of *D. bellum* “with many narrow acute filamentous staminodes covering the stamens in the early states of anthesis, the stamens clearly separated from the filamentous staminodes” (Figure 5.49). However the flowers of *Drosanthemum bellum* is described with “petals pink to deep purple, the base regularly whitish to cream coloured, also cream coloured all along and rarely yellow” (Figure 5.49), the authors concluded that flower colour cannot be used to identify a species (Hartmann & le Roux 2011). A few plants with orange and red coloured flowers occur within the population dominated by plants with soft pink and cream coloured flowers (Figure 5.50).



Figure 5.49: Bright pink (a), pale pink (b) pale yellow (c) and pale yellow with pink (d) colour forms of the flowers of *Drosanthemum bellum* (Aizoaceae) on the hills north of the Greater Brandvlei Dam, the filamentous staminodes covering the stamens in young flowers.

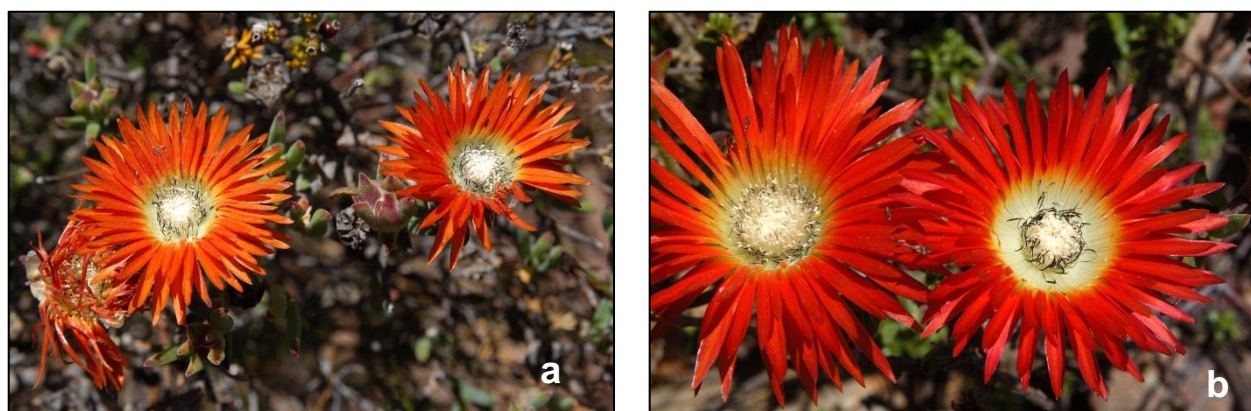


Figure 5.50: These flower forms, orange (a) and red (b) occur on the range of hills bordering the Greater Brandvlei Dam to the north. Until further study provide clarity, concerning habitat and the morphology of the staminodes, this study treats these plants as *Drosanthemum bellum*.

Based on the morphology of the black staminodes, the orange and red flowered plants are accepted to be *D. bellum*. Scanning electron microscopic images show that pollen grains from pale pink and that of pale yellow flowers are morphologically similar (Figures 5.51 & 5.52).

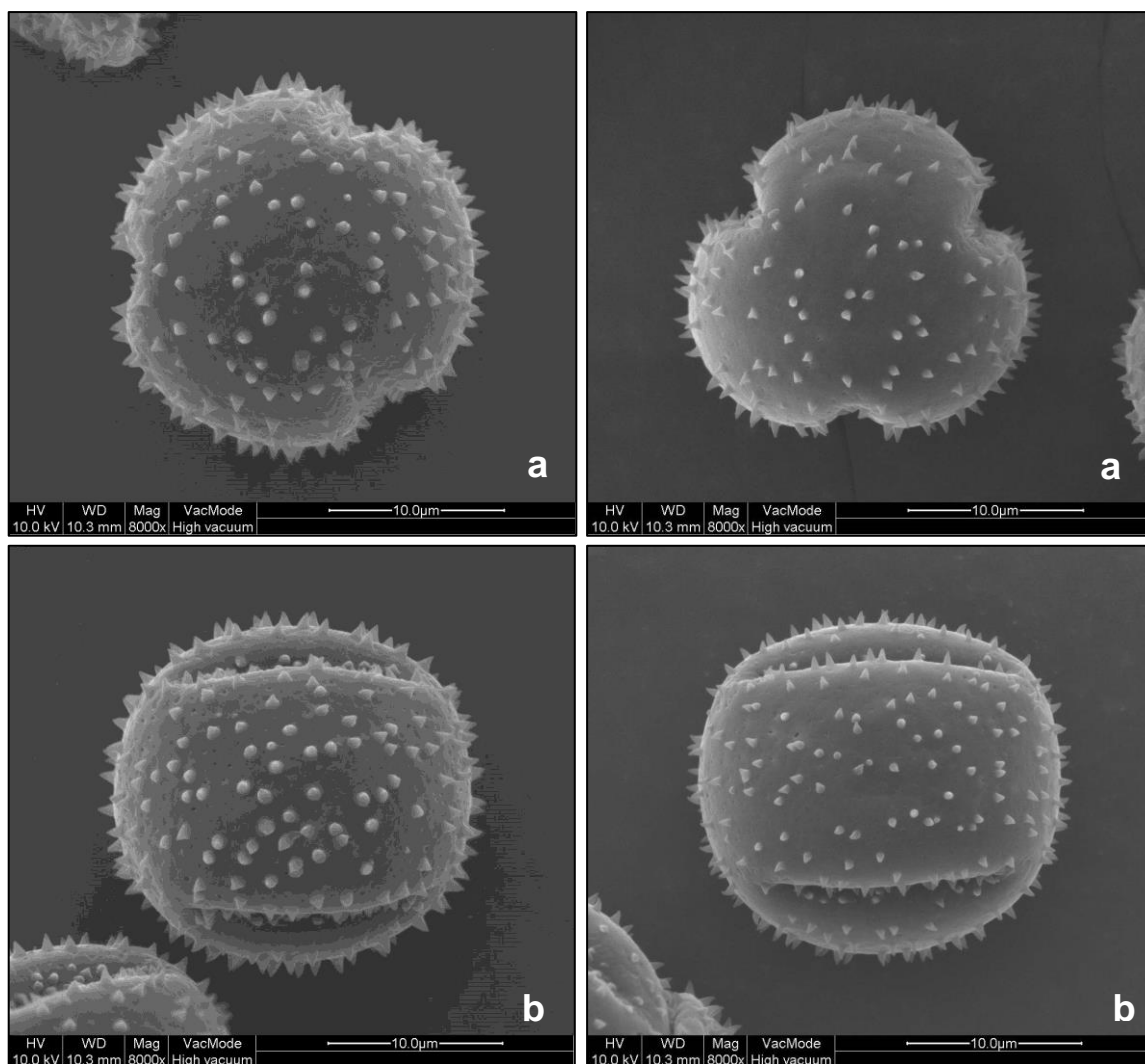


Figure 5.51: Polar- (a) and side (b) view of a pollen grain from a pale pink coloured flower of *Drosanthemum bellum*. Scale bar: 10 µm.

Figure 5.52: Polar- (a) and side (b) view of a pollen grain from a pale yellow coloured flower of *Drosanthemum bellum*. Scale bar: 10 µm.

Drosanthemum hallii (Figures 5.43 – 5.45) is a constant species in sub-community 9.3, where it occurs together with *D. bellum* (Chapter 4). While *D. hallii* occurs in major communities 3 and 4 on the hills surrounding the Greater Brandvlei Dam, another closely related species, *D. micans* (Figure 5.53) occurs to the south and southeast of the localities of *D. hallii* and *D. bellum*, on Hammansberg, Droogeriviersberg, Ouhangsberg and Gannaberg. While the filamentous staminodes of *D. bellum* (Figure 5.49) differs morphologically from that of *D. hallii*, there are no clear morphological characters by which *D. bellum* occurring here, and *D. micans* (of which the filamentous staminodes are morphologically similar) (Figure 5.53) occurring in the southern part of the study area, can be distinguished (Hartmann 2008; Hartmann and Le Roux 2011).

Further taxonomic- and phylogenetic studies could provide proof that these two closely related species are indeed separate or possibly representatives of the same species. Based on the morphological differences in staminodes, Hartmann & le Roux (2011) could not conclude that the species *D. hallii* and *D. micans* are indeed one species, however Bayer (pers. com.) consider *D. hallii*, *D. micans* as well as *D. bellum* to be one species (Bayer 2008; Bayer 2012). Although the flowers and leaves are morphologically different, scanning electron microscopic images show that pollen grains of the *Drosanthemum* subgenus *Speciosa* species that occur in the study area are morphologically similar (Figures 5.43; 5.44; 5.46; 5.47; 5.51; 5.52; 5.54 & 5.55).



Figure 5.53: *Drosanthemum micans* (Aizoaceae) from Gannaberg in the southern part of the study area.

Nilsson & Praglowski (1992) describe the use of pollen morphology in the delimitation of plant families and genera, and state that large variations in pollen morphology can often occur within species, Sambamurty (2005) point out that pollen morphology alone cannot be used as a character in taxonomy. Erdtman (1971) states that pollen grains of the Aizoaceae are “fairly uniform

throughout the family, usually 3-colpate or 3-colporoidate.” According to the same author, the “sexine (the outer main layer of the exine) is as thick as the nexine or thicker, provided with spinules in the Mesembryanthemum-group and possibly also in other members of the family” (Erdtman 1971).

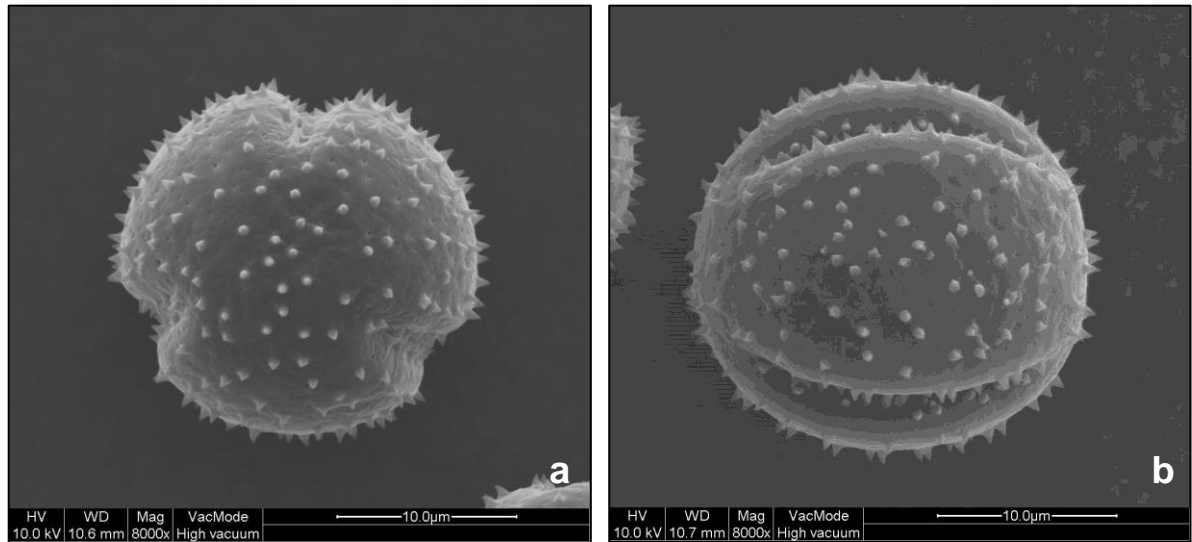


Figure 5.54: Polar- (a) and side (b) view of a pollen grain from a red coloured flower of *Drosanthemum micans* from Gannaberg. Scale bar: 10 µm.

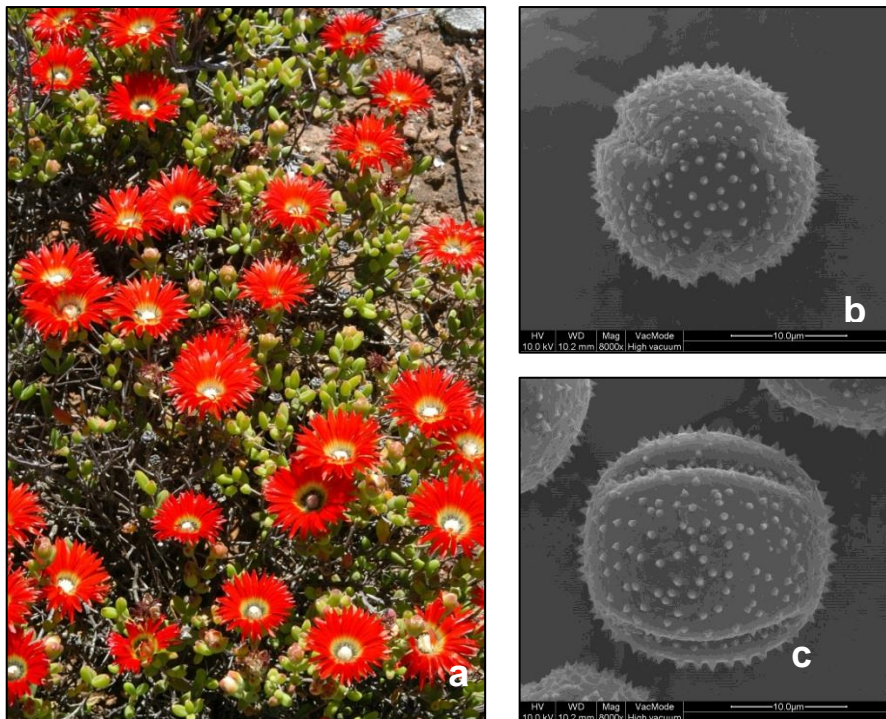


Figure 5.55: Flowers (a) as well as the polar- (a) and side (b) view of a pollen grain of *Drosanthemum speciosum* from Gannaberg. Scale bar: 10 µm.

Various other references agree that tricolpate, microspinulose and punctate/perforate pollen grains are common in the Aizoaceae, but

interpretations differ if this represents the primitive condition (Nowicke and Skvarla 1979; Bittrich and Hartmann 1988; Bittrich and Struck 1989; Hartmann 1991; Kurzweil and Chesselet 2003). According to Bittrich and Hartmann (1988) tricolpate pollen only appears as a synapomorphy for the Aizoaceae family.

5.3.2 *Mesembryanthemum caudatum* L.Bolus (*Phyllobolus caudatus* (L.Bolus) Gerbaulet)

With the revision of the genus *Phyllobolus*, Gerbaulet speculated that *Mesembryanthemum caudatum* (*Phyllobolus caudatus*) (Klak and Bruyns 2013), a species that was only known from its type locality near De Doorns, could possibly be a giant form of *M. grossum* (*P. grossus*) (Gerbaulet 1997) (Figures 5.56 & 5.57).



Figure 5.56: *Mesembryanthemum grossum* with small salmon coloured flowers and short leaves with fairly large idioblasts.



Figure 5.57: *Mesembryanthemum caudatum* (Mopkop vygie) with large bright yellow flowers and distinct long cylindrical leaves.

Gerbaulet was not able to make an informed decision regarding the matter as no living material could be found from the type locality. Several populations of

Mesembryanthemum caudatum were recently discovered in the study area (Figure 5.58), but a population was also found near Nieuwoudtville in Northern Cape Province (Le Roux *et al.* 2010). A comparison of collections from the study area to collections at the Compton Herbarium concluded that the *M. caudatum* and *M. grossum* are indeed distinct taxa (Figures 5.58 & 5.59). Because of the vast expanse (about 200 km) between the Worcester-and Nieuwoudtville populations as well as differences in habitat, there was uncertainty if the Nieuwoudtville- and Worcester populations are indeed the same species (Le Roux *et al.* 2010) (Figures 5.58 & 5.59).

Although the morphology of the exine of pollen grains was classically used as a means of identification and phylogeny, the sculptured region of the exine contain hydrolytic enzymes and proteins that play an important role during intra- as well as interspecific pollen-stigma recognition and compatibility (Shivanna 1982). Recent studies furthermore suggest that interspecific compatibility is controlled genetically (Shivanna 1982). However Knox & Singh (1987) agree that “the surface of the receptive stigma has a number of determinants interacting with pollen surface” and that “integrity of the surface proteins of the stigma surface pellicle appears to be essential for the stigma to respond to pollen information,” the authors also state that “recent research has indicated that during pollen development several haploid genome-specific genes are expressed. These genes are not expressed in any other tissues of the diploid sporophyte. These genes control steps in pollen-specific functions, for example, microspore and pollen development, germination and tube formation, sperm cell formation, and stigma/style recognition and penetration. In order to make further progress in our understanding of these processes, it is necessary to isolate the genes expressed in pollen, so that they can be identified and characterized and their developmental regulation can be determined” (Knox & Singh 1987). Although various references point out that pollen morphology alone often do not aid in a clear distinction between species of the same genus, the matter was investigated by Dr MB Buys and Dr LR Tiedt¹¹.

¹¹ Dr. Louwrens R. Tiedt Head: LEM Lab. for Electron Microscopy Chemical Resource Beneficiation (CRB) Potchefstroom Campus, NWU.



Figure 5.58: Dr M.B. Buys and Dr L.R. Tiedt in the habitat (a) of *Mesembryanthemum caudatum* (b) on the northern perimeter of the Greater Brandvlei Dam in the study area.

Figure 5.59: The near Nieuwoudtville habitat (a) of *Mesembryanthemum caudatum* (b).

A comparison of the pollen (Figures 5.60 & 5.61), leaf surfaces (Figures 5.62 & 5.63) and seeds (Figures 5.64 & 5.65) from a plant at the locality near Worcester, and from a plant at the locality near Nieuwoudtville was made. Until further examination such as phylogenetic studies provides a distinction, it is believed that the two populations are likely to be of the same species (based on the present evidence concerning morphological similarities).

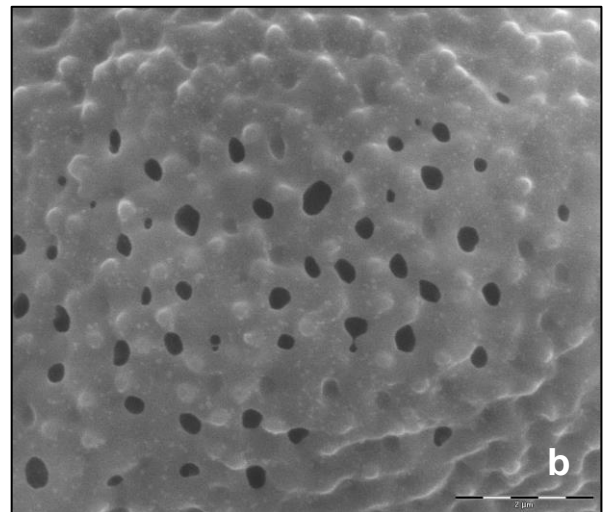
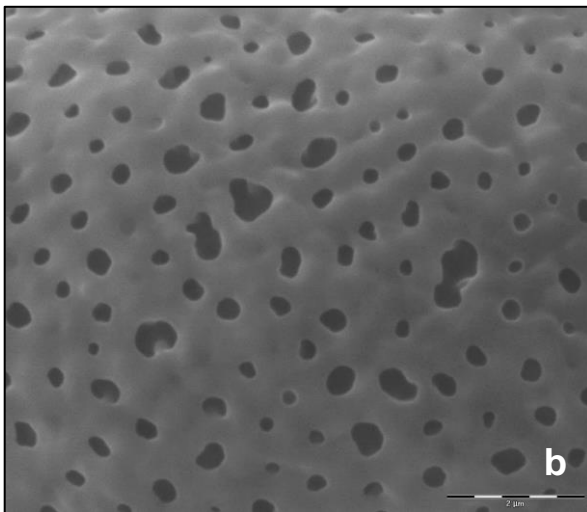
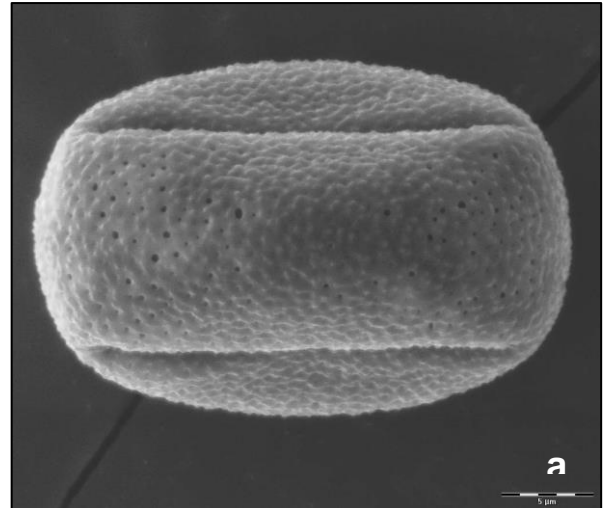
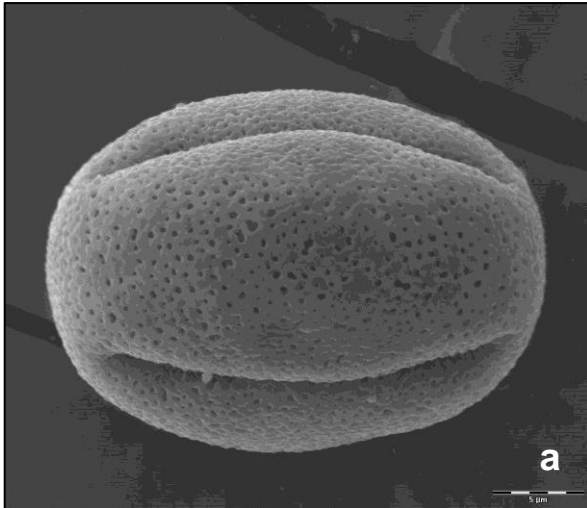


Figure 5.60: An 8000 x enlargement of the side view (a) and exine sculpture (b) of a pollen grain (*Mesembryanthemum caudatum*, Worcester).

Figure 5.61: An 8000 x enlargement of the side view (a) and exine sculpture (b) of a pollen grain (*Mesembryanthemum caudatum*, Nieuwoudtville).

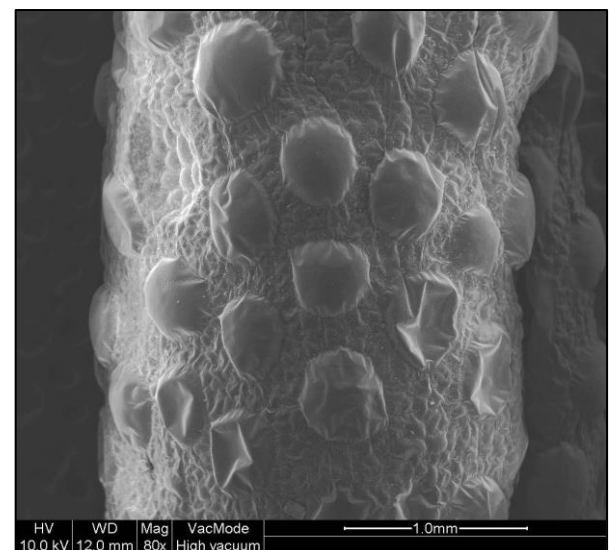
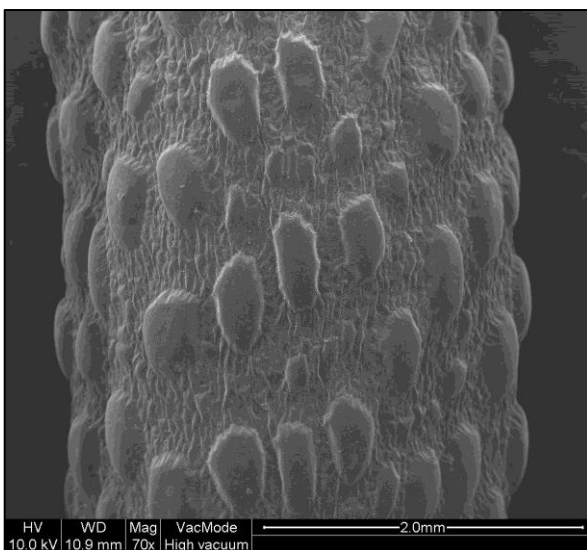


Figure 5.62: A 70 x enlargement of the abaxial leaf surface of *Mesembryanthemum caudatum* (Worcester population).

Figure 5.63: A 70 x enlargement of the abaxial leaf surface of *Mesembryanthemum caudatum* (Nieuwoudtville population).

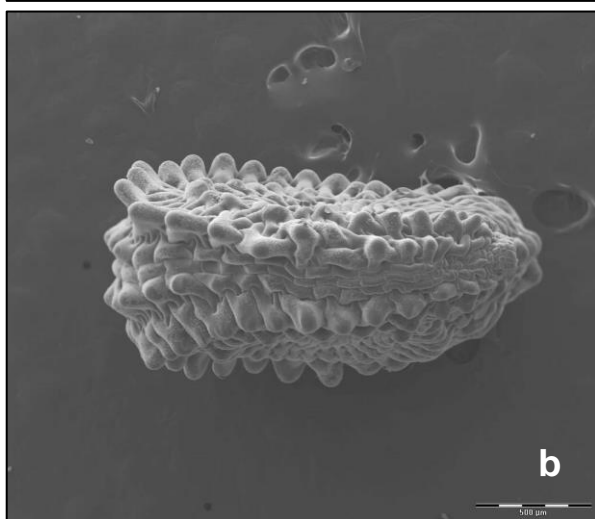
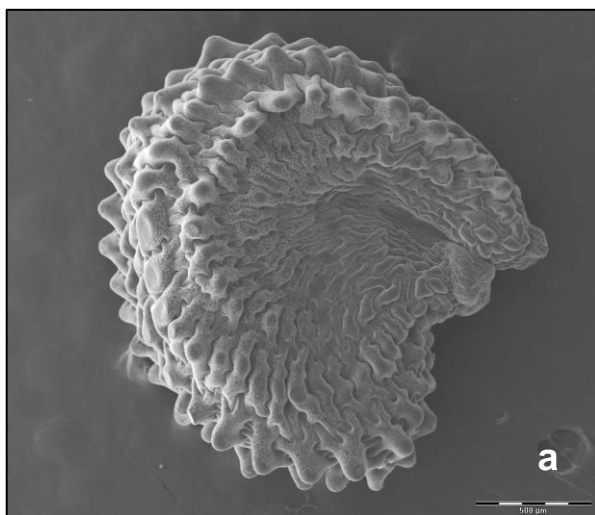


Figure 5.64: The view from the side (a) and from the top (b) of a seed of *Mesembryanthemum caudatum* from the Worcester population.

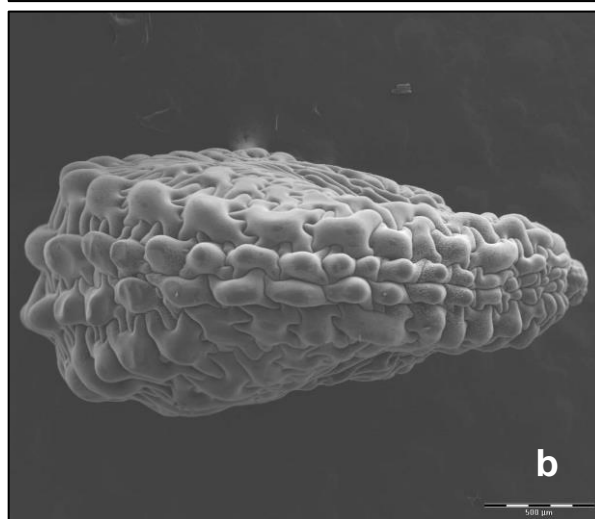
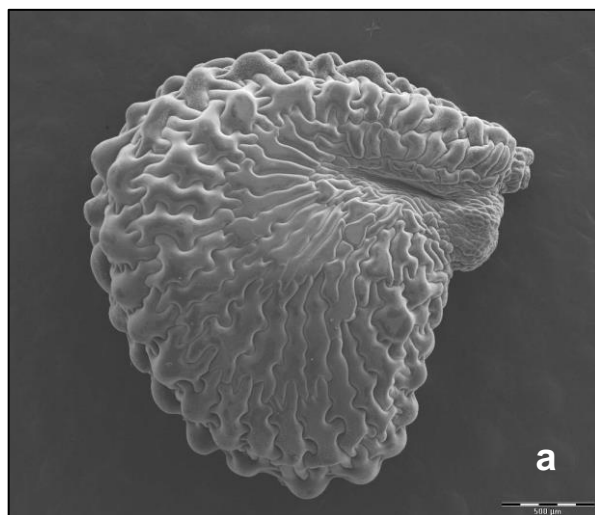


Figure 5.65: The view from the side (a) and from the top (b) of a seed of *Mesembryanthemum caudatum* from the Nieuwoudtville population.

5.3.3 *Adromischus* species

Collection: A. le Roux & H. de Wet nr. 1464

An interesting *Adromischus* species that occurs on the high sandstone rocky outcrops in the study area could either be an undescribed species, or a possible hybrid between *A. maculatus* and *A. hemisphaericus* (Dr E.J. van Jaarsveld pers. com.). Dr van Jaarsveld confirmed that this species occurs on most of the peaks consisting of Witteberg quartzite in the study area and considers the species stable, producing true offspring and remaining on the peaks.

A comparison of the indeterminate *Adromischus* species and *A. maculatus* is provided in Figures 5.66 & 5.67.



Figure 5.66: *Adromischus maculatus* (a) flowering (b) in the study area (picture b: H. de Wet).



Figure 5.67: A possible hybrid between *Adromischus maculatus* and *A. hemisphaericus* (a) was found on Hammansberg in February 2015. The flowers differ from that of *Adromischus maculatus* (b).

5.3.4 A smaller cliff dwelling *Crassula* species and *C. rupestris*.

This compact, small leaved *Crassula* species grows on the sandstone rocky outcrops in the study area. A comparison with *C. rupestris* is given in Figure 5.68. Because these two taxa differ morphologically, do not occur in the same habitat, and do not flower at the same time, it is assumed that they likely are separate entities.

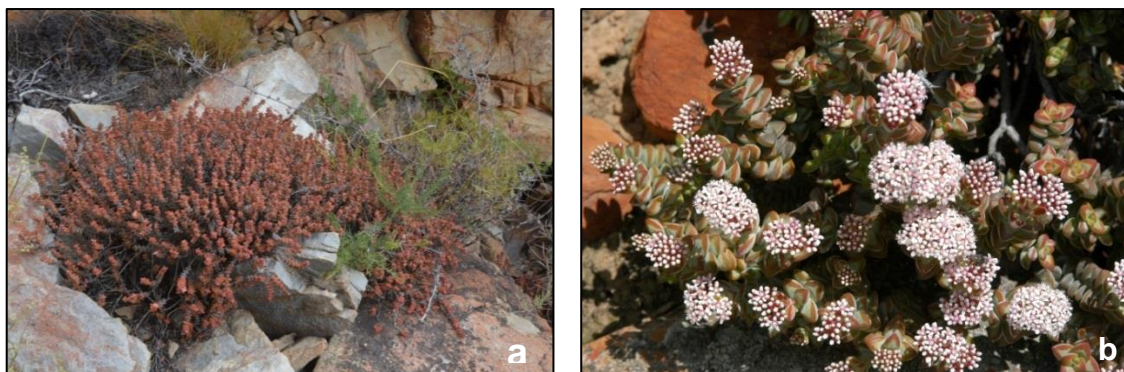


Figure 5.68: The difference between a smaller cliff dwelling *Crassula* species (a) and *Crassula rupestris* (b).

5.3.5 A possible *Crassula saxifraga* – species complex

In association with Dr E.J. van Jaarsveld, a small geophyte found on the farm Sandberg is currently investigated (Figure 5.69 a). Although the flowering time is similar to that of *Crassula saxifraga* (Figure 5.69 b), ecological as well as morphological differences regarding the leaves and flowers may indicate that the recently found plants (Figure 5.69 a) may likely be a unique taxon.



Figure 5.69: The difference between the flowers of a small geophytic *Crassula* species (a) and *Crassula saxifraga* (b).

5.3.6 *Wiborgia* cf. *sericea*

Collection: A. le Roux nr. 1457

However this small shrub (Figure 5.70) was identified as *W. tenuifolium*, several differences raise the doubt to the possibility that the identification may be wrong. This small shrub occurs in major community 4, while *W. tenuifolium* occurs in major community 1. The flowers of this shrub are considerably paler and the fruits much larger than those known for *W. tenuifolium*.



Figure 5.70: An indeterminate *Wiborgia* species growing on the farm Sandberg in the south of the study area.

5.3.7 *Oxalis* species

The study of *Oxalis* presents great difficulties (Salter 1944). Identification of the *Oxalis* species in the study area was the collaborate effort of the Compton herbarium, Dr K.C. Oberlander¹² and Mr M.B. Bayer. This study follows the conclusions of Bayer (1992) where 11 *Oxalis* species recognised in the sub-section *Pardales* by the revision of T.M. Salter in 1944, are combined in one species group, namely *Oxalis pardalis* Jacq: *O. pardalis* (Figure 5.71), *O. cf. confertifolia* (Figure 5.72), *O. cf. camelopardalis* (Figure 5.73), *O. capillaceae* (Figure 5.74), *O. cf. leptogramma* (Figure 5.75) and an indeterminate species which possibly is a unknown form of this species group (Figure 5.76) that occur in the study area, are part of the taxonomically difficult sub-section *Pardales* where the species boundaries are very difficult (Bayer 1992; Dr K.C. Oberlander pers. com.).



Figure 5.71: *Oxalis pardalis* in the study area around the Greater Brandvlei Dam.

¹² Stellenbosch University, Department of Conservation Ecology and Entomology, Stellenbosch, South Africa



Figure 5.72: This *Oxalis* species (a) (A. le Roux no 1121), occurring in the southeast of the study area, is identified as *Oxalis confertifolia* (Dr K.C. Oberlander). The bulbs with old tunics (b) are typical of the sub-subsection *Pardales*. Bayer (1992) combined *Oxalis confertifolia* in the species group *O. pardalis*.



Figure 5.73: An *Oxalis* species (A. le Roux nr 1344) occurring on a hill bordering the Greater Brandvlei Dam (a & b) on the eastern side could be what Salter (1944) described as *O. camelopardalis*, but what Bayer (1992) combined in the group-species *O. pardalis*.



Figure 5.74: This *Oxalis* species (A. le Roux nr 572) occurring in sandy soil on the hills bordering the Greater Brandvlei Dam to the north, was identified by the Compton herbarium as *Oxalis capillaceae*, but combined by Bayer (1992) in the group-species *Oxalis pardalis*.



Figure 5.75: This *Oxalis* species (A. le Roux nr 1117) occurring in the southeastern part of the study area, was identified by Dr K.C. Oberlander as what Salter (1944) described as *Oxalis leptogramma*, but what Bayer (1992) combined in the group-species *Oxalis pardalis*.



Figure 5.76: An indeterminate *Oxalis* species (possibly undescribed and likely to belong in the subsection *Pardales*) (A. le Roux no. 818) growing on the hills east of the Greater Brandvlei Dam (a & b).

Other indeterminate *Oxalis* species found in the study area are described in Figures 5.77 – 5.79.



Figure 5.77: Although identified by the Compton herbarium as *Oxalis* cf. *annae* (A. le Roux nr 541), the identity of this species, growing in sandy soil on the hills bordering the Greater Brandvlei Dam on the northern side, is uncertain.



Figure 5.78: Other indeterminate *Oxalis* species growing in the study area: a from the older formations, and b & c from the within Witpoort rocks of the Witteberg Group in the southeast of the study area.



Figure 5.79: This *Oxalis* species (A. le Roux nr 918) occurring in sandy soil on the perimeter of the Greater Brandvlei Dam on the eastern side (a & b), was identified by the Compton herbarium as *Oxalis commutata*, but Dr K.C. Oberlander considers this to be *Oxalis eckloniana*.

5.4 CONCLUSION

An analysis of the floristic data of 138 sample plots identified five major floristic units, namely an *Elytropappus rhinocerotis* Shrubland, a *Passerina truncata* shrubland, a *Capeochloa arundinacea* Shrubland, a *Hirpicium integrifolium* Shrubland and a *Thamnochortus bachmannii* Sandveld which is indicative of a diverse flora and habitat. Among the plant species occurring in this natural system, 13 new species were described during the course of the study while an additional 17 new species are currently being investigated and described. Five indeterminate taxa are furthermore being examined by taxonomic specialists. Taxonomic problematic taxa were dealt with and other unresolved taxonomic difficulties in the Aizoaceae, Asteraceae, Crassulaceae, Fabaceae, Oxalidaceae and Rutaceae are being investigated by taxonomic specialists. This supports the findings of many researchers describing the CFR as a biodiversity hotspot (Cowling *et al.* 2003; Myers *et al.* 2000). The fact that several new species were identified is further proof of the plant ecological importance of the study area and specifically the Greater Brandvlei Dam area.

**The vegetation ecology of the Witteberg and Dwyka Groups south of
Worcester, Western Cape Province, South Africa.**

Volume 2

by

ANSO LE ROUX

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for the degree of

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CO-SUPERVISOR: PROF P.J. DU PREEZ

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A Dwyka tillite hill (in the upper right part of the picture) overlies the Witteberg Group (in the upper left part of the picture) on Gannaberg in the study area. This small area is exposed to a similar climate, but distinct differences in vegetation supported by the different geological formations are evident.

Student number: 8773548

I, Anso le Roux, declare that The Vegetation Ecology of the Witteberg and Dwyka Groups South of Worcester, Western Cape Province, South Africa (Volume 2) is my own work. Apart from where mentioned otherwise, all photographs were taken by me. The copyright for the photographs in this thesis remains with the owners.

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Date: 19 January 2018

VOLUME II

CHAPTER 5: SPECIES NEW TO SCIENCE AND TAXONOMIC PROBLEMATIC TAXA.....	306
5.1 SECTION A: SPECIES NEW TO SCIENCE	315
5.1.1 ASPHODELACEAE.....	316
5.1.1.1 <i>Bulbine</i> sp. nov.	316
5.1.1.2 <i>Trachyandra</i> sp. nov.	317
5.1.2 HYACINTHACEAE.....	317
5.1.2.1 <i>Ledebouria</i> sp. nov.	317
5.1.3 IRIDACEAE.....	319
5.1.3.1 <i>Moraea helicoidea</i> Goldblatt & J.C.Manning, sp. nov.	319
5.1.3.2 <i>Moraea vuvuzela</i> Goldblatt & J.C.Manning sp. nov.	320
5.1.3.3 <i>Watsonia</i> sp. nov. sp.1	324
5.1.3.4 <i>Watsonia</i> sp. nov. sp.2	325
5.1.4 APIACEAE	326
5.1.4.1 <i>Annesorhiza laticostata</i> Magee.....	326
5.1.5 ASTERACEAE	327
5.1.5.1 <i>Athanasia</i> aff <i>filiformis</i> sp. nov.	327
5.1.5.2 <i>Dimorphotheca</i> sp. nov.....	328
5.1.5.3 <i>Ursinia</i> sp. nov.	329
5.1.6 CHENOPODIACEAE	330
5.1.6.1 <i>Chenolea convallis</i> Snijman & J.C.Manning, sp. nov.....	330
5.1.7 CRASSULACEAE	332
5.1.7.1 <i>Crassula</i> sp. nov. 1	332
5.1.7.2 <i>Crassula</i> sp. nov. 2.....	333
5.1.8 FABACEAE	334

5.1.8.1 <i>Amphithalea ornata</i> Boatwr. & J.C.Manning sp. nov.....	334
5.1.8.2 <i>Aspalathus</i> sp. nov. 1	335
5.1.8.3 <i>Aspalathus</i> sp. nov. 2	336
5.1.8.4 <i>Indigofera</i> sp. nov. cf. <i>angustifolia</i>	337
5.1.9 GERANIACEAE	338
5.1.9.1 <i>Pelargonium flabelliforme</i> E.M.Marais, sp. nov.....	338
5.1.9.2 <i>Pelargonium conradiae</i> J.C. Manning & A.le Roux, sp. nov.	339
5.1.9.3 <i>Pelargonium</i> sp. nov. 1	340
5.1.9.4 <i>Pelargonium</i> sp. nov. 2	341
5.1.10 MOLLUGINACEAE	342
5.1.10.1 <i>Psammotropha</i> sp. nov.....	342
5.1.11 OXALIDACEAE	344
5.1.11.1 <i>Oxalis</i> sp. nov	344
5.1.12 RUTACEAE.....	345
5.1.12.1 <i>Agathosma</i> sp. nov 1	345
5.1.12.2 <i>Agathosma</i> sp. nov. 2	346
5.2 SECTION B: INDETERMINATE TAXA	347
5.2.1 <i>Drosanthemum</i> sp. cf. nov. (Aizoaceae)	347
5.2.2 <i>Othonna</i> sp. cf. nov. (Asteraceae).....	348
5.2.3 A representative of the Asteraceae family.....	349
5.2.4 <i>Coleonema</i> sp. nov. cf. <i>album</i> (Rutaceae)	350
5.3 SECTION C: TAXONOMIC PROBLEMATIC TAXA	351
5.3.1 <i>Drosanthemum</i> subgenus <i>Speciosa</i>	351
5.3.2 <i>Mesembryanthemum caudatum</i> L.Bolus (<i>Phyllobolus caudatus</i> (L.Bolus) Gerbaulet)	360
5.3.3 <i>Adromischus</i> species	365
5.3.4 A smaller cliff dwelling <i>Crassula</i> species and <i>C. rupestris</i>	366

5.3.5 A possible <i>Crassula saxifraga</i> species complex.....	366
5.3.6 <i>Wiborgia cf. sericea</i>	367
5.3.7 <i>Oxalis species</i>	368
5.4 CONCLUSION.....	373
CHAPTER 6: FLORISTIC ANALYSIS OF THE VEGETATION SUPPORTED BY THE WITTEBERG- AND DWYKA GEOLOGICAL GROUPS SOUTH OF WORCESTER IN THE WESTERN CAPE.....	374
6.1 INTRODUCTION.....	377
6.2 RESULTS AND DISCUSSION.....	377
6.2.1 Floristic composition.....	377
6.2.2 Endemism.....	386
6.2.3 Physiognomy.....	390
6.2.4 Medicinal, poisonous and plants utilised for their specific attributes.....	399
6.2.5 Rare and endangered plant species.....	400
6.2.6 Species richness and plant community diversity.....	401
6.3 CONCLUSION.....	406
CHAPTER 7: THE EFFECT OF FIRE IN BREEDE SHALE RENOSTERVELD AND BREEDE QUARTZITE FYNBOS.....	409
INTRODUCTION.....	415
7.1 PRE-FIRE DATA COMPARED WITH POST-FIRE DATA.....	418
7.1.1 Vegetation classification: Synoptic table.....	418
7.1.1.1 The <i>Lichtensteinia interrupta</i> – <i>Elytropappus rhinocerotis</i> community.....	421
7.1.1.2 The <i>Drosanthemum hallii</i> – <i>Passerina truncata</i> community.....	428
7.1.1.3 The <i>Protea laurifolia</i> – <i>Passerina truncata</i> community.....	433
7.2 LIFE FORMS.....	438

7.3 SPECIES CONSTANCY AND DOMINANCE BEFORE- AND AFTER FIRE.....	440
7.4 CONCLUDING REMARKS.....	443
CHAPTER 8: CONCLUSIONS.....	461
ACKNOWLEDGEMENTS.....	467
REFERENCES.....	469

ANNEXURES

ANNEXURE 1: Phytosociological table

ANNEXURE 2: Synoptic table

ANNEXURE 3: Post fire Phytosociological table

ANNEXURE 4: Species list

ANNEXURE 5: Red data species

ANNEXURE 6: Le Roux, A., Van Jaarsveld, E. & Buys, M. 2010. Mopkop Vygies - the thin end of the wedge. *Veld & Flora* 96:32 – 33.

ANNEXURE 7: Le Roux, A. 2011. Brandvlei burns: a controlled burn in Breede Shale Renosterveld gives new life to plants, including the hitherto unknown *Moraea vuvuzela*. *Veld & Flora* 97:16 – 18.

ANNEXURE 8: Hartmann, H.E.K. and Le Roux, A. 2011. *Drosanthemum* subgenus *Speciosa* (Aizoaceae): towards a revision of the plants with black staminodes. *Bradleya* 29:143 – 178.

ANNEXURE 9: Le Roux, A. 2012. Drawing a line in the sand. *Veld & Flora* 98:34 – 37.

ANNEXURE 10: Goldblatt, P., Manning J. C., le Roux, A. 2015. New taxa in *Moraea* subgenera *Moraea* and *Vieusseuxia* (Iridaceae: Irideae) from Western Cape, South Africa *South African Journal of Botany* 99:69–74.

ANNEXURE 11: Manning, J.C. & Le Roux, A. 2016. *Pelargonium conradiae* (Geraniaceae), a new species in section *Ligularia* From Worcester, Western Cape, South Africa. *South African Journal of Botany* 105: 313–316.

- ANNEXURE 12: Boatwright, J.S., A. le Roux, A., Manning, J.C. 2016.
Amphithalea ornata (Podalyrieae, Fabaceae), a rare new species from the Western Cape Province, South Africa. *South African Journal of Botany* 102: 217–220.
- ANNEXURE 13: Le Roux, A., Viljoen J.H.A. and Brown, L.R. The Breede Alluvium Renosterveld in the region of the Greater Brandvlei Dam, Southern Western Cape, South Africa (article in preparation).

CHAPTER 6

FLORISTIC ANALYSIS OF THE VEGETATION SUPPORTED BY THE WITTEBERG- AND DWYKA GEOLOGICAL GROUPS SOUTH OF WORCESTER IN THE WESTERN CAPE

“The farther researches we make into things,
the more beauty and harmony we see in them”.

From: Vegetable staticks Stephen Hales, 1727



Leucospermum calligerum – picture, H. de Wet

TABLE OF CONTENTS

6.1 INTRODUCTION	377
6.2 RESULTS AND DISCUSSION	377
6.2.1 Floristic composition	377
6.2.2 Endemism	386
6.2.3 Physiognomy	390
6.2.4 Medicinal, poisonous and plants utilised for their specific attributes.....	399
6.2.5 Rare and endangered plant species.....	400
6.2.6 Species richness and plant community diversity	401
6.3 CONCLUSION	406

LIST OF TABLES

Table 6.1: A summary of the species and genera and degree of endemism of the largest families in the study area with regard to figures provided for the Cape Core Flora (CCR) as provided by Manning & Goldblatt (2012).	386
Table 6.2: Indigenous families and life-form of the representative species.....	390
Table 6.3: Variation in the cryptophytes life-form.....	395
Table 6.4: Variation in the phanerophytes life-form 4.	396
Table 6.5: Variation in the chamaephytes life-form.....	396
Table 6.6: Variation in the hemicryptophyte life-form.....	397
Table 6.7: Variation in the phanerophytes life-form.	398
Table 6.8: Variation of life-forms of succulent plants in the study area.	399
Table 6.9: Variation amongst plants (part of the plant / whole plant) with medicinal, poisonous, aromatic or other attributes that make them useful for people and animals.....	400
Table 6.10: Species richness, frequency distributions, deviation and standardized residuals for the plant communities 1-15.....	403

Table 6.11: Residuals and coefficients for the multiple regression analysis for environmental data.....	405
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LIST OF FIGURES

Figure 6.1: Percentages of the total number of species as represented in the respective families.	380
Figure 6.2: The largest family present in this vegetation, the Asteraceae, is represented by 176 species in 56 genera.	381
Figure 6.3: The Iridaceae is the second largest family and comprises 9% of the flora.	382
Figure 6.4: The Aizoaceae is the third largest family comprising 7% of the flora of the study area.	383
Figure 6.5 The genus <i>Aspalathus</i> comprises of just more than half of the Fabaceae in the study area.	384
Figure 6.6: The genera <i>Drimia</i> , <i>Lachenalia</i> and <i>Albuca</i> make up the larger part of the Hyacinthaceae in the study area.....	384
Figure 6.7: <i>Selago</i> dominates the genera of the Scrophulariaceae family.	385
Figure 6.8: The largest part of the Crassulaceae consists of the genus <i>Crassula</i> ...385	
Figure 6.9: Most of the species in the study area are endemic to the CCR.	388
Figure 6.10: The life-form spectrum of the vegetation of the study area according to the categories of the Raunkaier classification system.....	394
Figure 6.11: The number of rare and endangered species occurring in the study area	400
Figure 6.12: Species richness as well as Menhinick's and Margalef's indices for the plant communities.	402
Figure 6.13: Shannon-Wiener Index and Gini Simpsons index effective number of species values for the different plant communities.....	402
Figure 6.14: Panel display of the data showing the response variable (Shannon Entropy) on the y axis of the bottom row.....	404

6.1 INTRODUCTION

Although the Fynbos Biome had intensively been studied since 1977, Rebelo *et al.* (2006) states that “an understanding of the biogeography of the Fynbos Biome requires detailed inventories of species for the different vegetation types.” According to Manning & Goldblatt (2012), accurate information such as how many species there are, what they look like and where they occur, is essential to the successful outcome of conservation efforts. Myers (1990) mentioned that one third of the original Fynbos has already been lost to agriculture, urban expansion, roads, dams as well as the invasion of exotic plant species. Due to these human impacts, much of the remaining parts are fragmented into a patchwork of relics among farmlands and urban areas. Brought by the need to identify areas of botanical importance for conservation purposes, studies of vegetation at a local level are required (Myers 1990). Furthermore, procedures implemented in the selection of areas for nature reserves, as well as the successful management of such conservation areas, require data regarding endemic as well as threatened plants (Kruckeberg & Rabinowitz 1985; Rebelo 1994; Terborgh 1974; Trinder-Smith *et al.* 1996).

The Worcester area has rich habitat diversity and an exceptionally high species richness. For these reasons this region has been recognised as a Centre of Endemism (Van Wyk & Smith 2001; Rebelo *et al.* 2006).

This chapter aims to describe the floristic composition and species richness and includes an account of the different indigenous plant taxa of the study area. Taxonomic information follows Manning & Goldblatt (2012), Trinder-Smith (2003) as well as the work of taxonomic specialists. Apart for Manning & Goldblatt (2012), endemism and conservation status were furthermore checked on SANBI's Redlist website (<http://redlist.sanbi.org>).

6.2 RESULTS AND DISCUSSION

6.2.1 Floristic composition

The indigenous vegetation identified in this study area during this study includes 1042 species that can be grouped in 324 genera and 79 families. The Pteridophytes (ferns) comprise three families, while the angiosperms (flowering plants) consist of the palaeodicotyledons, which includes two families, the monocotyledons, which includes 18 families, and the eudicotyledons, which includes 56 families (Annexure 4).

The largest family represented in this study is the Asteraceae with 179 indigenous species (17% of all the species) followed by the Iridaceae with 97 species (9% of all the species), the Aizoaceae with 79 representatives (8 % of all the species), the Fabaceae with 58 species (6% of all the species), the Hyacinthaceae with 48 species (5% of all the species), the Scrophulariaceae with 40 species (4% of all the species) as well as the Crassulaceae with 36 species (3% of all the species) (Figure 6.1).

The Asteraceae (Daisy family) is represented by 179 species of herbs and shrubs in 55 genera. Of the Asteraceae, representatives of the annual / perennial genus *Senecio* (Groundsel / Ragwort / Hongerblom) makes up 9 % of the family (17 species). The annual / herbaceous / slightly woody genus, *Helichrysum* (Strooibloom / Kooigoed), comprises 9 % of the family (16 species) followed by the shrub genus *Pteronia* (Gombos) which makes up 6% of the family (11 species) and the shrub / herb genus *Othonna* (Bobbejaankool) which also comprises 6 % (ten species) of the family, followed by the annual / small herb / shrub genera *Ursinia* (Bergmagriet), *Osteospermum* (Bietou) and *Metalsia* (Blombos) each comprising 4% of the family (Figure 6.2).

The second largest family present in the study area is the Iris family (Iridaceae) which is represented by 97 species in 20 genera. The Iridaceae includes rhizomatous perennials as well as plants with corms. The geophytic genus *Moraea* (Uintjie) is the fifth largest genus in the study area, comprises 22 species, and has the highest in number of species in this family followed by the geophytic genera *Gladiolus* (Afrikaner / Pypie) (12 species), *Geissorhiza* (Satin flower / Sysie) (ten species), *Romulea* (Knikkertjie / Frutang) and *Ixia* (Kalossie) both with nine species (Figure 6.3).

The third largest family present in this vegetation is the vygies, the Aizoaceae, which are predominantly succulent annual or perennial herbs, shrublets or shrubs and is

here represented by 79 species in 28 genera. Of the Aizoaceae, representatives of the genus *Drosanthemum* (Douvygie) (16 species) is the highest in number followed by the genera *Lampranthus* (Vygie) and *Tetragonia* (Kinkelbos / Klapperbrak, both with seven species and *Ruschia* (Vygie) (six species) (Figure 6.4).

The fourth largest family present in this vegetation is the legume family, the Fabaceae, which consists of a small tree, shrubs, shrublets or herbs represented by 58 species in 15 genera. Just more than half of the Fabaceae in the study area (30 species) comprises of the sometimes-spiny shrub / shrublet genus *Aspalathus* (Cape Gorse) which is the second largest genus in the study area. Well represented genera in the other portion of this family include the herb / shrub genus *Indigofera* (Indigo) (five species), the herb or small shrub genus *Lotononis* as well as the occasionally spiny shrub genus *Wiborgia* (Penny Pod) with four species each (Figure 6.5).

The fifth largest family present in this vegetation is the geophytic bulb Hyacinthaceae family, which is represented by 48 species in seven genera. The highest number of species is present in the genera *Drimia* (Poison Squill) (15 species), *Lachenalia* (Violtjie) and *Albuca* (Slymliele) with 12 species each, followed by *Ornithogalum* (Chincherinchee / Tjienk) (six species) (Figure 6.6).

The snapdragon family, Scrophulariaceae (annuals, herbs, shrubs or occasionally small trees), is the sixth largest family present in the vegetation of the study area. This family is represented by 40 species in 18 genera. Here the highest number of species is found in the genus *Selago* (Bitter bush / Aarbossie) (nine species) followed by *Nemesia* (Kaapse Leeubekkie) and *Chaenostoma* (Skunk Bush / Stinkbossie) with 4 species each. *Phyllopodium* (Capewort / Opslag) and *Polycarena* (Cape-phlox) follow with three species in each genus (Figure 6.7).

The seventh largest family present in this vegetation is the mostly perennial, sometimes annual or geophytic, herbaceous or shrubby succulent *Crassula* family. The Crassulaceae is represented by 36 species in four genera. The largest number of species here belongs to the genus *Crassula* (Stonecrop), which is the third largest genus in the study area comprising 30 species (Figure 6.8).

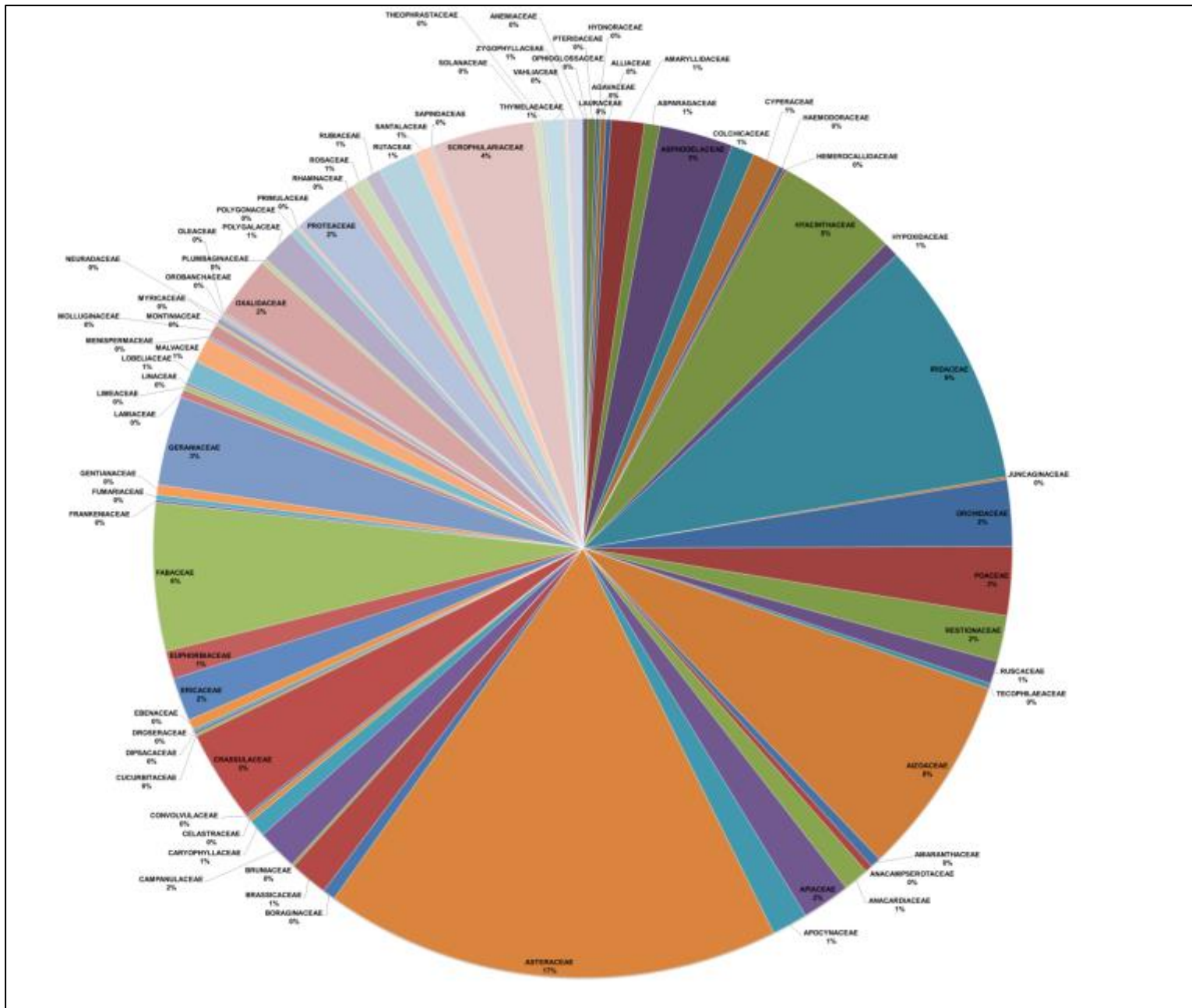


Figure 6.1: Percentages of the total number of species as represented in the respective families.

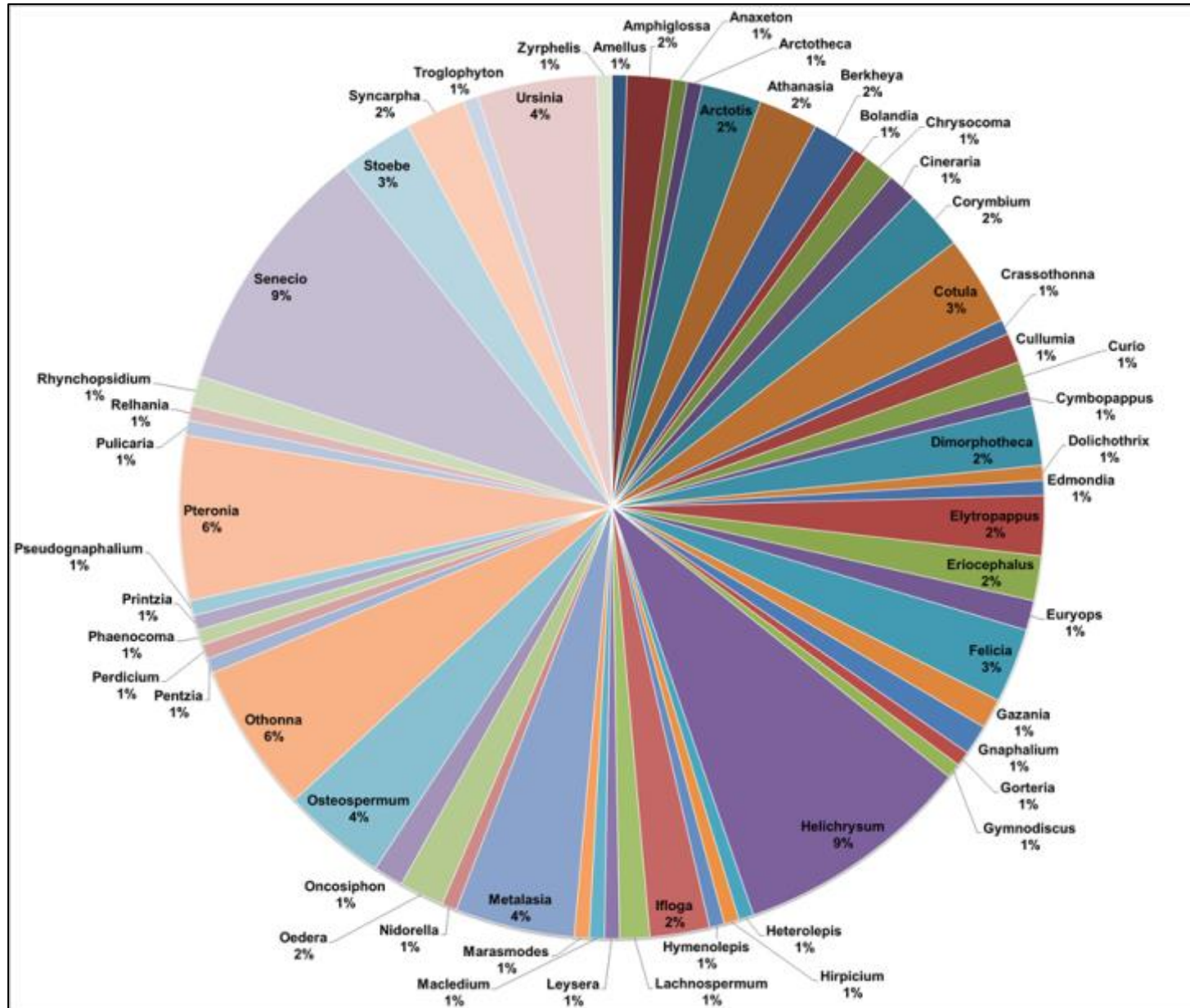


Figure 6.2: The largest family present in this vegetation, the Asteraceae, is represented by 176 species in 56 genera.

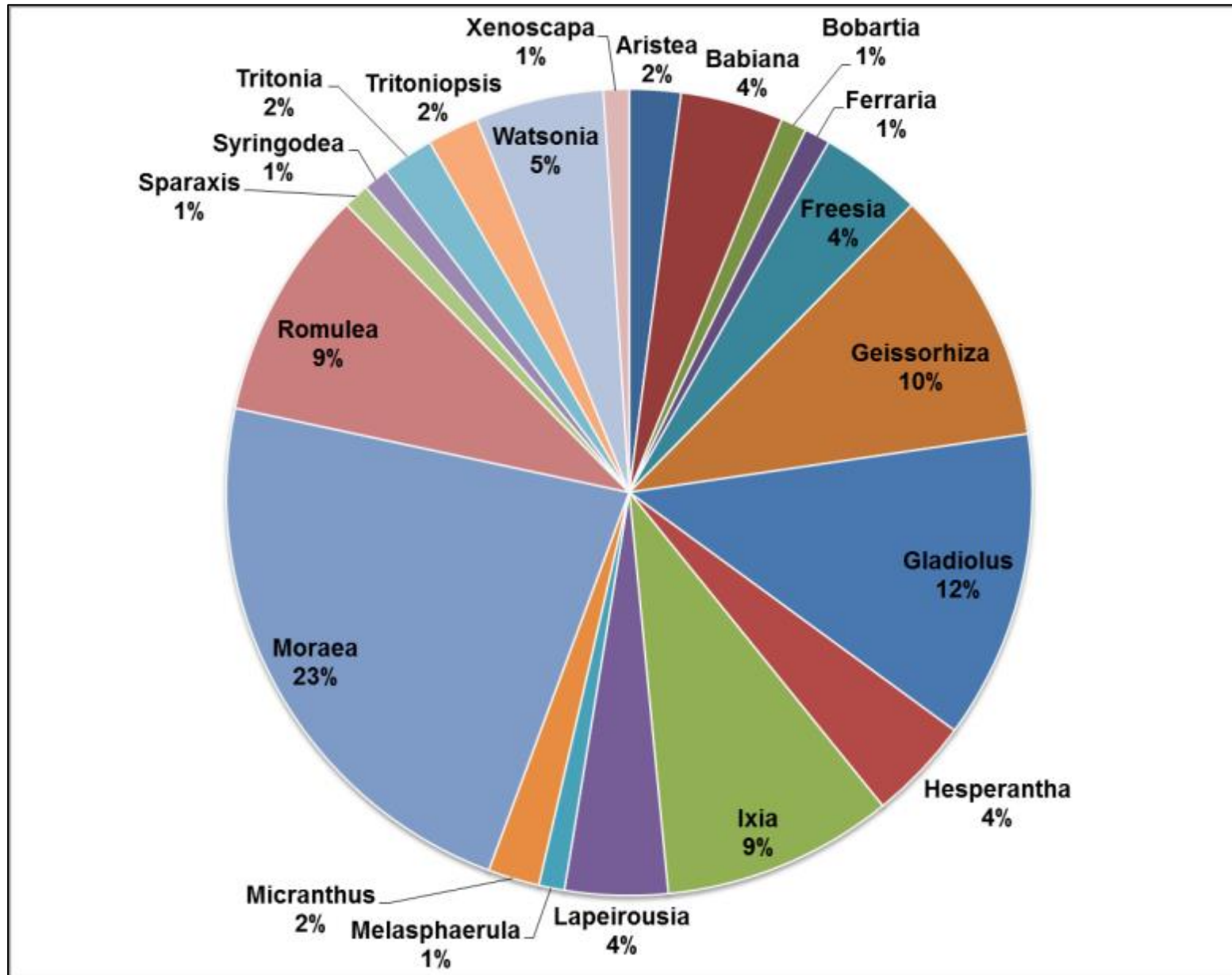


Figure 6.3: The Iridaceae is the second largest family and comprises 9% of the flora.

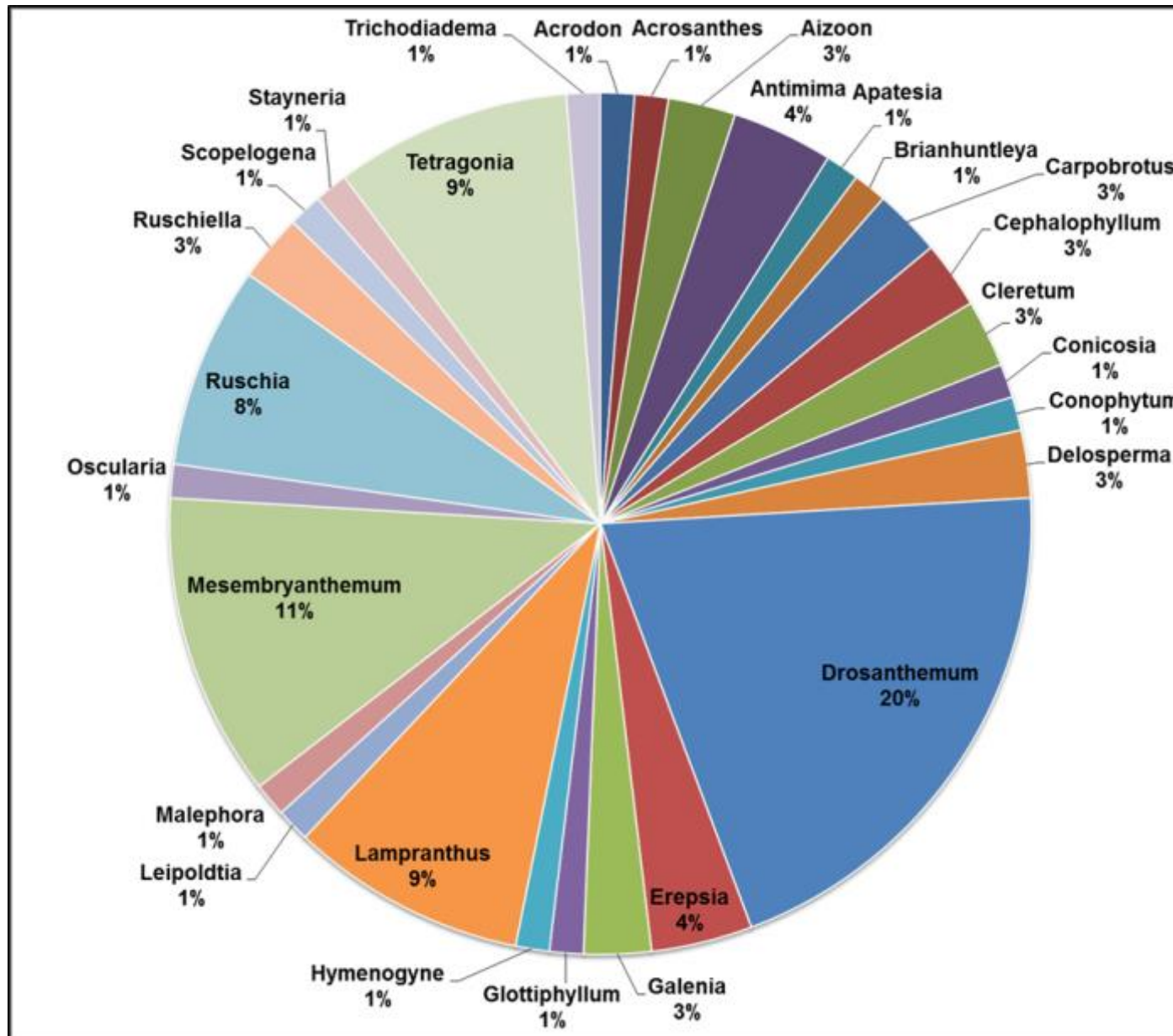


Figure 6.4: The Aizoaceae is the third largest family comprising 7% of the flora of the study area.

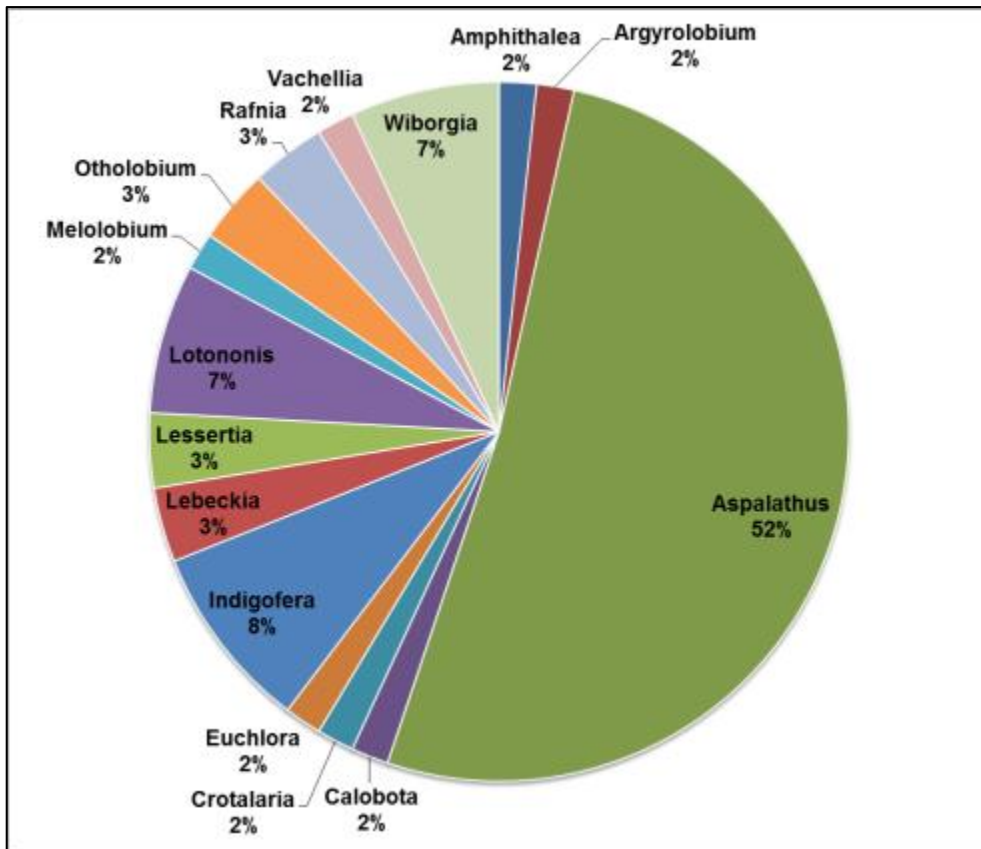


Figure 6.5 The genus *Aspalathus* comprises of just more than half of the Fabaceae in the study area.

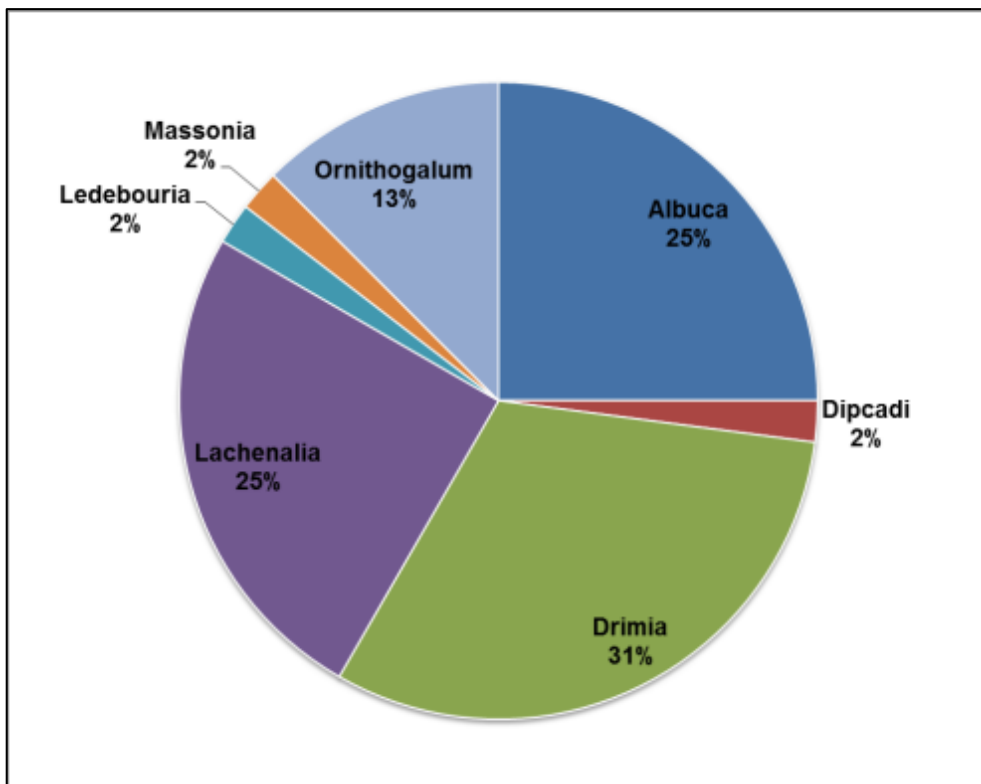


Figure 6.6: The genera *Drimia*, *Lachenalia* and *Albuca* make up the larger part of the Hyacinthaceae in the study area.

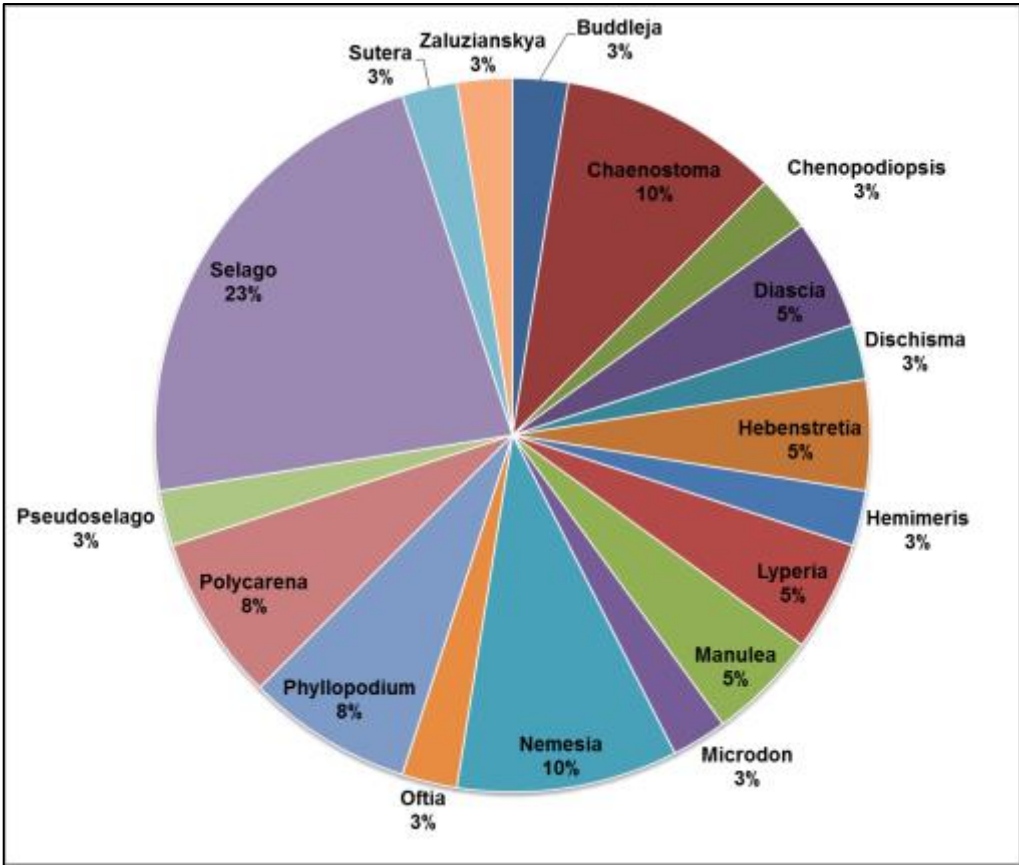


Figure 6.7: *Selago* dominates the genera of the Scrophulariaceae family.

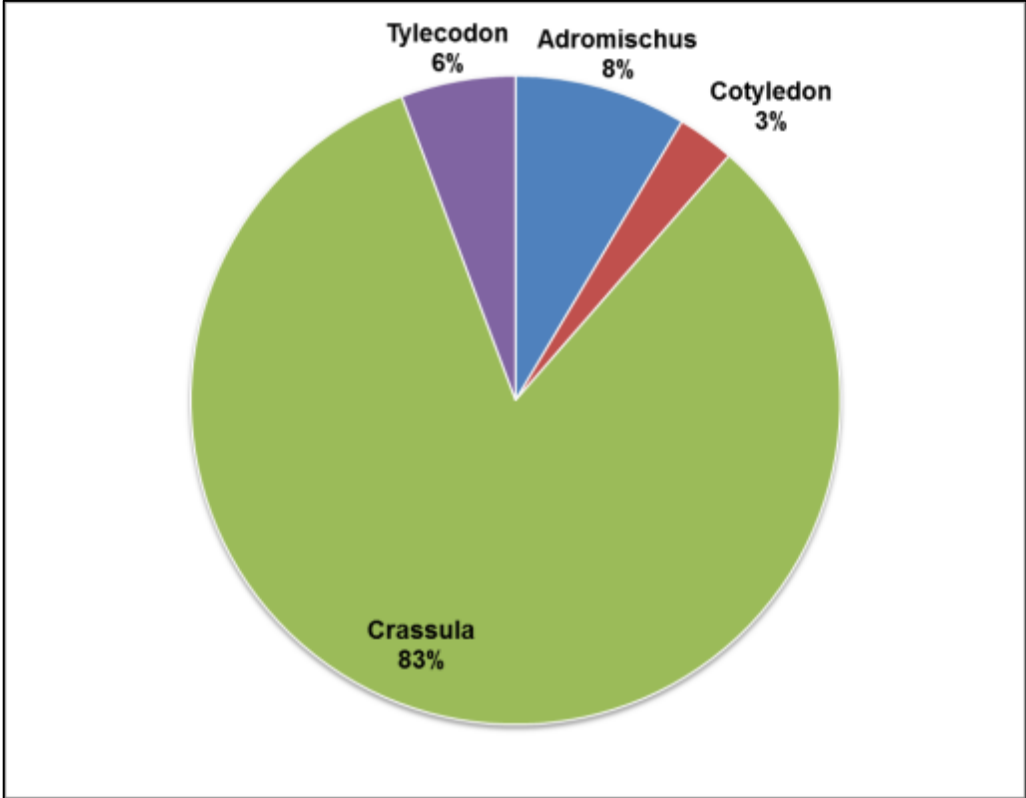


Figure 6.8: The largest part of the Crassulaceae consists of the genus *Crassula*.

The Geraniaceae and Oxalidaceae families are well represented in the study area. The Geranium and Storkbill family (Geraniaceae) is represented in the study area by the annual / herbaceous / succulent / shrubby / geophytic genus *Pelargonium* (Stork's Bill / Malva) which is the largest genus in the study area. The genus *Pelargonium* includes 3 % of the flora of the study area comprising 35 species of which 50% are geophytes. The Sorrel / Suring family (Oxalidaceae) includes 24 species of the geophytic herb genus *Oxalis* which is the fourth largest genus in the study area (Figure 6.1; Annexure 4).

6.2.2 Endemism

The Worcester area has an exceptionally high species richness as well as habitat diversity and for these reasons this region has been recognised as a Centre of Endemism (Van Wyk & Smith 2001, Rebelo *et al.* 2006). Van Wyk & Smith (2001) note the following families to be particularly rich in regional endemic species: Aizoaceae, Asphodelaceae, Fabaceae, Iridaceae, Apocynaceae and Crassulaceae.

A summary of the degree of endemism of the largest families in the study area with regard to figures provided for the Cape Core Flora is given in Table 6.1.

Table 6.1: A summary of the species and genera and degree of endemism of the largest families in the study area with regard to figures provided for the Cape Core Flora (CCR) as provided by Manning & Goldblatt (2012).

FAMILIES	SPECIES						GENERA					
	SPECIES PRESENT			SPECIES ENDEMIC TO CCR			GENERA PRESENT			GENERA ENDEMIC TO CCR		
	STUDY	CCR	% of CCR in study	STUDY	CCR	% of CCR in study	STUDY	CCR	% of CCR in study	STUDY	CCR	% of CCR in study
ASTERACEAE (largest family in CCR)	179	1077	16.6	81	669	12.1	55	125	44.0	4	32	12.5
IRIDACEAE (3 rd largest family in CCR)	97	758	12.8	64	594	10.8	20	29	69.0	0	6	0.0
AIZOACEAE (5 th largest family in CCR)	79	624	12.7	49	454	10.8	28	76	36.8	7	19	36.8
FABACEAE (2 nd largest family in CCR)	58	764	7.6	41	634	6.5	15	43	34.9	0	43	0.0
HYACINTHACEAE (13 th largest family in CCR)	48	200	24.0	14	93	15.1	7	12	58.3	0	1	0.0
SCROPHULARIACEAE (6 th largest family in CCR)	40	419	9.5	23	294	7.8	18	32	56.3	2	5	40.0
CRASSULACEAE (20 th largest family in CCR)	36	130	27.7	8	39	20.5	4	5	80.0	0	0	0.0

The largest family in the CCR, the Asteraceae (Manning & Goldblatt 2012), is also the largest in the study area. While 44.0% of the Asteraceae genera present in the CCR is found in the study area, only 16.6% of species present in the CCR occur in the study area. Regarding the Asteraceae endemics, 12.5% of CCR endemic genera and 12.1% of CCR endemic species are found in the study area (Table 6.1).

Although 65.5% of the CCR Iridaceae genera occur in the study area, none of these genera are endemic to the CCR (Table 6.1).

The Aizoaceae genera in the study area make a fairly large percentage of genera endemic to the CCR, but only 10.8% of species endemic to the CCR are found in the study area (Table 6.1).

While 34.9% of the CCR Fabaceae genera grow in the study area, none of these genera are endemic to the CCR (Table 6.1).

The CCR Hyacinthaceae genera, however none endemic, are fairly well represented in the study area (58.3%). While the study area holds 24% of the species present in the CCR, 15.1% are CCR endemics (Table 6.1).

While 7.8% species of the endemic CCR Scrophulariaceae family (the sixth largest family in the CCR as well as in the study area) are represented in the study area, 40% of the genera represented in the study area are endemic to the CCR (Table 6.1).

Although none of the Crassulaceae genera found in the study area are endemic to the CCR, the study area holds 20.5% of the CCR endemics of this family (Table).

The larger part (48%) of the indigenous species in the study area (502 species), is endemic to the Core Cape Subregion (CCR) (Figure 6.9) which is limited to the south-western tip of Africa between latitudes 31° and 34°30' South, encompasses 89% of the Fynbos Biome, including the fynbos heathlands of the Cape Fold Belt with the lower course of the Olifants River as a natural boundary in the northwest (Manning & Goldblatt 2012). Regarding the remaining part, 228 species (22%) are endemic to the Greater Cape Floristic

Region (GCE) which “covers the predominantly winter rainfall area in the west of southern Africa as well as a non-seasonal rainfall area in the extreme south and southeast” (Snijman 2013), 181 species (13%) are endemic to South Africa (17%) and 130 species are not endemic to South Africa (Figure 6.9). As far as current knowledge exists, of the 502 species endemic to the Core Cape Subregion, 26 species are limited to the study area only (Annexure 4).

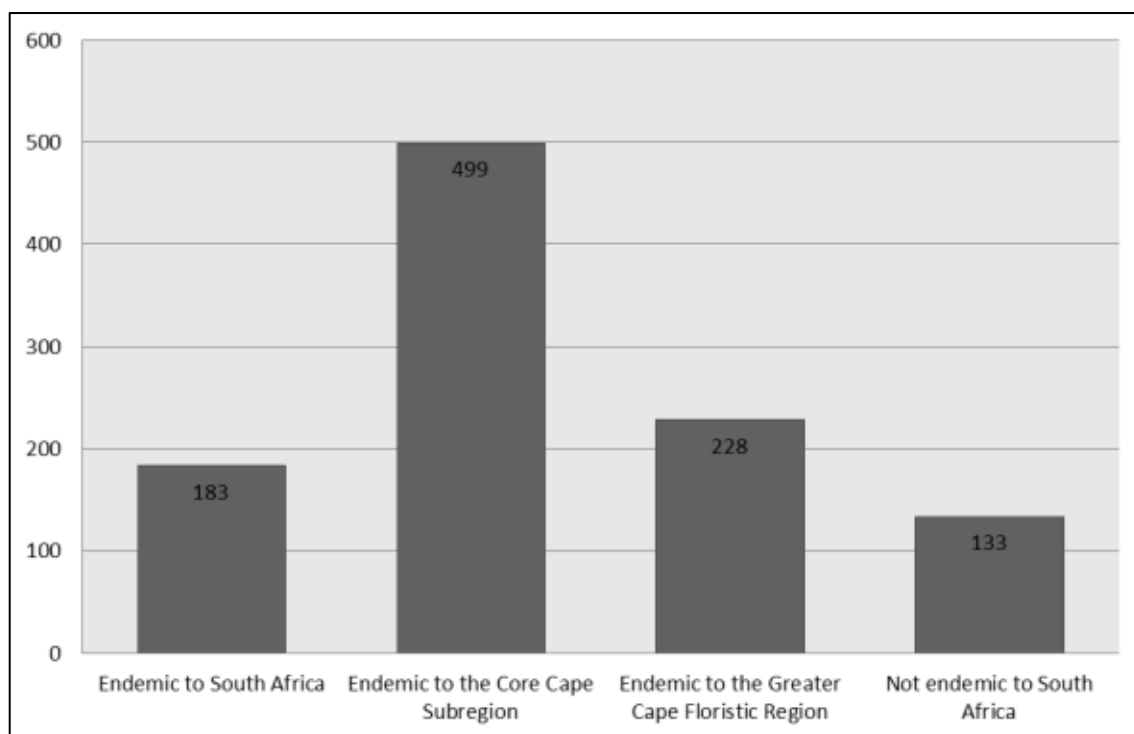


Figure 6.9: Most of the species in the study area are endemic to the CCR.

The following families are noted for a high number of representatives occurring in the study area that are endemic to the Core Cape Subregion:

- Asphodelaceae: All the *Haworthia* species except for *H. arachnoidea*
- Hyacinthaceae: Half of the *Lachenalia* species.
- Iridaceae: 66% of representatives.
- Orchidaceae: 69% of representatives, including all the *Pterygodium* species in the study area.
- Restionaceae: 44.4% of representatives, including the *Cannomois* genus which is endemic to the Core Cape Subregion.
- Rusceae: 66.7% of the *Eriospermum* species in the study area.

- Aizoaceae: 62.0% of representatives, including the *Acrodon*, *Acrosanthes*, *Apatesia*, *Brianhuntleya*, *Erepsia*, *Oscularia* and *Stayneria* genera which are endemic to the Core Cape Subregion.
- Anacardiaceae: 40% of the representatives are endemic to the Core Cape Subregion, the genus *Heeria* only occurs in the Core Cape Subregion.
- Apiaceae: 68.4% of representatives, including the *Itasina* genus which is endemic to the Core Cape Subregion.
- Asteraceae: 45.5% of representatives, including the *Anaxeton*, *Dolichostrix*, *Edmondia* and *Marasmodes* genera which are endemic to the Core Cape Subregion.
- Boraginaceae: 60% of representatives, including the *Echiostachys* genus which is endemic to the Core Cape Subregion.
- Brassicaceae: 46.7 % of representatives.
- Bruniaceae: The *Staavia* genus is endemic to the Core Cape Subregion.
- Campanulaceae: 62.5% of representatives, including the *Microcodon* genus which is endemic to the Core Cape Subregion.
- Ericaceae: 88.2 % of representatives.
- Fabaceae: 70.7% of representatives.
- Gentiaceae: 50.0% of representatives.
- Geraniaceae: 57.1% of representatives.
- Lobeliaceae: 66.7% of representatives.
- Malvaceae: 60% of representatives.
- Polygalaceae: 57.1% of representatives.
- Proteaceae: 71.4 % of representatives, including the *Paranomus* and *Serruria* genera which are endemic to the Core Cape Subregion.
- Rhamnaceae: 80% of representatives.
- Rosaceae: 83.3% of representatives.
- Rutaceae: 66.7% of representatives, including the *Macrostylis* genus which is endemic to the Core Cape Subregion.
- Scrophulariaceae: 57.5% of representatives, including the *Chenopodiopsis* and *Pseudoselago* genera which are endemic to the Core Cape Subregion.

- Thymelaeaceae: 50% of representatives, including the *Lachnaea* genus which is endemic to the Core Cape Subregion.

6.2.3 Physiognomy

In addition to Westman (1983), who states that available moisture is the primary, and nutrients the secondary determinant of physiognomy and plant form in mediterranean-climate regions, Campbell & Werger (1988) conclude that “soil nutrient levels are of primary importance in determining the distribution patterns of plant-form features in the Cape.” The indigenous families with the number of species in each family and the life-form of their representative species are given in Table 6.2.

Table 6.2: Indigenous families and life-form of the representative species

Family	Species	Life-forms of the species in each family: Percentages of the respective life-forms given for each family, counts given where specific life-forms are low in number.
ANEMIACEAE	1	Perennial (rhizomatous)
OPHIOGLOSSACEAE	1	Perennial (rhizomatous)
PTERIDACEAE	3	Perennials (rhizomatous)
HYDNORACEAE	1	Parasite (root)
LAURACEAE	1	Parasite (vine)
AGAVACEAE	2	Geophytes (rhizomatous)
ALLIACEAE	2	Geophytes (bulbous)
AMARYLLIDACEAE	13	Geophytes (bulbous)
ASPARAGACEAE	6	50.0% shrublets 50.0% shrubs Some scrambling, some with spines
ASPHODELACEAE	29	27.6% Perennials (rhizomatous) 41.4% Geophytes (succulent) 24.14% Shrublets (succulent) 6.9% Perennials (succulent)
COLCHICACEAE	9	Geophytes (cormous)
CYPERACEAE	11	Perennials
HAEMODORACEAE	2	Geophytes (rhizomatous)
HEMEROCALLIDACEAE	1	Geophytes (rhizomatous)
HYACINTHACEAE	48	Geophytes (bulbous)
HYPOXIDACEAE	6	Geophytes (cormous)
IRIDACEAE	97	96.9% Geophytes (cormous) 3.1% Perennial (rhizomatous)

JUNCAGINACEAE	1	Geophyte (bulbous)
ORCHIDACEAE	26	Geophytes (tuberous)
POACEAE	27	77.8% Perennials 22.2% Annuals
RESTIONACEAE	18	Perennials (dioecious)
RUSCACEAE	9	Geophytes (tuberous)
TECOPHILAEACEAE	2	Geophytes (cormous)
AIZOACEAE	79	8.9% Annuals (succulent) 2.5% Geophytes (succulent) 19.0% Shrubs (succulent) 43.0% Shrublets (succulent) 20.3% Perennials (succulent) 3.8% Shrublets 1.3% Shrub 1.3% Perennials
AMARANTHACEAE	4	One annual One shrublet (succulent) Two shrubs
ANACAMPSEROTACEAE	3	Succulents
ANACARDIACEAE	10	80.0% Shrubs (dioecious) 20.0% Small trees (one monoecious, one dioecious)
APIACEAE	19	10.5% Annuals 78.9% Perennials 10.5% Shrubs
APOCYNACEAE	14	28.6% Climbers One geophyte (climber) One perennial 14.3% Scramblers 21.4% Shrubs 21.4% Succulents
ASTERACEAE	179	20.2% Annuals 19.1% Perennials (some succulent, some tuberous, some trailing) 32.0% Shrubs (some prickly, some spiny) 28.7% Shrublets (some succulent)
BORAGINACEAE	5	73.3% Annuals 13.3% Perennials One shrub One shrublet
BRASSICACEAE	15	73.3% Annuals 13.3% Perennials Two shrublets
BRUNIACEAE	1	Shrub
CAMPANULACEAE	16	37.5% Annuals One Shrub 56.3% Shrublets
CARYOPHYLLACEAE	7	One annual 71.4% Perennials One shrublet

CELASTRACEAE	2	Shrubs, one spiny
CONVOLVULACEAE	1	Perennial climber
CRASSULACEAE	36	14.3% Annuals 40.0% Perennials 5.7% Shrubs 28.6% Shrublets 11.4% Geophytes
CUCURBITACEAE	1	Perennial (tuberous climber)
DIPSACACEAE	1	Perennial
DROSERACEAE	1	Perennial insectivorous plant
EBENACEAE	4	Shrubs, one small tree
ERICACEAE	17	17.6% Shrubs 82.4% Shrublets
EUPHORBIACEAE	11	18.2% Perennials 63.6% Shrubs 18.2% Succulents
FABACEAE	58	One annual 3.4% Perennials 50.0% Shrubs 41.4% Shrublets Two trees
FRANKENIACEAE	1	Annual
FUMARIACEAE	2	Annuals (trailing)
GENTIANACEAE	4	Two annuals Two shrublets
GERANIACEAE	35	Two annuals Two perennials Two shrubs 34.3% Shrublets 48.6% Geophytes (tuberous, one rhizomatous)
LAMIACEAE	3	Two shrubs One shrublet
LIMEACEAE	2	One shrublet One perennial
LINACEAE	1	Shrublet
LOBELIACEAE	9	77.8% Geophytes (tuberous) Two perennials, one creeping
MALVACEAE	10	60.0% Shrubs 40.0% Shrublets
MENISPERMACEAE	1	Shrublet (climber)
MOLLUGINACEAE	5	One annual 80% Shrublets
MONTINIACEAE	1	Shrub
MYRICACEAE	2	Two shrubs
NEURADACEAE	1	Annual
OLEACEAE	1	Tree
OROBANCHACEAE	1	Parasite (root)

OXALIDACEAE	24	Geophytes (cormous)
PLUMBAGINACEAE	2	One shrublet One perennial (rhizomatous)
POLYGALACEAE	14	50.0% Shrubs (some spiny) 50.0% Shrublets
POLYGONACEAE	3	Perennials (two tuberous)
PRIMULACEAE	1	Annual
PROTEACEAE	21	85.7% Shrubs (six dioecious) Three small trees (one dioecious)
RHAMNACEAE	5	Four shrubs One shrublet
ROSACEAE	6	Shrubs (monoecious / dioecious)
RUBIACEAE	6	Two perennials (scrambling, one dioecious) One shrub Three shrublets (two dioecious)
RUTACEAE	15	66.7% Shrubs 33.3% Shrublets
SANTALACEAE	7	Three shrubs (hemi-parasitic) One small tree (hemi-parasitic) One shrublet (hemi-parasitic) Two stem parasites (one monoecious, one dioecious)
SAPINDACEAE	1	Small tree
SCROPHULARIACEAE	40	57.5% Annuals 7.5% Perennials Two shrubs 27.5% Shrublets One small tree
SOLANACEAE	3	Two shrubs (one spiny) One small tree (spiny)
THYMELAEACEAE	8	Shrubs
VAHLIACEAE	1	Shrublet
ZYGOPHYLLACEAE	6	One annual Two shrubs Three shrublets

Regarding the different life-forms (according to the Raunkiaer life-form spectrum) (Kent & Coker 1992) occurring in the study area, Cryptophytes (geophytes) dominates with 285 species, followed by almost similar quantities of phanerophytes (trees & shrubs) (236 species) and chamaephytes (shrublets & climbers) (231 species), while hemicryptophytes (perennials) include 179 species and therophytes (annuals) 110 species (Figure 6.10).

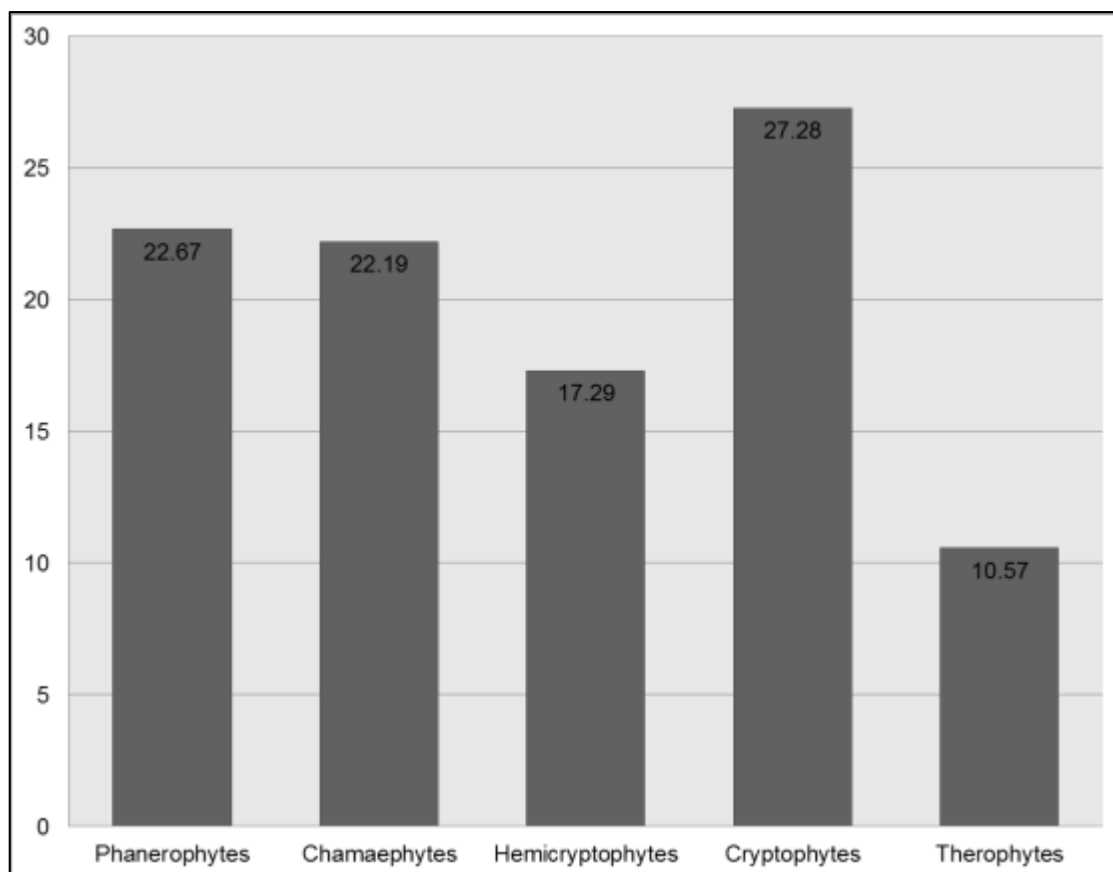


Figure 6.10: The life-form spectrum of the vegetation of the study area according to the categories of the Raunkiaer classification system.

The Cryptophytes in the study area includes 2 root parasites, *Hydnora africana* and *Hyobanche sanguinea*, while 47.4% of the cryptophytes are cormous geophytes (mostly of the Colchicaceae, Iridaceae, Hypoxidaceae, Tecophilaeaceae and Oxalidaceae families), 25.6% are tuberous geophytes (of which some are succulent, mostly form the Orchidaceae, Ruscaceae, Aizoaceae, Cucurbitaceae, Crassulaceae, Geraniaceae and Lobeliaceae), 22.5% are bulbous geophytes (mostly of the Alliaceae, Amaryllidaceae and Hyacinthaceae families) and 3.9% are rhizomatous geophytes (of which some are succulent, mostly from the Asphodelaceae, Agavaceae, Haemodoraceae and Hemerocallidaceae families) (Table 6.2).

Variation in the cryptophytes life-form is given in Table 6.3.

Table 6.3: Variation in the cryptophytes life-form.

CRYPTOPHYTES	NUMBER OF SPECIES	% OF LIFE FORM
Root parasites	2	0.7
Cormous geophytes	135	47.4
Bulbous geophytes	64	22.5
Tuberous geophytes (some succulent)	73	25.6
Rhizomatous geophytes (some succulent)	11	3.9
TOTAL	285	100.0

The phanerophytes (236 species) includes two stem parasites, *Viscum capense* and *V. rotundifolium* as well as one parasitic vine, *Cassytha ciliolata*. The larger part (73.3%) of the phanerophytes is shrubs of which 9.7% are prickly or spiny shrubs, 9.7% are succulent shrubs and 5.9% are small trees (Table 6.2). This group furthermore include 24 dioecious shrubs mainly from the Anacardiaceae, Ebenaceae, Euphorbiaceae, Montiniaceae and Rubiaceae, 2 succulent dioecious shrubs from the Euphorbiaceae (*Euphorbia hamata* and *E. rhombifolia*), 6 monoecious or dioecious shrubs from the genus *Cliffortia*, the monoecious shrub, *Manochlamys albicans* (Amaranthaceae), and the monoecious succulent shrub, *Euphorbia mauritanica*. Other succulent shrubs (20 species) include mainly representatives of the Aizoaceae but also from the genera *Othonna* and *Senecio* (Asteraceae) as well as the genera *Cotyledon* and *Tylecodon* (Crassulaceae). Other shrubs include representatives of the Aizoaceae, Amaranthaceae, Anacardiaceae (some spiny), Asteraceae (some prickly or spiny), Apocynaceae (spiny), Boraginaceae, Brassicaceae, Bruniaceae, Campanulaceae, Celastraceae, Ebenaceae, Ericaceae, Fabaceae (some spiny), Geraniaceae, Lamiaceae, Malvaceae, Polygalaceae (some spiny), Proteaceae, Rhamnaceae, Rutaceae (aromatic), Santalaceae (hemi-parasitic), Scrophulariaceae, Solanaceae (spiny), Thymelaeaceae and Zygophyllaceae families. Trees (mostly small) include *Otholobium striatum*, *Buddleja saligna*, *Leucadendron eucalyptifolium*, *Euclea undulata*, *Searsia angustifolia* (dioecious), *S. tomentosa* (dioecious), *Lycium oxycarpum* (spiny), *Heeria argentea* (monoecious), *Protea laurifolia*, *Dodonaea viscosa* var.

angustifolia, *Olea europaea* subsp. *africana*, *Protea nitida* and *Vachellia karroo* (thorny). Variation in the phanerophytes life-form is given in Table 6.4.

Table 6.4: Variation in the phanerophytes life-form 4.

PHANEROPHYTES	NUMBER OF SPECIES	% OF LIFE FORM
Parasites	3	1.3
Shrubs (three hemi-parasites)	173	73.3
Prickly or spiny shrubs	23	9.7
Succulent shrubs	23	9.7
Trees (mostly small)	14	5.9
TOTAL	236	100.0

Most of the chamaephytes (71.4%) are shrublets (some scramblers or climbers, one hemi-parasite, one sticky) where 27.3% are succulent shrublets (one spiny) and 1.3% spiny shrublets (Table). The larger part of the chamaephytes includes shrublets from the Asparagaceae (some scramblers), Aizoaceae (succulent), Amaranthaceae (succulent), Anacampserotaceae (succulent), Apocynaceae (climbers, scramblers and succulents), Asteraceae, Brassicaceae, Campanulaceae, Caryophyllaceae, Crassulaceae (succulents), Ericaceae, Euphorbiaceae (some spiny), Fabaceae (some spiny), Gentiaceae, Geraniaceae, Lamiaceae, Linaceae, Malvaceae, Menispermaceae, Molluginaceae, Limeaceae, Plumbaginaceae, Polygalaceae, Rhamnaceae, Rubiaceae, Rutaceae (aromatic), Santalaceae (hemi-parasites), Scrophulariaceae, Vahliaceae and Zygophyllaceae families (Table). Variation in the chamaephytes life-form is given in Table 4.5.

Table 6.5: Variation in the chamaephytes life-form.

CHAMAEPHYTES	NUMBER OF SPECIES	% OF LIFE FORM
Shrublets (some scramblers or climbers, one hemi-parasite, one sticky)	165	71.4
Spiny shrublets	3	1.3
Succulent shrublets (one spiny)	63	27.3
TOTAL	231	100.0

Of the hemicryptophytes, 56.4% are perennial shrublets, one plant is carnivorous, with 2.8% creepers / scramblers / climbers, 2.2% stoloniferous, 14.0% rhizomatous, 4.5% tuberous and 19.6% succulent (Table 6.6). Hemicryptophytes include the Pteridophytes, namely the Anemiaceae (*Mohria caffrorum*), Ophioglossaceae (*Ophioglossum nudicaule*) and Pteridaceae (*Cheilanthes* species) families as well as all species of the Cyperaceae and the Restionaceae (all species dioecious) families and also the Poaceae (excluding the annual grasses). Other families include the genera *Aloe* and *Trachyandra* (Asphodelaceae), *Aristea* and *Bobartia* (Iridaceae) as well as some species of the succulent genera *Acrodon*, *Acrosanthes*, *Carpobrotus*, *Conicosia*, *Conophytum*, *Delosperma*, *Glottiphyllum*, *Lampranthus*, *Mesembryanthemum*, *Ruschia*, *Scopelogena* and *Tetragonia* of the Aizoaceae family. The larger part of the Apiaceae, as well as some species of the Apocynaceae (of which some are scramblers and climbers), numerous species of the Asteraceae (some succulent), some species of the Brassicaceae, Caryophyllaceae and Convolvulaceae (climber), most species of the Crassulaceae (succulents) as well as species of the Dipsacaceae, Droseraceae (insectivorous), Euphorbiaceae, Fabaceae, Geraniaceae, Lobeliaceae (including creepers), Plumbaginaceae, Polygonaceae, Rubiaceae, Scrophulariaceae and Theophrastaceae are included in the hemicryptophyte part of the vegetation. Variation in the hemicryptophyte life-form is given in Table 6.6.

Table 6.6: Variation in the hemicryptophyte life-form.

HEMICRYPTOPHYTES	NUMBER PF SPECIES	% OF LIFE FORM
Perennial shrublets	101	56.4
Carnivore	1	0.6
Creeper / scrambler / climber	5	2.8
Stoloniferous	4	2.2
Rhizomatous (one succulent)	25	14.0
Tuberous (some succulent)	8	4.5
Succulent (some trailing)	35	19.6
TOTAL	179	100.0

Therophytes (annual species) comprise a portion of the Poaceae (37%), Aizoaceae (succulents), Amaranthaceae, Apiaceae, numerous species of the

Asteraceae, almost all of the Brassicaceae, numerous species of the Campanulaceae, one species of the Caryophyllaceae, several succulent species of the Crassulaceae, the only species of the Frankeniaceae, one species of the Fabaceae, both species of the Fumariaceae, the genus *Sebaea* in the Gentiaceae family, a few of the Pelargonium species (Geraniaceae), only one species (*Adenogramma glomerata*) of the Molluginaceae, the only representative of the Neuradaceae (*Grielum humifusum* var. *humifusum*), *Anagallis* cf. *huttonii* of the Primulaceae and just more than half of the Scrophulariaceae families. The larger part of the therophytes consists of non-succulents (89.1%), where 10.9% are succulents (Table 6.7). Variation in the phanerophytes life-form is given in Table 6.7.

Table 6.7: Variation in the phanerophytes life-form.

Therophytes	Number of Species	% of Life Form
Non-succulent	98	89.1
Succulent	12	10.9
TOTAL	110	100.0

More than a third of the world's succulent plants occur in southern Africa (Van Jaarsveld 1987; Cowling *et al.* 1997). An association was found between the occurrence of succulence and particular habitat conditions such as saline environments, environments with low but predictable rainfall and environments without regular frost (Cowling *et al.* 1997). Succulents constitute 14.8% of the plant species of the study area and occur in various life-forms (Table 6.8). Succulent richness in the study area is somewhat lower than that of the Nama Karoo and the Eastern Karoo (where 18.5% of the flora is succulent) and much lower than the Succulent Karoo (where 32% of the flora comprises succulents) (Van Jaarsveld 1987; Werger & Ellis 1981). The Asphodelaceae, Aizoaceae, Anacampserotaceae, Apocynaceae, Asteraceae, Crassulaceae, Euphorbiaceae and the Geraniaceae families contain succulent species. The larger part (41%) of the succulents in the study area consists of shrublets, 25% of perennials, 15% of shrubs, 11% of geophytes and 8% of annuals (Table 6.2). Variation of the different life-forms of the succulent plants found in the study area is given in Table 6.8.

Table 6.8: Variation of life-forms of succulent plants in the study area.

SUCCULENT SPECIES	NUMBER OF SPECIES	% OF SUCCULENT SPECIES
Annuals	12	7.8
Perennials	38	24.7
Shrublets	64	41.6
Shrubs	23	14.9
Geophytes	17	11.0
TOTAL	154	100.0

Sclerophylly is an evolutionary adaptation to the summer drought conditions and nutrient poor soils of mediterranean ecosystems where sclerophyllous plants are found in both the overstorey and the understorey (Cowling *et al.* 1997). Cowling *et al.* (1997) state that however the term sclerophylly is not clearly defined, it is commonly used to describe several co-occurring leaf properties such as thickness, hardness, moisture content, resistance to puncture or tearing as well as leaf mass and area as well as the presence of biochemical components and nutrients. In this study, the term sclerophylly is applied to species with small ericoid, relatively hard and/or strongly revolute leaves and comprise 25.7% of all the phanerophyte and chamaephytes species. Of these, 49.2% are shrubs and 50.8% are shrublets.

Various forms of spinescence occur in 10% of the woody plants of southern Africa (Milton 1991). Only 27 species (2.6% of the flora of the study area and mainly shrubs) contain thorns or spines (Table 6.2). Cowling *et al.* (1997) state spinescence to be relatively scarce in the Fynbos Biome as the presence of spine is a strategy of plants to reduce leaf losses due to herbivory (Cooper & Owen-Smith 1986). As a result of the low soil fertility, angulates were probably never abundant in the fynbos (Campbell 1986).

6.2.4 Medicinal, poisonous and plants utilised for their specific attributes

A summary of the number of plants (part of the plant / whole plant) with medicinal, poisonous, aromatic or other attributes that make them useful for people and animals is given in Table 6.9. More detailed descriptions are

provided in Annexure 4 (Watt and Breyer-Brandwijk 1962; Van Wyk and Gericke 2000).

Table 6.9: Variation amongst plants (part of the plant / whole plant) with medicinal, poisonous, aromatic or other attributes that make them useful for people and animals.

PLANT SPECIES	NUMBER OF SPECIES	% OF MEDICINAL PLANTS
Aromatic	28	13.6
Edible	45	21.8
Medicinal	79	38.3
Poisonous/possibly poisonous	39	18.9
Other	15	7.3
TOTAL	206	100.0

6.2.5 Rare and endangered plant species

Regarding the Cape Core Flora, Manning & Goldblatt (2012) state that “the combination of high species diversity in the region, coupled with a high proportion of range-restricted taxa, makes it especially vulnerable.” The study area has a fairly high number of species with conservation concern (Figure 6.11). A total of 109 species are listed in the National Red List Categories which aim to highlight species that are most urgently in need of conservation (Annexure 5; <http://redlist.sanbi.org>).

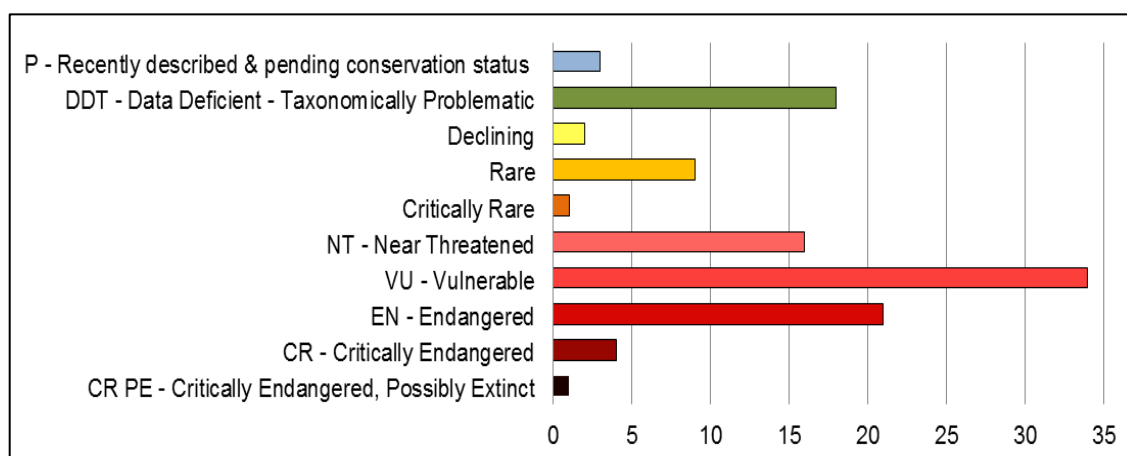


Figure 6.11: The number of rare and endangered species occurring in the study area

The highest occurrence of rare and endangered plant species is in the *Elytropappus rhinocerotis* shrubland (major community 1) with the largest number of rare or endangered species was found in the *Tylecodon*

ventricosus–Elytropappus rhinocerotis community (Community 1), the *Selago triquetra–Elytropappus rhinocerotis–Wiborgia mucronata* sub-community (Sub-community 2.2), the *Pelargonium carneum* variant of the *Oedera genistifolia–Elytropappus rhinocerotis–Wiborgia tenuifolia* sub-community (Sub-community 3.1 Variant ii), and the *Lichtensteinia interrupta–Elytropappus rhinocerotis* community (Community 4) (Chapter 4).

The *Capeochloa arundinacea* shrubland (major community 3) has the second highest occurrence of species with conservation concern where the highest occurrence is found in the *Metalasia acuta–Capeochloa arundinacea–Erepsia anceps* sub-community (Sub-community 10.2) (Chapter 4).

The *Passerina truncata* shrubland (major community 2) has the third highest occurrence of species of conservation concern where the highest occurrence is found within the *Protea laurifolia–Passerina truncata–Phyllica constricta* sub-community (Sub-community 9.3) (Chapter 4).

The *Thamnochortus bachmannii* Sandveld (major community 5) has the fourth highest occurrence of species with conservation concern followed by the *Hirpicium integrifolium* shrubland (major community 4) which has the highest occurrence in the *Leucospermum rodolentum–Thamnochortus bachmannii* Community (community 14) (Chapter 4).

6.2.6 Species richness and plant community diversity

Within all the plant communities in the study area, communities 3, 9, 10, 2, 11 and 15 have the highest species richness with all more than 200 species recorded (Figure 6.12). This is also reflected in the Margalef's index (Figure 6.12). Communities 1, 4 and 6 are of intermediate species richness, while communities 7, 14, 13, 5, 8 and 12 have the lowest species richness (Figure 6.12).

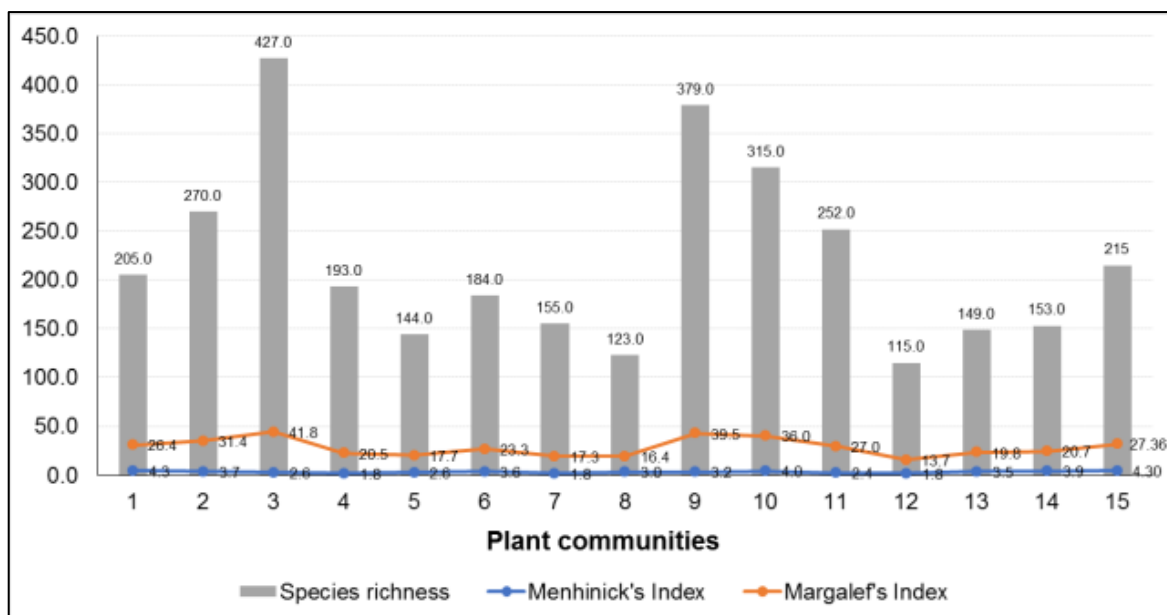


Figure 6.12: Species richness as well as Menhinick's and Margalef's indices for the plant communities.

The Shannon Wiener entropy showed that communities 10 and 9 have the highest diversity followed by communities 2, 5, 6 and 1 and 15 although not all of them are amongst those communities with the highest species richness (Figures 6.12 & 6.13).

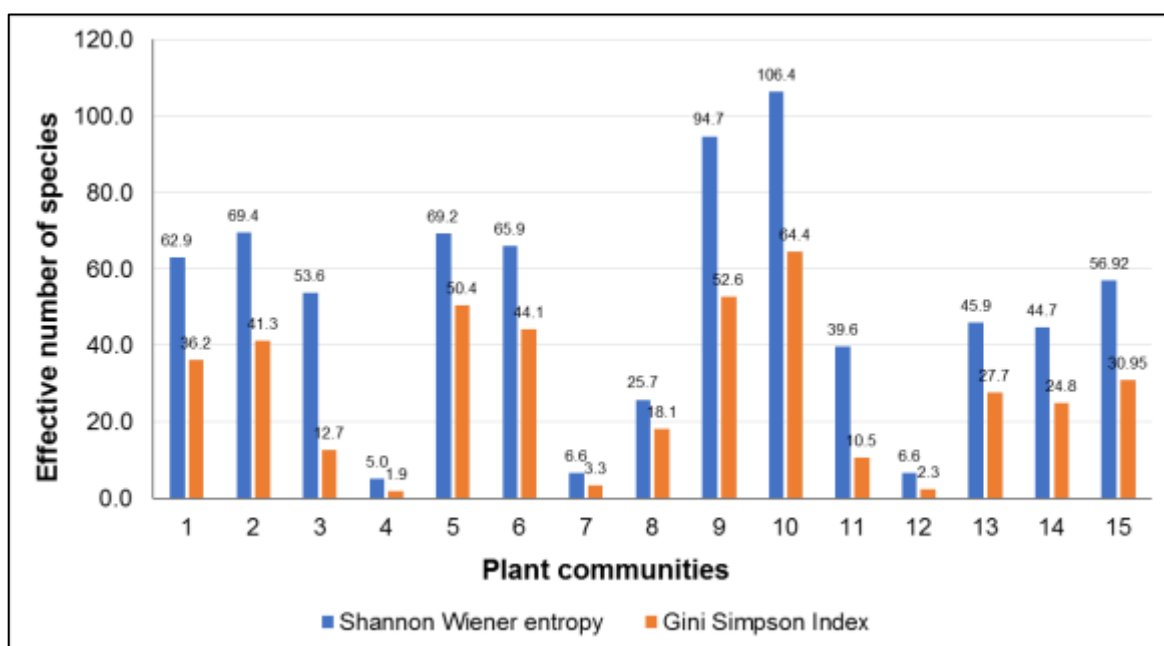


Figure 6.13: Shannon-Wiener Index and Gini Simpson's index effective number of species values for the different plant communities.

This is also reflected in the Gini Simpson Index (Figure 6.13). Comparing species richness with the effective number of species in the respective communities, although having lower species richness, communities 5 and 6 proportionally have a relative high diversity (Figures 6.12 & 6.13).

A chi-square test was carried out ($X^2(15) = 562.11$, $P < 0.001$), which shows there is a statistically significant difference in species richness between the different plant communities. Species richness and frequency distributions for communities 1-15 are, together with their standardised residual values, indicated in Table 6.10. The residual value is the vertical distance between the expected frequency and the actual frequency observed of a regression graph. If the residual value is positive (i.e. above the graph) it means the value is more than expected.

Table 6.10: Species richness, frequency distributions, deviation and standardized residuals for the plant communities 1-15.

Plant community	Species richness/ Observed frequency	Expected frequency	% Deviation (Obs. value - Exp. Value)	Standardized Residuals
1	205	218.6	-6.22	-0.92
2	270	218.6	23.51	3.48
3	427	218.6	95.33	14.10
4	193	218.6	-11.71	-1.73
5	144	218.6	-34.13	-5.05
6	184	218.6	-15.83	-2.34
7	155	218.6	-29.09	-4.30
8	123	218.6	-43.73	-6.47
9	379	218.6	73.38	10.85
10	315	218.6	44.1	6.52
11	252	218.6	15.28	2.26
12	115	218.6	-47.39	-7.01
13	149	218.6	-31.84	-4.71
14	153	218.6	-30.01	-4.44
15	215	218.6	-1.65	-0.24

Based on standardized residuals, communities 5, 6, 7, 8, 12, 13 and 14 all have lower than expected frequencies which can be ascribed to their relatively low species richness compared to the other communities. The standardized residuals for communities 1 and 15 are not much lower than expected (which is reflected in them being of intermediate species richness compared to the other communities) (Table 6.10; Figure 6.13). Communities 2, 3, 9, 10 and 11 have high residual values that are as a result of their high species richness (Table 6.10; Figure 6.13). The high species richness of communities 2, 3, 9, 10 and 11 is the main contributor to the statistical significant differences between the communities.

A multiple regression analysis was done using environmental data (pH, Water Holding Capacity, Altitude, and Rock cover) as explanatory variables and Shannon Entropy as the response variable, to determine if there were any significant relationships between the explanatory variables and Shannon Entropy. We included the four explanatory variables mentioned, interactions between these four variables and quadratic terms for each of the explanatory variables to test for curvature in response to each of these terms (Figure 6.14).

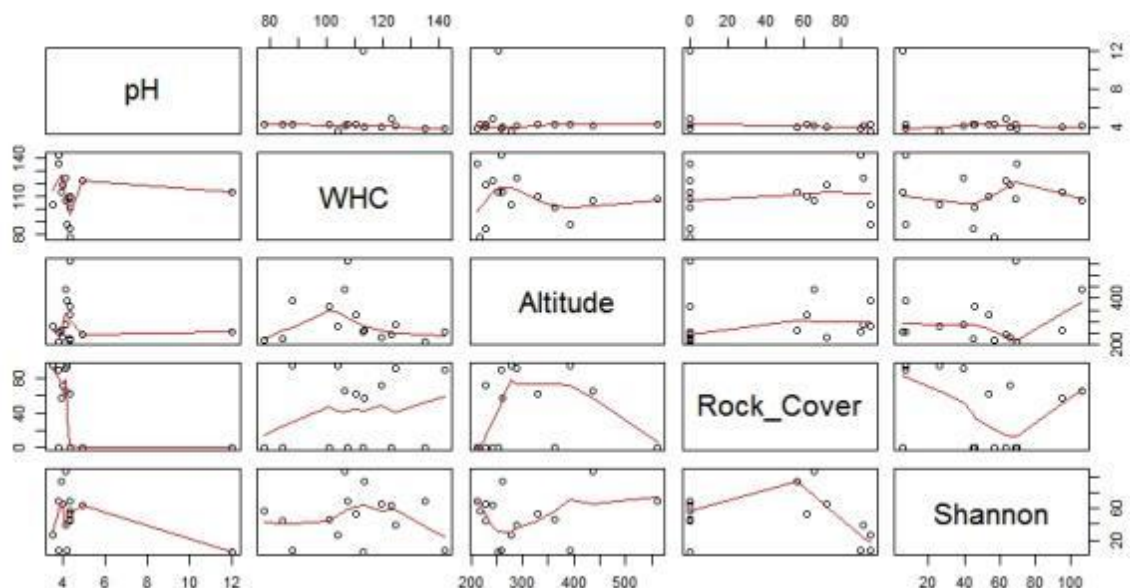


Figure 6.14: Panel display of the data showing the response variable (Shannon Entropy) on the y axis of the bottom row.

The minimum adequate model depicted in Table 6.10 suggests that pH and Rock Cover are significant but that there are no interactions, and there is a single quadratic term for Rock Cover.

Table 6.11: Residuals and coefficients for the multiple regression analysis for environmental data.

Coefficients:					
	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	58.450172	39.213630	1.491	0.17027	
pH	-6.539705	2.554480	-2.560	0.03068 *	
WHC	0.153455	0.291744	0.526	0.61161	
Altitude	0.035227	0.051461	0.685	0.51088	
Rock_Cover	1.926503	0.554494	3.474	0.00700 **	
I(Rock_Cover^2)	-0.025277	0.006143	-4.115	0.00262 **	

Signif. codes:	0 '***'	0.001 '**'	0.01 '*'	0.05 '.'	0.1 ' ' 1

According to the model there is a statistically significant relationship between soil pH and diversity ($P < 0.01$) and rock cover and diversity ($P < 0.01$). For both factors the graphs are humped curves (bottom row Figure 6.14). According to Figure 6.14 areas with a low pH are mostly associated with high diversity, though in some cases extremely acidic soil is related to low diversity. Medium-high rock cover (40-60%) is associated with high diversity, while moderate diversity is associated with low rock cover (Figure 6.14).

This is especially true for the high diversity communities (9; 10; 2 and 5) which all have low pH soil and medium rock cover ranging between 30-60%. Plant community 10 is also regarded as being nutrient rich (Chapter 4) that also contributes to the high species diversity. The low diversity communities (4; 7; 12) all have low pH, but most importantly high rock cover (between 80-98%) which explains the low diversity encountered in these communities. Most of the communities with a moderate diversity (e.g. 3; 13; 14; 15) have low rock cover and slightly higher (though still acidic) pH.

Altitude did not have a statistically significant association with diversity, though it does seem that low and high altitude areas had the highest diversity (Figure 6.14).

A multiple regression analysis attempting to determine how Species Richness is related to the main soil properties/nutrients (soil salinity, %C, %Na, %K, %Ca, and %Mg) showed no meaningful results.

Although Community 3, the *Euryops rehmannii*–*Elytropappus rhinocerotis* community has the highest species richness, it has a low number of viable species populations (Figures 6.13 & 6.14). Community 3 is mostly found on the south facing slopes underlain mainly by mudrock derived finer grained soils of the Witteberg Geological Series that is situated on most of the south facing foothills, mid-slopes and upper-slopes in the study area (Chapter 4) where the soils in some areas may be susceptible to erosion due to fine structure and a high Magnesium proportion on the saturation that can cause dissociation of the soil particles (Table 4.1). The low number of viable species populations together with high species richness, may be a consequence of the variability of the soil and water holding capacity. Similarly does community 11 have relatively high species richness with low number of viable species populations (Figures 6.13 & 6.14). The high species richness of these communities with relative low effective species populations may possibly reflect a patchily distribution in microhabitats, which indicate the inherent character, stability, but also vulnerability of this natural mosaic-veld.

Although communities 4, 7, 12 do not have the lowest species richness, these communities have the lowest species diversity and lowest evenness (Figures 6.12 & 6.13).

6.3 CONCLUSION

Similar to the floras of other semi-arid to arid areas, the Asteraceae typically is not only the largest family represented in the study area, but also the most diverse (Manning & Goldblatt 2012, Figure 6.2).

The *Elytropappus rhinocerotis* Shrubland is dominated by phanerophytes, chamaephytes and cryptophytes but also comprise hemicryptophytes and therophytes. The *Passerina truncata* Shrubland is dominated by phanerophytes (contains small Protea trees), chamaephytes and cryptophytes but also comprise hemicryptophytes and therophytes. The *Capeochloa arundinacea*

Shrubland is dominated by hemicryptophytes (especially the grass *C. arundinacea*), phanerophytes, chamaephytes and cryptophytes but also comprise and therophytes.

The *Hirpicium integrifolium* shrubland is dominated by chamaephytes and cryptophytes but also comprise phanerophytes, hemicryptophytes and therophytes. The *Thamnochortus bachmannii* Sandveld is dominated by hemicryptophytes (especially of the Restionaceae), phanerophytes, chamaephytes and cryptophytes but also comprise therophytes.

With a total number of 1042 different plant species recorded in this area the area is regarded as having high species richness. Rare or endangered plant species occur in all the plant communities except for community 4 (Chapter 4). The high number of red data plant species as well as those that have other (e.g. medicinal, aromatic, poisonous etc.) values emphasise the importance of the remaining natural areas within the study area.

The *Protea laurifolia*–*Passerina truncata* community (community 9) (Chapter 4.9) and the *Metalasia acuta*–*Capeochloa arundinacea* community (community 10) (Chapter 4.10) are important because they have highest species diversity and also high species richness. The *Tylecodon ventricosus*–*Elytropappus rhinocerotis* community (community 1), *Selago triquetra*–*Elytropappus rhinocerotis* community (community 2), *Erica boucheri*–*Elytropappus rhinocerotis* community (community 5) and *Struthiola confusa*–*Elytropappus rhinocerotis* community (community 6) in major community 1, and the *Willdenowia incurvata*–*Thamnochortus bachmannii* community (community 15) in major community 5 (Chapter 4) are also important because of high species richness as well as high species diversity. However, communities such as community 3 with high species richness and lower species diversity are also important due to the patchiness of species distribution. Although they have lower species richness, communities such as 5, 6, 13 and 14 proportionally have a relative high number of viable species in relation to species richness and are not unimportant (Figures 6.12 & 6.13).

Communities 9, 10, 2, 5, 6 and 1 are considered as ecologically stable systems that would be able to recover to equilibrium should any disturbances occur.

According to the diversity stability hypothesis these systems have many species that could compensate for the loss of others in cases where degradation takes place making these stable systems (Hamilton 2005). These communities also have a high diversity of microhabitats and the soils supporting them are relatively low in Fe and Mn as described in chapter 4, which could explain this phenomenon. In comparison communities 4, 7 and 12 have low diversity and moderate species richness. All three these communities have less diverse habitats, mostly as a result of a high rock cover, while they also have highly acidic soils with high levels of Mn or Fe, except for community 12 which has relatively low levels of Mn and Fe, but a high base saturation percentage of Mg (chapter 4). Acidic soil together with high rock cover (meaning less microhabitats and resources) could constrain plant growth since it normally results in toxic concentrations of mineral elements and nutrient availability that could inhibit plant growth (Marschner 1991). These communities are regarded as being less stable ecosystems and would most probably not easily recover should any disturbance take place. Most of the communities of the study area have moderate to high plant species diversity and are therefore regarded as being stable ecosystems with a natural species distribution.

CHAPTER 7

**THE EFFECT OF FIRE IN BREEDE SHALE RENOSTERVELD
AND BREEDE QUARTZITE FYNBOS**

“Without fire there would be no fynbos”

From: Cowling and Richardson (2003)



Haemanthus coccineus after controlled fire in 2009

TABLE OF CONTENTS

INTRODUCTION	415
7.1 PRE-FIRE DATA COMPARED WITH POST-FIRE DATA	418
7.1.1 Vegetation classification: Synoptic table	418
7.1.1 The <i>Lichtensteinia interrupta</i> – <i>Elytropappus rhinocerotis</i> community	421
7.1.2 The <i>Drosanthemum hallii</i> – <i>Passerina truncata</i> community	428
7.1.3 The <i>Protea laurifolia</i> – <i>Passerina truncata</i> community.....	433
7.2 LIFE FORMS	438
7.3 SPECIES CONSTANCY AND DOMINANCE BEFORE- AND AFTER FIRE ...	440
7.4 CONCLUDING REMARKS	443

LIST OF TABLES

Table 7.1: Relevé numbers of post fire samples matching the numbers of pre- fire sample plots.....	418
Table 7.2: A comparison of the synoptic analyses of the pre- and post-fire data for community 4.	422
Table 7.3: A comparison of the synoptic analyses of the pre- and post-fire data for community 8.	429
Table 7.4: A comparison of the synoptic analyses of the pre- and post-fire data for community 9.	434

LIST OF FIGURES

Figure 7.1: A controlled fire was done in an area on the northern perimeter of the Greater Brandvlei Dam, 8 April 2009.	415
Figure 7.2: Sample plot 11 (community 4) in 2007 before the fire, illustrating moribund renosterbos dominated veld.....	421
Figure 7.3: Community 4 just after the fire in 2009.	426
Figure 7.4: <i>Corymbium glabrum</i> flowering abundantly and the annual grass <i>Stipa capensis</i> dominant in sample plot 13 2009.....	426
Figure 7.5: Community 4 in 2010 with <i>Oxalis glabra</i> flowering abundantly.	426
Figure 7.6: Community 4 in 2011 with <i>Aspalathus muraltioides</i> , the dominant grey-leaved shrub in the foreground.	426
Figure 7.7: Community 4 in 2012 with <i>Printzia polifolia</i> in seed.	426
Figure 7.8: Community 4 in 2013 with young <i>Elytropappus rhinocerotis</i> shrubs dominant and <i>Aspalathus submissa</i> flowering abundantly.....	426
Figure 7.9: Community 4 in 2010 with grass species and <i>Aspalathus recurva</i> (the grey-green shrub in the foreground) dominant in the first year after the fire.....	427
Figure 7.10: Due to the effects of fire, <i>Aspalathus</i> species such as <i>A. recurva</i> and <i>A. muraltioides</i> , the grey shrubs in the centre of the picture become dominant in community 4 in the first year after the fire.....	427
Figure 7.11: <i>Aspalathus muraltioides</i> is well established and flowering abundantly in community 4 four years after the fire (2013).....	427
Figure 7.12: Sample plot 16 (community 8) in 2007 before the fire.	428
Figure 7.13: Sample plot 16 just after the fire in 2009.	431
Figure 7.14: Sample plot 16 in 2010 with <i>Tenaxia stricta</i> and <i>Mesembryanthemum longistylum</i> establishing first.....	431
Figure 7.15: <i>Drosanthemum hallii</i> flowering abundantly, <i>Mesembryanthemum longistylum</i> , <i>Tenaxia stricta</i> , <i>Passerina truncata</i> and <i>Restio</i> species establishing in sample plot 14, 2011.....	431
Figure 7.16: Sample plot 16 in 2012 with <i>Elytropappus rhinocerotis</i> , <i>Mesembryanthemum longistylum</i> , <i>Oedera squarrosa</i> and <i>Pentameris eriostoma</i> established.....	431

Figure 7.17: <i>Drosanthemum hallii</i> , <i>Mesembryanthemum longistylum</i> , <i>Oedera squarrosa</i> , <i>Passerina truncata</i> and <i>Pentameris eriostoma</i> dominant in sample plot 16 in 2013.	431
Figure 7.18: <i>Drosanthemum hallii</i> shrubs resprouted and established from seeds, flowering abundantly (a, b & c) in the four years the area was monitored following the fire.	432
Figure 7.19: Sample plot 17 (community 9) in 2007 before the fire, with <i>Protea laurifolia</i> shrubs in the background and <i>Drosanthemum hallii</i> flowering in the front.	433
Figure 7.20: Sample plot 17 just after the fire in April 2009.	437
Figure 7.21: Sample plot 17 in October of 2009 with <i>Ehrharta villosa</i> and <i>Helichrysum hebelepis</i> establishing first. <i>Geissorhiza confusa</i> is flowering abundantly.	437
Figure 7.22: Sample plot 17 in September 2010 with <i>Ehrharta villosa</i> dominant, but shrubs such as <i>Passerina truncata</i> starting to re-establish in the area.	437
Figure 7.23: Sample plot 17 in September 2011 with <i>Drosanthemum hallii</i> re-established and flowering abundantly.	437
Figure 7.24: Sample plot 17 in November 2012 with seedlings of <i>Protea laurifolia</i> as well as other dominant shrubs such as <i>Thesium strictum</i> , <i>Passerina truncata</i> , <i>Eriocephalus africanus</i> and the grass <i>Capeochloa arundinacea</i> established.	437
Figure 7.25: Sample plot 17 in November 2013 with well-established vegetation cover after the fire four years earlier. The yellow flowering shrub in the foreground is <i>Aspalathus spicata</i> , which became a dominant species after the fire.	437
Figure 7.26: The percentage of life forms of the species which synoptic analyses showed to be significant regarding pre- and post-fire constancy and dominance.	439
Figure 7.27: A climate diagram for Aan-de-Doorns Wine Cellar, just east of the Greater Brandvlei Dam, data for 2009 (Agromet-ISCW).	444
Figure 7.28: A climate diagram for Aan-de-Doorns Wine Cellar, just east of the Greater Brandvlei Dam, data for 2010 (Agromet-ISCW).	444

- Figure 7.29: Amongst other, geophytic species which flowered abundantly after the fire are *Disa satyroides* (a), *Mesembryanthemum grossum* (b), *Oxalis pardalis* (c), *Tritonia crispa* (d), *Watsonia spectabilis* (e), *Gladiolus guthriei* (f), *Colchicum variabilis* (g), *Tritoniopsis ramosa* (h), *Moraea vuvuzela* (i), *Gladiolus floribundus* (j), *Moraea neglecta* (k), *Lapeirousia micrantha* (l), *Geissorhiza confusa* (m) and *Satyrium coriifolium* (orange flowers) including a *S. coriifolium* x *S. erectum* hybrid (n).....445
- Figure 7.30: Species that showed remarkable growth and flowering after the fire are: *Aspalathus submissa* (a), *Arctotis acaulis* (b), *Othonna lingua* (c), *Othonna digitata* (d), *Phyllopodium capillare* (e), *Phyllopodium heterophyllum* (f), *Disa satyroides* (g), *Lachenalia pustulata* (h), *Drosera cistiflora* (i), *Pteronia hirsuta* (j), *Perdium capense* (k) and *Cyphia volubilis* (l).....448
- Figure 7.31: Due to the effects of fire, geophytes such as *Euphorbia silenifolia* and *E. tuberosa* grew much more vigorously in the year after the fire than before.....449
- Figure 7.32: *Protea nitida* (sample plot 15) was found resprouting after the fire.....450
- Figure 7.33: Although *Erica inaequalis* re-established from seeds after the fire, several resprouting shrubs were also found.450
- Figure 7.34: *Erica inaequalis* and *Indigofera* sp. nov. cf. *angustifolia* resprouted after the fire.....450
- Figure 7.35: *Passerina truncata* resprouting during the growing season following the fire.....450
- Figure 7.36: Abnormal resprouting growth was found in *Passerina truncata* after the fire.....452
- Figure 7.37: The abnormal growth on *Passerina truncata* does not develop further.452
- Figure 7.38: *Satyrium candidum* flowering abundantly after the fire in community 4, September 2011.453
- Figure 7.39: *Protea restionifolia* seeds just after the fire in April 2009.454
- Figure 7.40: *Protea restionifolia* had resprouted and re-established from seeds at the end of 2010.454
- Figure 7.41: *Protea restionifolia* flowering abundantly in October 2013.454

Figure 7.42: <i>Protea laurifolia</i> seeds.	455
Figure 7.43: Carpets of seeds released from <i>Protea laurifolia</i> flowerheads were noticed within eight days after the fire in April 2009.	455
Figure 7.44: Some of the newly released <i>Protea</i> seeds were carried to underground nests by termites in an unburned patch of vegetation adjacent to sampling plot 17.	455
Figure 7.45: Seedlings of <i>Protea laurifolia</i> were well established in November 2012.	455
Figure 7.46: <i>Tylecodon paniculatus</i> (with <i>Haemanthus coccineus</i> flowering) in the week after the fire, April 2009 (a) and already resprouting in September that same year (b).	458

INTRODUCTION

This chapter includes a comparison of pre-fire floristic data with data collected for four years following a controlled fire in Breede Shale renosterveld and Breede Quartzite Fynbos on the northern perimeter of the greater Brandvlei Dam (Figure 7.1).



Figure 7.1: A controlled fire was done in an area on the northern perimeter of the Greater Brandvlei Dam, 8 April 2009.

Bond and Van Wilgen (1996) state that susceptibility to fire is influenced by the morphological and chemical properties of individual species and the arrangement of species and communities in space. They also state that: “Communities will burn if they contain one or many of the ‘right’ properties. These properties include enough fuel, low moisture contents in the leaves, an optimum arrangement of plant parts in space, low decomposition rates and high levels of secondary compounds” (Bond and Van Wilgen 1996). The same authors state that production or retention of dead material is the most important property making vegetation susceptible to fire. Although living plants contribute to energy release in fires when they start to burn, it is dry material that initially carries and sustain a fire. Most of the plants in the study area possess traits

that enhance flammability such as small scleromorphic leaves, e.g. *Erica inaequalis*, *Passerina truncata* and *Elytropappus rhinocerotis* (Figure 4.45) and secondary compounds (e.g. oils in *Agathosma* species and waxes in restios and grasses) (Bond and Van Wilgen 1996). A study of the role of vegetation structure and fuel chemistry in excluding fire from forest patches in Fynbos, did not only find that the mean monthly moisture content for all individual fynbos species was significantly lower than the mean for any individual forest species in most months, but that the range of plant oil in fynbos species was much greater (Van Wilgen *et al.* 1990). Such inherent characters predispose most fynbos plants to fire.

Kruger (1984) states that most of the annual net primary production of fynbos, not lost to other natural processes or browsing by animals, becomes available as fuel for fires. The age of the fynbos/renosterveld community relative to the previous fire determines biomass and thus available fuel, though the lowest biomass is found in low rainfall renosterveld areas (Kruger 1984). Decomposition rates in Mediterranean shrublands are very slow (Bond and Van Wilgen 1996) and as a consequence of the relatively dry climate of the study area and lack of fire over several decades, a considerable quantity of dead dry material had accumulated in parts of the study area over time. That, as well as low moisture content of fynbos species, especially at the end of the dry season, provides fuel for fire.

Results of fire that can influence species recruitment are listed by Crawley (2005) as:

- release of nutrients recycled from accumulated dead biomass
- the breakdown of hydrophobic plant litter which leads to improved soil wettability
- the breaking of dormancy in fire adapted species and
- the removal of inhibiting chemicals including allelochemicals from the soil surface.

The area on the northern perimeter of the Greater Brandvlei Dam where the controlled burn was done includes plant communities 4 (*Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community), 8 (*Drosanthemum hallii*–*Passerina truncata* community) and 9 (*Protea laurifolia*–*Passerina truncata* community). According to Mucina and Rutherford (2006), fire is an ecological driver in fynbos and renosterveld plant communities, and “plays a major role in determining species composition and community type.” Sample plots were placed within each of the communities and the corners marked with steel droppers. Detailed Braun-Blanquet surveys were conducted in each sample plot while species density was determined by placing ten 1m² quadrats in each and counting each specific species. The same sample plots were surveyed annually for four consecutive years after the fire in exactly the same manner as the initial surveys. To determine if there is a difference in the classification of the plant communities regarding pre- and post-fire vegetation, both the pre- and post-fire relevés were included in the Twinspan analysis for the study area. The results show the post-fire floristic data for each sample plot grouped with the pre-fire floristic data for the specific sample plot (Annexure 3).

7.1 PRE-FIRE DATA COMPARED WITH POST-FIRE DATA

7.1.1 Vegetation classification: Synoptic table

Pre-fire sample plot numbers are given with the corresponding relevé numbers of the post-fire samples (collected in the same marked sample plot) in Table 1.

Table 7.1: Relevé numbers of post fire samples matching the numbers of pre-fire sample plots.

Pre-fire relevés	Post-fire relevés for the same pre-fire sample plots			
	2010	2011	2012	2013
2007				
10	93	109	119	123
11	no data	no data	116	124
12	88	103	117	122
13	92	108	118	125
14	91	107	115	126
15	90	106	114	127
16	no data	105	112	129
17	89	104	113	128
18	87	102	110	121
21	no data	no data	111	120

The analysis of the complete data set for community 4 (pre-fire sampling plots 8, 11, 12, 10, 13 and 14) with the post-fire data included (Table 1; Annexure 3), still lumped all the sample plots for this community together, however divided the community into three sub-communities and two variants:

- all post-fire floristic data for sample plot 12 is classified as a first sub-community;
- the pre-fire floristic data for sample plots 8, 11, 12, 10 and 13 together with all the post-fire data comparing with sample plot 13 is classified as a first variant of a second sub-community;
- all post-fire relevés comparing with sample plots 10 and 11 is classified as a second variant for the second sub-community;

- and pre-fire floristic data for sample plot 14 is classified with all the post-fire relevés of sample plot 14 as a third sub-community) (Annexure 3).

Data analysis of the complete floristic data set (pre and post-fire) classified community 8 as undivided (exactly the same as for the complete data set for the study area) (Annexure 3).

Data analysis with the post-fire relevés omitted, classified community 9 in three sub-communities where the first sub-community has three variants(Annexure 1), while the analysis of the complete data set with the post-fire floristic data included, divided community 9 into five sub-communities (Annexure 3) where:

- the unburnt sample plots 22, 36, 42 and 38 is classified as a first sub-community (Annexure 3) (comparing with sub-community 9.1 variant i, just with sample plot 17 included in Annexure 1);
- all the post-fire floristic data comparing with sample plot 18, all the post-fire data comparing with sample-plot 21 and all the post-fire data comparing with sample plot 17 together with pre-fire data for sample plot 17 is classified in a second sub-community (Annexure 3) (comparing with sub-community 9.1 variant i in Annexure 1, adding only sample plot 17);
- the unburnt sample plots 171, 33 and 35 are classified as a third sub-community (Annexure 3) (comparing with sub-community 9.1 variant ii in Annexure 1);
- the unburnt sample plots 50, 7 and 23 together with pre-fire data of sample plots 21 and 18 are classified as a third sub-community (Annexure 3) (comparing with sub-community 9.1 variant iii in Annexure 1);
- all the post-fire sample plots comparing with sample plot 15 together with unburnt sample plots 151 and 158 (Annexure 3) (sub-community 9.2 in Annexure 1) are classified as a fourth sub-community and
- the unburnt sample plots 81, 43, 46, 59, 48, 71, 72, 70, 86, 85, 58 and 57 are classified as a fifth sub-community (Annexure 3) (comparing with sub-community 9.3 in Annexure 1).

Post-fire regeneration is described based on a comparison of the species found to be statistically significant regarding constancy and dominance and involves the analysis including the post-fire relevés, and the analysis excluding the post-fire relevés (Annexure 2). The species underlined agree with the pre-fire vegetation classification. The species indicated in bold under the heading “constant species” are those that have 100% constancy in the specific plant community.

7.1.1 The *Lichtensteinia interrupta*–*Elytropappus rhinocerotis* community

Major community 1, community 4 (Chapter 4) (Figure 7.2)

Number of relevés: 24



Figure 7.2: Sample plot 11 (community 4) in 2007 before the fire, illustrating moribund renoosterbos dominated veld.

Diagnostic species: None

Constant species: *Aspalathus submissa*, ***Babiana patula***, *Berkheya armata*, *Cyphia digitata*, ***Ehrharta capensis***, ***Elytropappus rhinocerotis***, ***Eriocephalus africanus***, *Eriospermum dielsianum* subsp. *dielsianum*, *Helichrysum rosum*, *Helichrysum rutilans*, *Heliophila pendula*, ***Restio capensis***, *Lichtensteinia interrupta*, ***Tenaxia stricta***, *Mohria caffrorum*, *Montinia caryophyllacea*, ***Muraltia trinervia***, *Nenax hirta*, *Oedera squarrosa*, *Pelargonium radiatum*, ***Pentameris airoides* subsp. *airoides***, ***Pterygodium alatum***, ***Satyrium erectum***, *Stipa capensis*, *Tribolium hispidum*, ***Tribolium utriculosum***, ***Troglophyton parvulum***, ***Ursinia anthemoides***, and *Wurmbea variabilis*.

Dominant species:

Aspalathus muraltioides, *Aspalathus recurva*, *Aspalathus submissa*, *Elytropappus rhinocerotis*, *Eriocephalus africanus*, *Helichrysum rosum*, *Restio sieberi*, *Tenaxia stricta*, *Mohria caffrorum*, *Nenax hirta*, *Pentameris airoides* subsp. *airoides*, *Printzia polifolia*, *Stipa capensis*, *Troglophyton parvulum* and *Ursinia anthemoides*.

A comparison of dominant and constant species before- and after the fire is given in Table 7.2.

Table 7.2: A comparison of the synoptic analyses of the pre- and post-fire data for community 4.

Species	Constant before fire	Constant after fire	Dominant before fire	Dominant after fire	Life form
ANEMIACEAE					
<i>Mohria caffrorum</i>	x	x	x	x	Perennial (rhizomatous)
PTERIDACEAE					
<i>Cheilanthes hastata</i>	x				Perennial (rhizomatous)
COLCHICACEAE					
<i>Wurmbea variabilis</i>	x	x			Geophyte (cormous)
IRIDACEAE					
<i>Babiana patula</i>	x	x			Geophyte (cormous)
ORCHIDACEAE					
<i>Satyrium candidum</i>	x				Geophyte (tuberous)
<i>Satyrium erectum</i>	x	x			Geophyte (tuberous)
<i>Pterygodium alatum</i>	x	x			Geophyte (tuberous)
<i>Pterygodium catholicum</i>	x				Geophyte (tuberous)
POACEAE					
<i>Ehrharta capensis</i>	x	x			Perennial
<i>Pentameris airoides</i> subsp. <i>airoides</i>	x	x	x	x	Annual
<i>Stipa capensis</i>	x	x		x	Annual
<i>Tenaxia stricta</i>	x	x	x	x	Perennial
<i>Tribolium hispidum</i>		x			Perennial
<i>Tribolium utriculosum</i>	x	x			Annual
RESTIONACEAE					
<i>Restio capensis</i>	x	x			Perennial

<i>Restio sieberi</i>	x		x	x	Perennial
RUSCACEAE					
<i>Eriospermum dielsianum</i> subsp. <i>dielsianum</i>		x			Geophyte (tuberous)
TECOPHILAEACEAE					
<i>Cyanella lutea</i>	x				Geophyte (cormous)
APIACEAE					
<i>Lichtensteinia interrupta</i>	x	x			Perennial
ASTERACEAE					
<i>Berkheya armata</i>	x	x			Perennial
<i>Elytropappus rhinocerotis</i>	x	x	x	x	Shrub
<i>Eriocephalus africanus</i>	x	x	x	x	Shrub
<i>Felicia filifolia</i> subsp. <i>schaeferi</i>	x				Shrub
<i>Helichrysum rosom</i>	x	x	x	x	Shrub
<i>Helichrysum rutilans</i>		x			Shrublet
<i>Oedera genistifolia</i>	x				Shrub
<i>Oedera squarrosa</i>	x	x			Shrub
<i>Troglophyton parvulum</i>	x	x	x	x	Annual
<i>Printzia polifolia</i>				x	Shrub
<i>Ursinia anthemoides</i>	x	x	x	x	Annual
BRASSICACEAE					
<i>Heliophila pendula</i>		x			Annual
FABACEAE					
<i>Aspalathus muraltioides</i>				x	Shrub
<i>Aspalathus recurva</i>				x	Shrub
<i>Aspalathus submissa</i>		x		x	Shrub
GERANIACEAE					
<i>Pelargonium radiatum</i>	x	x			Geophyte (cormous)
LOBELIACEAE					
<i>Cyphia digitata</i>		x			Geophyte (tuberous)
MONTINIACEAE					
<i>Montinia caryophyllacea</i>	x	x			Shrub
POLYGALACEAE					
<i>Muraltia trinervia</i>	x	x			Shrublet
RUBIACEAE					
<i>Anthospermum spathulatum</i>	x				Shrub
<i>Nenax hirta</i>	x	x		x	Shrublet

Figures 7.3 – 7.6 illustrate the post-fire regeneration in sample plots of Community 4.

The fire in community 4 was of intermediate intensity. Dead branches and stumps of large shrubs such as *renosterbos* (*Elytropappus rhinocerotis*) remained after the fire (Figure 7.3).

Aspalathus submissa, *Cyphia digitata*, *Eriospermum dielsianum* subsp. *dielsianum* *Helichrysum rutilans*, *Heliophila pendula* and *Tribolium hispidum* were constant after the fire, but not before (Table 7.2). Whilst *Aspalathus submissa*, *Cyphia digitata*, *Helichrysum rutilans*, *Heliophila pendula* and *Tribolium hispidum* are grouped with the general species for major communities 1 – 5 before the fire, *Eriospermum dielsianum* subsp. *dielsianum* was considered an important species for community 4 before the fire (Annexure 1).

Anthospermum spathulatum, *Cheilanthes hastata*, *Cyanella lutea*, *Felicia filifolia* subsp. *schaeferi*, *Restio sieberi*, *Oedera genistifolia*, *Pterygodium catholicum* and *Satyrium candidum* were constant in community 4 before the fire, but not thereafter (Chapter 4; Table 7.2). With the exception of *Cyanella lutea*, which was considered an important species in sub-community 3.2 after the fire, the other species were either grouped as important species within community 4 or as general species for major communities 1 – 5 (Annexure 3).

All the dominant species of the pre-fire data were present with some remaining dominant after the fire (Chapter 4).

Species which were not statistically significant regarding constancy and dominance before the fire, but which became dominant within the four years after the fire comprise:

- the shrub *Aspalathus muraltioides* (Figures 7.6, 7.10 & 7.11)
Before fire: an important species in community 1 (Chapter 4) and constant in sub-community 6.2 (Chapter 4)
- the shrub *A. recurva* (Figures 7.9 & 7.10)

Before fire: an infrequent species for Major Communities 1 – 5 (Annexure 1) and

- the shrub *A. submissa* (Figure 7.8)

Before fire: constant in sub-community 2.1 (Chapter 4), constant in community 7 (Chapter 4), and a general species in major communities 1 – 5 (Species Group AR, Annexure 1).

Dominant species after the fire but not before are:

- the shrub *Printzia polifolia* (Figure 7.7)

Before fire: an important species in community 4 (Chapter 4)

- the annual grass *Stipa capensis* (Figure 7.4)

Before fire: constant in sub-community 2.1 (Chapter 4) and constant as well as an important species in community 4 (Chapter 4).

Although more than half of fynbos species may resprout (from epicormic buds, lignotubers, geophytic bulbs, corms and rhizomes), many species depend on seeds for recruitment after fire (Holmes and Richardson 1999; Kruger and Bigalke 1984). In the study area, canopy storage of seeds (serotiny) is found to occur in the overstorey shrub, *Protea laurifolia*, and is also recognized in *Oedera* species of the Asteraceae family (Bond and Van Wilgen 1996). The majority of reseeders species, such as members of the Asteraceae, Rutaceae, Thymelaeaceae and the genera *Anthospermum* as well as *Aspalathus* have soil stored seeds that have biochemical inhibitors or impermeable testas or pericarps which can promote dormancy so that the seeds may remain viable on or in the soil for several years (Kruger and Bigalke 1984). Holmes and Richardson (1999) found that Fynbos species with dormant soil seed banks are cued to germinate by fire because the post fire environment provides the main opportunity for successful recruitment. The cues can be direct such as heat pulse and smoke (Brown 1993; Brown *et al.* 1994; Newton *et al.* 2005; Pierce and Moll 1994; Van Staden *et al.* 2000) or indirect such as increased soil oxygen levels due to reduced root respiration (Brits 1986) and an increase in diurnal air- as well as soil temperature fluctuation as result of vegetation removal (Frost 1984; Pierce and Moll 1994; Van Staden *et al.* 2000).

Aspalathus species became dominant in community 4 during the year following the fire (Figures 7.6, 7.9, 7.10 & 7.11) and flowered abundantly in the following years (Figure 7.11).



Figure 7.3: Community 4 just after the fire in 2009.



Figure 7.4: *Corymbium glabrum* flowering abundantly and the annual grass *Stipa capensis* dominant in sample plot 13 2009.



Figure 7.5: Community 4 in 2010 with *Oxalis glabra* flowering abundantly.

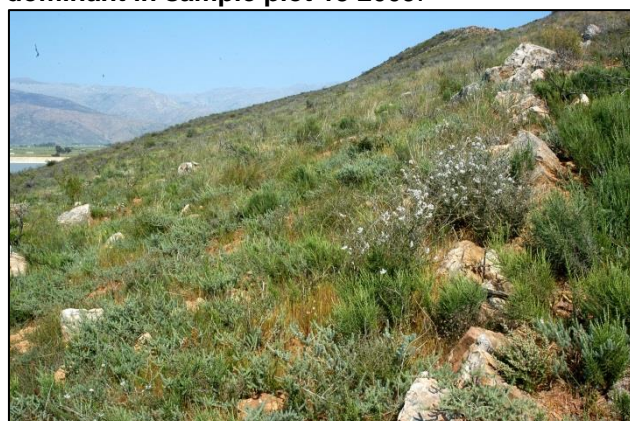


Figure 7.6: Community 4 in 2011 with *Aspalathus muraltoides*, the dominant grey-leaved shrub in the foreground.



Figure 7.7: Community 4 in 2012 with *Printzia polifolia* in seed.



Figure 7.8: Community 4 in 2013 with young *Elytropappus rhinocerotis* shrubs dominant and *Aspalathus submissa* flowering abundantly.



Figure 7.9: Community 4 in 2010 with grass species and *Aspalathus recurva* (the grey-green shrub in the foreground) dominant in the first year after the fire.



Figure 7.10: Due to the effects of fire, *Aspalathus* species such as *Aspalathus recurva* and *Aspalathus muraltioides*, the grey shrubs in the centre of the picture become dominant in community 4 in the first year after the fire.



Figure 7.11: *Aspalathus muraltioides* is well established and flowering abundantly in community 4 four years after the fire (2013).

7.1.2 The *Drosanthemum hallii*–*Passerina truncata* community

Major community 2, community 8 (Chapter 4) (Figure 7.12)

Number of relevés: 7



Figure 7.12: Sample plot 16 (community 8) in 2007 before the fire.

Diagnostic species: None

Constant species: *Adromischus filicaulis* subsp. *marlothii*, *Albuca papyracea*, *Anthospermum spathulatum*, *Babiana patula*, ***Crassula atropurpurea***, ***Drosanthemum hallii***, *Drosanthemum parvifolium*, *Elytropappus rhinocerotis*, ***Felicia filifolia* subsp. *schaeferi***, *Restio sieberi*, ***Lapeirousia pyramidalis***, *Tenaxia stricta*, ***Mesembryanthemum longistylum***, ***Oedera squarrosa***, *Othonna lingua*, *Oxalis convexula*, ***Passerina truncata***, *Pelargonium radiatum*, *Pentameris airoides* subsp. *airoides*, ***Pentameris eriostoma*** and *Satyrium erectum*.

Dominant species:

Drosanthemum hallii, *Elytropappus rhinocerotis*, *Felicia filifolia* subsp. *schaeferi*, *Restio sieberi*, *Mesembryanthemum longistylum*, *Oedera squarrosa*, *Passerina truncata* and *Pentameris eriostoma*.

A comparison of dominant and constant species before- and after the fire is given in Table 7.3.

Table 7.3: A comparison of the synoptic analyses of the pre- and post-fire data for community 8.

Species	Constant before fire	Constant after fire	Dominant before fire	Dominant after fire	Life form
IRIDACEAE					
<i>Babiana patula</i>	x	x			Geophyte (cormous)
<i>Lapeirousia pyramidalis</i>	x	x			Geophyte (cormous)
HYACINTHACEAE					
<i>Albuca papyracea</i>		x			Geophyte (bulbous)
ORCHIDACEAE					
<i>Holothrix secunda</i>	x				Geophyte (tuberous)
<i>Satyrium erectum</i>	x	x			Geophyte (tuberous)
POACEAE					
<i>Pentameris airoides</i> subsp. <i>airoides</i>		x			Perennial
<i>Pentameris eriostoma</i>	x	x		x	Perennial
<i>Tenaxia stricta</i>	x	x			Perennial
RESTIONACEAE					
<i>Restio sieberi</i>	x	x	x	x	Perennial
ASTERACEAE					
<i>Elytropappus rhinocerotis</i>		x	x	x	Shrub
<i>Felicia filifolia</i> subsp. <i>schaeferi</i>	x	x	x	x	Shrub
<i>Oedera squarrosa</i>	x	x	x	x	Shrub
<i>Helichrysum rutilans</i>	x				Shrub
<i>Othonna lingua</i>		x			Perennial
AIZOACEAE					
<i>Drosanthemum hallii</i>	x	x		x	Shrub (succulent)
<i>Drosanthemum parvifolium</i>		x			Shrub (succulent)
<i>Mesembryanthemum longistylum</i>	x	x	x	x	Annual (succulent)
CRASSULACEAE					
<i>Adromischus filicaulis</i> subsp. <i>marlothii</i>		x			Perennial (succulent)
<i>Crassula atropurpurea</i>	x	x			
GERANIACEAE					
<i>Pelargonium radiatum</i>	x	x			Geophyte (cormous)

OXALIDACEAE					
<i>Oxalis convexula</i>	x	x			Geophyte (cormous)
RUBIACEAE					
<i>Anthospermum spathulatum</i>		x			Shrub
THYMELAEACEAE					
<i>Passerina truncata</i>	x	x	x	x	Shrub

Figures 7.13 – 7.17 illustrate the post-fire regeneration in sample plots of Community 8. The fire in community 8 was of intermediate intensity. Dead branches and stumps of shrubs such as *Elytropappus rhinocerotis* and *Passerina truncata* remained after the fire (Figure 7.13).

Restio sieberi, *Felicia filifolia* subsp. *schaeferi*; *Oedera squarrosa* (Figures 7.16 & 7.17) *Mesembryanthemum longistylum* (Figures 7.14, 7.15, 7.16 & 7.17) and *Passerina truncata* (Figures 7.15 & 7.17) were constant as well as dominant before as well as after the fire (Table 7.3).

Adromischus filicaulis subsp. *marlothii*, *Albuca papyracea*, *Anthospermum spathulatum*, *Drosanthemum parvifolium*, *Elytropappus rhinocerotis* and *Othonna lingua* were constant after, but not before the fire (Table 7.3). The shrublet *Helichrysum rutilans* and the small ground orchid *Holothrix secunda* were constant before the fire, but not thereafter (Table 7.3; Chapter). The succulent shrub *Drosanthemum hallii* (Figures 7.15 & 7.17) and the perennial grass *Pentameris eriostoma* (Figures 7.16 & 7.17) were constant species before the fire, but became dominant after the fire (Table 7.3; Chapter 4).

All the species which were dominant in the analysis without the post-fire data (Chapter 4) remained dominant after the fire (Table 7.3). All of the species that became dominant within the four years after the fire, have been statistically significant species regarding constancy and dominance, before the fire (Table 7.3; Annexure 2).



Figure 7.13: Sample plot 16 just after the fire in 2009.



Figure 14: Sample plot 16 in 2010 with *Tenaxia stricta* and *Mesembryanthemum longistylum* establishing first.



Figure 7.15: *Drosanthemum hallii* flowering abundantly, *Mesembryanthemum longistylum*, *Tenaxia stricta*, *Passerina truncata* and *Restio* species establishing in sample plot 14, 2011.



Figure 7.16: Sample plot 16 in 2012 with *Elytropappus rhinocerotis*, *Mesembryanthemum longistylum*, *Oedera squarrosa* and *Pentameris eriostoma* established.

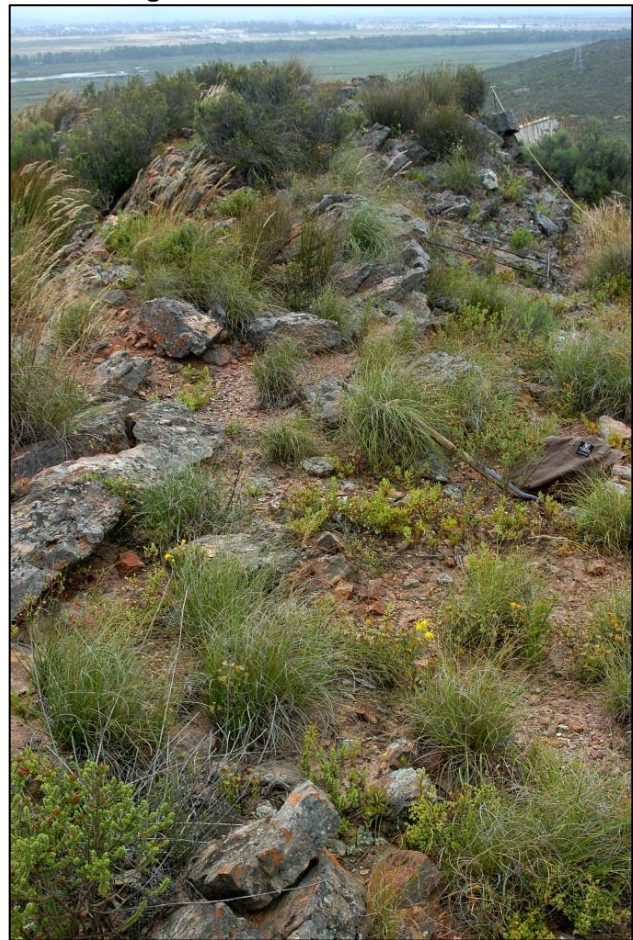


Figure 7.17: *Drosanthemum hallii*, *Mesembryanthemum longistylum*, *Oedera squarrosa*, *Passerina truncata* and *Pentameris eriostoma* dominant in sample plot 16 in 2013.

One of the dominant shrubs here, *Drosanthemum hallii* although succulent, resprouted after the fire (Figure 7.18; Hartmann and Le Roux 2011). These

shrubs, as well as young shrubs that established from seeds flowered abundantly after the fire (Figures 7.15 & 7.19).



Figure 7.18: *Drosanthemum hallii* shrubs resprouted and established from seeds, flowering abundantly (a, b & c) in the four years the area was monitored following the fire.

Just as in some species of the Poaceae, basal stem initials are protected by older stems or rise from subterranean rhizomes in Cyperaceae and in Restionaceae. Summer dormancy, and the protection of basal meristems by dead leaf-bases, enables plants to survive dry seasons and fires and exploit the post-fire period without having to establish in the community (Frost 1984). Grasses and restioids are an important fuel component of the Fynbos as their stems are usually covered in cuticular wax (Edwards 1984; Kruger and Bigalke 1984). Haaksma and Linder (2000) state that classifying the Restionaceae into reseeders and resprouters are still incomplete. In *Restio capensis* however, restoration by resprouting as well as seedling establishment was found in the study area. *Pentameris eriostoma* (Figures 7.16 & 7.17), *Ficinia nigrescens* and

Ehrharta villosa was found to be dominant after the fire and not before (Table 7.3).

7.1.3 The *Protea laurifolia*–*Passerina truncata* community

Major community 2, community 9 (Chapter 4) (Figure 7.19)

Number of relevés: 41



Figure 7.19: Sample plot 17 (community 9) in 2007 before the fire, with *Protea laurifolia* shrubs in the background and *Drosanthemum hallii* flowering in the front.

Diagnostic species: None

Constant species: *Albuca papyracea*, *Anthospermum spathulatum*, *Chrysocoma ciliata*, *Crassula atropurpurea*, *Drosanthemum hallii*, *Elytropappus rhinocerotis*, *Eriocephalus africanus*, *Felicia filifolia* subsp. *schaeferi*, *Ficinia nigrescens*, ***Oedera squarrosa***, ***Passerina truncata***, *Pentameris eriostoma* and *Searsia dissecta*.

Dominant species: *Aspalathus spicata*, *Aspalathus tuberculata*, *Drosanthemum hallii*, *Ehrharta villosa*, *Elytropappus gnaphaloides*, *Erica inaequalis*, *Eriocephalus africanus*, *Ficinia nigrescens*, *Restio gaudichaudiana*, *Restio*

sieberi, *Capeochloa arundinacea*, *Passerina truncata*, *Phylica constricta*, *Phylica rogersii*, *Protea laurifolia*, *Pteronia fasciculata* and *Thesium strictum*.

A comparison of dominant and constant species before- and after the fire is given in Table 7.4.

Table 7.4: A comparison of the synoptic analyses of the pre- and post-fire data for community 9.

Species	Constant before fire	Constant after fire	Dominant before fire	Dominant after fire	Life form
CYPERACEAE					
<i>Ficinia nigrescens</i>		x		x	Perennial
HYACINTHACEAE					
<i>Albuca papyracea</i>		x			Geophyte (bulbous)
ORCHIDACEAE					
<i>Satyrium erectum</i>	x				Geophyte (tuberous)
POACEAE					
<i>Capeochloa arundinacea</i>			x	x	Perennial
<i>Ehrharta villosa</i>				x	Perennial
<i>Pentameris eriostoma</i>	x	x			Perennial
RESTIONACEAE					
<i>Restio gaudichaudiana</i>			x	x	Perennial
<i>Restio sieberi</i>	x		x	x	Perennial
ANACARDIACEAE					
<i>Seersia dissecta</i>	x	x			Shrub
ASTERACEAE					
<i>Chrysocoma ciliata</i>	x	x			Shrublet
<i>Elytropappus gnaphaloides</i>			x	x	Shrub
<i>Elytropappus rhinocerotis</i>	x	x			Shrub
<i>Eriocephalus africanus</i>		x	x	x	Shrub
<i>Felicia filifolia</i> subsp. <i>schaeferi</i>	x	x			Shrub
<i>Oedera squarrosa</i>	x	x			Shrub
<i>Pteronia fasciculata</i>			x	x	Shrub
AIZOACEAE					
<i>Drosanthemum hallii</i>		x		x	Shrub (succulent)

ERICACEAE					
<i>Erica inaequalis</i>			x	x	Shrublet
CRASSULACEAE					
<i>Crassula atropurpurea</i>	x	x			Shrublet (succulent)
FABACEAE					
<i>Aspalathus spicata</i>				x	Shrub
<i>Aspalathus tuberculata</i>			x	x	Shrub
PROTEACEAE					
<i>Protea laurifolia</i>			x	x	Small tree
RHAMNACEAE					
<i>Phylica constricta</i>			x	x	Shrublet
<i>Phylica rogersii</i>			x	x	Shrub
RUBIACEAE					
<i>Anthospermum spathulatum</i>	x	x			Shrub
THYMELAEACEAE					
<i>Passerina truncata</i>	x	x	x	x	Shrub
SANTALACEAE					
<i>Thesium strictum</i>				x	Shrub

Figures 7.20 – 7.25 illustrate the post-fire regeneration in sample plots of Community 8. The fire in community 9 was of intermediate intensity. Dead branches and stumps of shrubs such as *Protea laurifolia* remained after the fire (Figure 7.20).

Albuca papyracea, *Drosanthemum hallii*, *Eriocephalus africanus* and *Ficinia nigrescens* were constant after the fire but not before, while *Restio sieberi* and the ground orchid *Satyrium erectum* were constant before the fire but not thereafter (Table 7.4).

While all the species which were dominant before the fire remained to be dominant after the fire, the following species only became dominant after the fire (Table 7.4):

- the shrub *Aspalathus spicata* (Figure 7.25)

Before the fire: an important species for sub-community 9.1 (Species group V) (Annexure 1); a constant species for sub-community 6.2 (Chapter 4) and an important species for sub-community 10.2 (Chapter 4) (Annexure 1).

- the succulent shrub *Drosantherum hallii* (Figure 7.23)

Before fire: a constant species in sub-community 3.3 variant iii (Chapter 4); an important species in major community 2 (Chapter 4); a constant species in community 8 (Chapter 4); a constant species in sub-community 9.1 variant i (Chapter 4); a constant species in sub-community 9.3 (Chapter 4); and a constant species in sub-community 11.2 (Chapter 4) (Annexure 1).

- the perennial grass *Ehrharta villosa* (Figures 7.21 & 7.22)

Before fire: a dominant species for Major community 1 (Chapter 4); a dominant species in community 2 (Chapter 4); a dominant species in sub-community 2.2 (Chapter 4); a dominant species in community 3 (Chapter 4); a dominant species in sub-community 3.3 (Chapter 4); a dominant species in sub-community 3.3 variant i; a constant species in sub-community 6.2 (Chapter 4); a constant species in sub-community 9.1 (Chapter 4); a constant species in sub-community 9.1 variant ii; a constant species in sub-community 9.1 variant iii; a constant species in sub-community 9.2 (Chapter 4); a constant species in major community 5 (Chapter 4); a constant species in community 15 (Chapter 4) and a general species for major communities 1-5 (Annexure 1).

- the perennial sedge *Ficinia nigrescens*

Before fire: a constant species in community 6 (Chapter 4); a constant species in sub-community 6.1; a constant species in sub-community 6.2; a constant species in sub-community 9.1 variants ii and iii (Chapter 4) and a general species for major communities 1-5 (Species Group AR, Annexure 1).

- the broom-like shrub *Thesium strictum* (Figure 24)

Before fire: an important species for sub-community 9.1 (Annexure 1; Chapter 4)



Figure 7.20: Sample plot 17 just after the fire in April 2009.



Figure 7.21: Sample plot 17 in October of 2009 with *Ehrharta villosa* and *Helichrysum hebelepis* establishing first. *Geissorhiza confusa* is flowering abundantly.



Figure 7.22: Sample plot 17 in September 2010 with *Ehrharta villosa* dominant, but shrubs such as *Passerina truncata* starting to re-establish in the area.



Figure 7.23: Sample plot 17 in September 2011 with *Drosanthemum hallii* re-established and flowering abundantly.



Figure 7.24: Sample plot 17 in November 2012 with seedlings of *Protea laurifolia* as well as other dominant shrubs such as *Thesium strictum*, *Passerina truncata*, *Eriocephalus africanus* and the grass *Capeochloa arundinacea* established.



Figure 7.25: Sample plot 17 in November 2013 with well-established vegetation cover after the fire four years earlier. The yellow flowering shrub in the foreground is *Aspalathus spicata*, which became a dominant species after the fire.

Bond and Van Wilgen (1996) noted that heat-stimulated germination of legume seeds can fail if a fire was of low intensity. The intensity of the fire in this study, although low-intermediate, was sufficient enough to have caused germination of seeds of species of the Fabaceae. Seedlings of *Aspalathus spicata* (Figure 7.25) established early in the restoration phase resulting in the species having an increased cover and abundance after fire compared to before (Annexures 1 & 3). The dominance of *Aspalathus* species after fire in this study agrees with that from a study of pyric succession in Costal Renosterveld, Levyns (1935) that seedling species of *Aspalathus* dominated a burned stand after the third or fifth year following fire. Cover and abundance of *A. tuberculata* and *Indigofera* sp. nov. cf. *angustifolia* (Chapter 5, section 1.8.4, Figures 5.28 & 5.29) also increased markedly after the fire. Where the re-establishment of *A. tuberculata* was found to occur from seed only, established seedlings as well as a large number of resprouting shrublets (especially where the fire burned at low intensity) were found for *Indigofera* sp. nov. cf. *angustifolia*.

In a study about post-fire succession in selected fynbos communities of the South-western Cape, Kruger (1987) lists four *Thesium* species as common fire ephemerals. In this study *Thesium strictum* became dominant in the post-fire environment of communities 8 and 9 (Table 7.4; Figure 24).

7.2 LIFE FORMS

The synoptic analyses of the pre- and post-fire relevés included a total of 66 species which are significant regarding pre- and post-fire constancy and dominance. The larger part, comprising 36 of the species were constant before as well as after the fire (Tables 7.2 – 7.3). Of the 66 species contained in the synoptic analysis, the most constant life form before as well as after the fire was the shrubs (16.67%), followed by the perennials (12.12%), the geophytes (10.61%), annuals (9.09%) and shrublets (6.06%) (Figure 7.26).

Ten species were constant before the fire but not thereafter, while 16 species were constant after the fire, but not before (Tables 7.2 – 7.3). Of these, the geophytic life form dominated constancy before the fire (7.58%), followed by

the perennials and the shrubs in equal proportions (3.03%) and the shrublets (1.52%) (Figure 7.26). The shrub life form dominated constancy after the fire (9.09%), followed by the perennials (7.58%), the geophytes (4.55%), the annuals (3.03%) and the shrublets (1.52%) (Figure 7.26).

Twenty-two species were dominant before as well as after the fire (Tables 7.2 – 7.3). Of the 66 species contained in the synoptic analysis, the shrub life form was dominant before as well as after the fire (15.15%), followed by the perennials (7.58%), the annuals (6.06%), the shrublets (3.03%) and one small tree (1.52%). None of the geophytes were dominant before and/or after the fire (Figure 7.26).

Of the new species dominant after fire, the shrub life form was the most dominant (10.61%), followed by the perennials (4.55%) and the annuals and shrublets in equal proportions (1.25%). None of the geophytes were dominant after the fire (Figure 7.26).

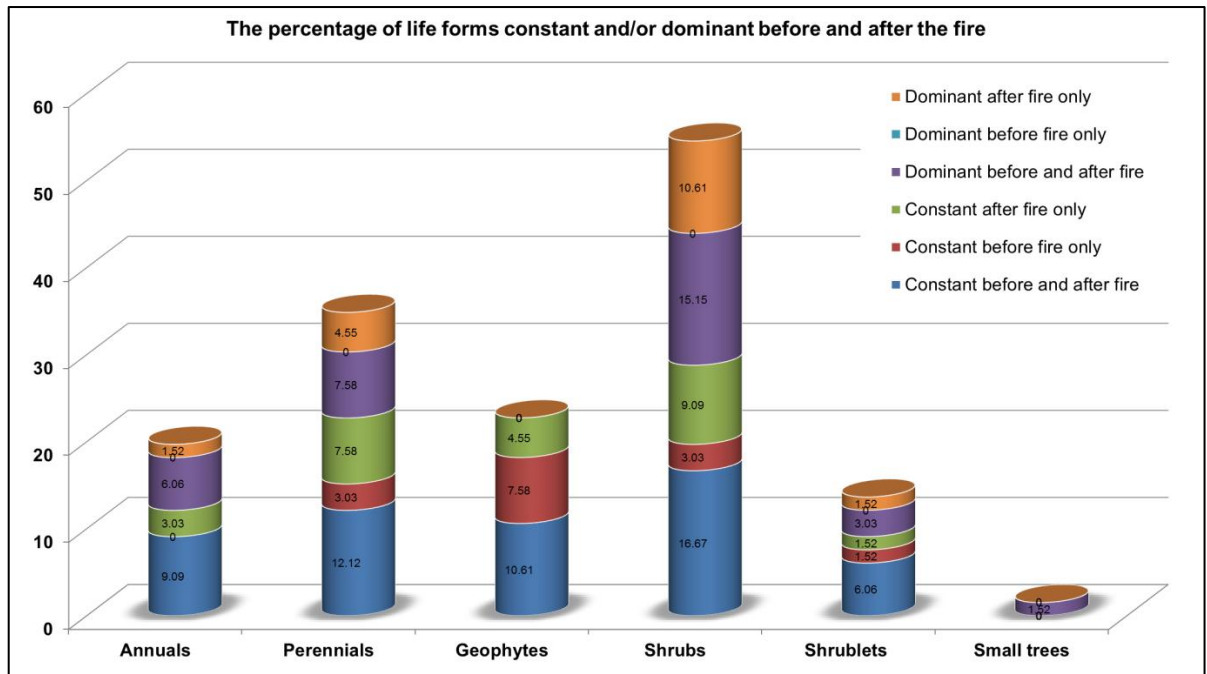


Figure 7.26: The percentage of life forms of the species which synoptic analyses showed to be significant regarding pre- and post-fire constancy and dominance.

The larger part of the species regarded to be significant in dominance and constancy in the synoptic analysis were constant as well as dominant before and after the fire (Figure 7.26). Apart from the geophytes, the sum of the percentages of all the other life forms that were constant only before the fire and those after the fire only, are lower compared to those that were constant before as well as after the fire (Figure 7.26).

Grasses and restios comprise the largest percentage of the perennials in this study (Tables 7.2 – 7.3). Although the shrub life form dominated the post-fire environment in the four years after the fire, annual and perennial grasses were dominant in the first year after the fire (Figures 7.4, 7.14, 7.15, 7.16, 7.17 & 7.22; Annexure 3). This is similar to a study about growth-form responses to fire in the Nama-Karoo escarpment grassland, where Kraaij *et al.* (2017) found that fire caused an increase of grass cover.

7.3 SPECIES CONSTANCY AND DOMINANCE BEFORE- AND AFTER FIRE

Species constant and dominant before as well as after fire:

Elytropappus rhinocerotis, *Erioccephalus africanus*, *Helichrysum rosum*, *Mohria caffrorum*, *Pentameris airoides* subsp. *airoides*, *Tenaxia stricta* (Figures 7.14 & 7.15), *Troglophyton parvulum* and *Ursinia anthemoides* were constant as well as dominant before and after the fire in community 4 (Table 7.2). *Felicia filifolia* subsp. *schaeferi*, *Mesembryanthemum longistylum* (Figures 7.14 & 7.15), *Oedera squarrosa* (Figures 7.16 & 7.17), *Passerina truncata* (Figures 7.19, 7.15, 7.17) and *Restio sieberi* were constant as well as dominant before and after the fire in community 8 (Table 7.3). *Passerina truncata* was constant as well as dominant before and after the fire in community 9 (Table 7.4; Figure 7.23).

Species constant before as well as after the fire, but only dominant after the fire:

Nenax hirta, and *Stipa capensis* were constant before as well as after the fire in community 4, but the species became dominant here after the fire (Table 7.2;

Figure 7.4). However *Drosanthemum hallii* and *Pentameris eriostoma* were constant before as well as after the fire in community 8, the species became dominant here after the fire (Table 7.3; Figure 7.17).

Species constant before as well as after the fire, but never dominant:

Babiana patula, *Berkheya armata*, *Ehrharta capensis*, *Lichtensteinia interrupta*, *Montinia caryophyllacea*, *Muraltia trinervia*, *Oedera genistifolia*, *Oedera squarrosa*, *Pelargonium radiatum*, *Pterygodium alatum*, *Restio capensis*, *Satyrium erectum*, *Tribolium utriculosum* and *Wurmbea variabilis* were constant in community 4 before as well as after the fire, but never dominant (Table 7.2).

Babiana patula, *Crassula atropurpurea*, *Lapeirousia pyramidalis*, *Oxalis convexula*, *Pelargonium radiatum*, *Satyrium erectum* and *Tenaxia stricta* were constant in community 8 before as well as after the fire, but never dominant here (Table 7.3).

Anthospermum spathulatum, *Chrysocoma ciliata*, *Crassula atropurpurea*, *Elytropappus rhinocerotis*, *Felicia filifolia* subsp. *schaeferi*, *Oedera squarrosa*, *Pentameris eriostoma*, *Searsia dissecta* were constant in community 9 before as well as after the fire, but never dominant (Table 7.4).

Species only constant before the fire, but dominant before as well as after the fire:

In communities 4 and 9, *Restio sieberi* was found to be dominant before as well as after the fire, however the species was not found to be constant after the fire (Tables 7.2 – 7.3).

Species constant before the fire, but not after the fire and never dominant:

In community 4, *Cheilanthes hastata*, *Anthospermum spathulatum*, *Cyanella lutea*, *Felicia filifolia* subsp. *schaeferi*, *Pterygodium catholicum* and *Satyrium candidum* were only found to be constant before the fire (Table 7.2).

Helichrysum rutilans and *Holothrix secunda* were only found to be constant before the fire in community 8 (Table 7.3), while *Satyrium erectum* was only found to be constant before the fire in community 9 (Table 7.2).

Species not constant before the fire, but constant after the fire and dominant before as well as after the fire:

However, *Elytropappus rhinocerotis* was constant in communities 8 and 9 only after the fire (Figure 7.16), but dominant before as well as after fire (Tables 7.3 and 7.4).

Species constant and dominant after the fire, but not before the fire:

Aspalathus submissa was constant as well as dominant after (Figure 7.8), but not before the fire in community 4 (Table 7.2) where *Drosanthemum hallii* and *Ficinia nigrescens* were constant as well as dominant after, but not before the fire in community 9 (Table 7.4).

Species only constant after the fire (not before), but never dominant:

In community 4, *Helichrysum rutilans*, *Heliophila pendula*, *Cyphia digitata*, *Eriospermum dielsianum* subsp. *dielsianum* and *Tribolium hispidum* were constant after, but not before the fire (Table 7.2).

In community 8, *Othonna lingua*, *Adromischus filicaulis* subsp. *marlothii*, *Albuca papyracea*, *Anthospermum spathulatum*, *Drosanthemum parvifolium*, *Pentameris airoides* subsp. *airoides* were constant after, but not before the fire (Table 7.3).

In community 9, *Albuca papyracea* was constant after, but not before the fire (Table 7.4).

Species dominant before as well as after the fire, but never constant:

In community 9, *Aspalathus tuberculata*, *Capeochloa arundinacea*, *Elytropappus gnaphaloides*, *Erica inaequalis*, *Phylica constricta*, *Phylica rogersii*, *Protea laurifolia*, *Pteronia fasciculata* and *Restio gaudichaudiana* were constant, as well as dominant after, but not before the fire (Table 7.4).

Species only dominant after the fire (not before), and never constant:

In community 4, *Printzia polifolia* (Figure 7.7), *Aspalathus muraltioides* (Figures 7.6, 7.10 and 7.11) and *Aspalathus recurva* were only dominant after the fire

(Table 7.2; Figures 7.9 & 7.10). In community 9, *Ehrharta villosa*, *Aspalathus spicata* and *Thesium strictum* were only dominant after the fire (Table 7.4).

7.4 CONCLUDING REMARKS

Kruger (1984) points out that species dominance is affected by fire. Where mature stands in fynbos- and renosterveld communities are often dominated by a few species, after fire biomass is usually distributed more uniformly (Kruger 1984). This is supported partially by the findings of this study where the cover and abundance of some previously dominant species was reduced, although still remaining dominant, while the cover abundance of other species increased considerably after the fire (Annexures 1 & 3).

Various studies interpret the effects of fire in terms of secondary succession following the disturbance of a previously vegetated site (Kruger 1984). Given the circumstances that the study area had not burned in 70+ years, together with lack of grazing, the before-fire plant community of the sample area most likely had reached the climatic climax state (Kruger 1984; Figure 7.2; Figure 7.12; Figure 7.19).

The fire in this study directly affected plant growth, recruitment and reproduction. Most species were stimulated by the fire to show improved vitality, flowering, seed germination and seedling recruitment. Vegetation height was reduced, but more of the surface area was covered after fire (Annexure 3). Good rains received during the first growing season (2009) (Figure 7.27) immediately after fire most likely provided a favourable start for germination of seeds and all over re-establishment of the vegetation. It is therefore believed that the good season following the fire facilitated ample recruitment, prolific growth, abundant flowering and ample seed production for most species so that even in the relatively dry growing season of 2010 (Figure 7.28) high canopy cover was found for most of the species (Annexure 3).

The rain received in October 2009 (Figure 7.27) could furthermore have played a significant role in the post-fire response of some plants, especially the

geophytes (Figure 7.28). Rossa and Von Willert (1999) state that “aseasonal rainfalls which allow a refill of the water store play a dominating if not the crucial role for the survival and also for the abundance of geophytes.”

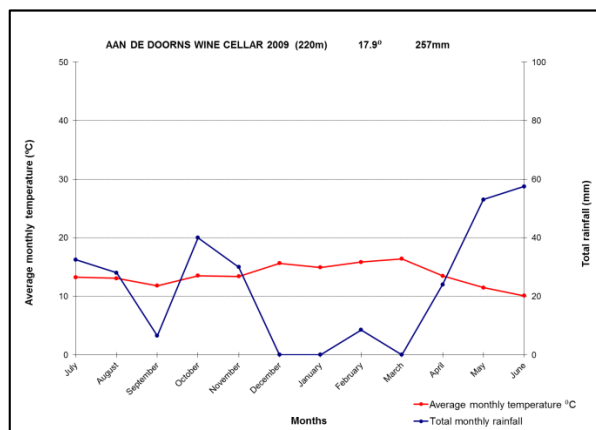


Figure 7.27: A climate diagram for Aan-de-Doorns Wine Cellar for 2009 (Agromet-ISCW).

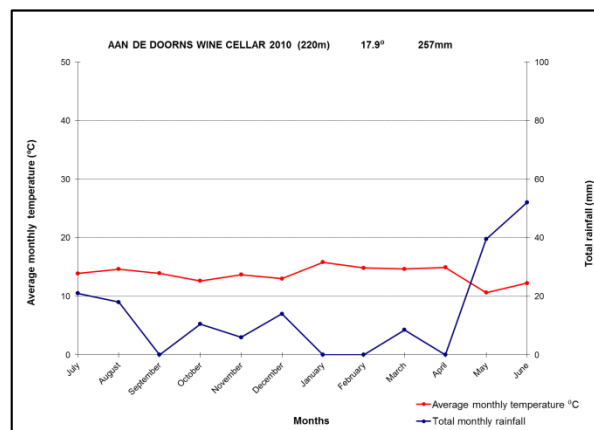


Figure 7.28: A climate diagram for Aan-de-Doorns Wine Cellar for 2010 (Agromet-ISCW).

Fire stimulated flowering is especially common in monocotyledons (Bond and Van Wilgen 1996). Most of these species are geophytes as their ability to survive fires, as well as the presence of underground energy and nutrient reserves, predispose them to flowering soon after fire (Figure 7.29). This rapid response presumably enables such species to make use of pollinators and set seed in the period before other plants have begun to recover after the fire (Frost 1984). Plants that primarily flower after fire must be able to attract suitable pollinators as maximum seed production is essential given that such plants appear at irregular intervals (Frost 1984). The stimulus for flowering in fire-adapted geophytes is not fully understood, but probably relates to changes in daily soil-temperature fluctuations, better light penetration, the physical and chemical characteristics of the soil and reduced competition from other plants (Cowling *et al.* 1995; Frost 1984). The flowers of *Corymbium glabrum* var. *glabrum* was not seen on the northern perimeter of the dam until the species flowered profusely in the first season, as well as in the second year after the fire (Figure 7.4). A *Satyrium coriifolium* x *S. erectum* hybrid was observed for the first time in community 4 after the fire (Figure 7.28 n). This marked post-fire flowering response is in agreement with previous reports of *Corymbium* flowering prolifically after fire and less so at other times (Frost 1984).



Figure 7.29: Amongst other, geophytic species which flowered abundantly after the fire are *Disa satyroides* (a), *Mesembryanthemum grossum* (b), *Oxalis pardalis* (c), *Tritonia crista* (d), *Watsonia spectabilis* (e), *Gladiolus guthriei* (f), *Colchicum variabilis* (g), *Tritoniopsis ramosa* (h), *Moraea vuvuzela* (i), *Gladiolus floribundus* (j), *Moraea neglecta* (k), *Lapeirousia micrantha* (l), *Geissorhiza confusa* (m) and *Satyrium coriifolium* (orange flowers) including a *S. coriifolium* x *S. erectum* hybrid (n).

Aspalathus submissa flowered abundantly after the fire in community 4 (Figure 7.29 a), *Arctotis acaulis* in community 9 (Figure 7.29 b), *Othonna lingua* in

communities 8 & 9 (Figure 7.29 c) and *Othonna digitata* in community 4 (Figure 7.29 d). The annuals *Phyllopodium capillare* (Figure 7.29 e) and *P. heterophyllum* (Figure 7.29 f) showed improved vitality and better flowering after the fire. Geophytes such as *Disa satyroides* (Figure 7.29 g) and *Lachenalia pustulata* (Figure 7.29 h) also utilised the post-fire environment to increased recruitment. The perennial carnivorous *Drosera cistiflora* (Figure 7.29 i) was observed in large numbers and flowered prolifically after the fire. *Pteronia hirsuta* (Figure 7.29 j) and *Perdicium capense* (Figure 7.29 k) were never seen to be flowering during data collection before the fire. The geophytic *Cyphia* species, such as *C. volubilis* (Figure 7.2 l) also flowered abundantly after the fire.

Figure 7.30 provides other species that showed remarkable growth and flowering after the fire. Species noted only after the fire are most likely the species that are sensitive to competition and those that require open spaces, light, heat, nutrients, available moisture or other qualities of a post-fire environment for efficient recruitment, or species that were directly or indirectly stimulated by fire to regenerate or rejuvenate. Such species may however have been missed in data collection before the fire due to underdevelopment as result of competition. Geophytes which were noticed for the first time after the fire such as *Othonna bulbosa*, *Euphorbia silenifolia* (Figure 7.31), *Euphorbia tuberosa* (Figure 7.31), *Pelargonium luteolum*, *P. rapaceum*, *Caesia contorta*, *Albuca juncifolia*, *Ferraria variabilis* and *Oxalis* species, have been missed during data collection before due to being inconspicuous or underdeveloped as a result of the shade of dominant plants before the fire (Annexures 1 & 3). Although most geophytes of the Iridaceae flowered prolifically after the fire, the flowers of *Watsonia spectabilis* (Figure 7.29 e) and *Gladiolus guthriei* (Figure 7.29 f) were only after the fire noticed for the first time in Sampling Plot 17. This corresponds to the statement of Kruger and Bigalke (1984) that *Watsonia* populations respond strongly in producing inflorescence after fire in the 'right' season.





Figure 7.30: Species that showed remarkable growth and flowering after the fire are: *Aspalathus submissa* (a), *Arctotis acaulis* (b), *Othonna lingua* (c), *Othonna digitata* (d), *Phyllopodium capillare* (e), *Phyllopodium heterophyllum* (f), *Disa satyroides* (g), *Lachenalia pustulata* (h), *Drosera cistiflora* (i), *Pteronia hirsuta* (j), *Perdicium capense* (k) and *Cyphia volubilis* (l).

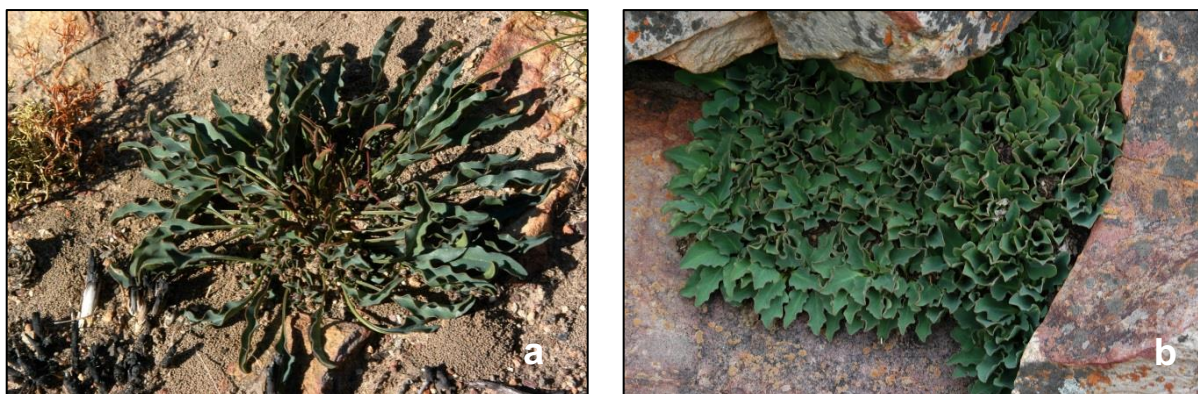


Figure 7.31: Due to the effects of fire, geophytes such as *Euphorbia silenifolia* and *E. tuberosa* grew much more vigorously in the year after the fire than before.

Seeds of species noted before but not after the fire were most likely either influenced by seed predation and/or removal by insects such as ants, or were destroyed in the fire. The seeds of such species may furthermore have been lost from the soil bank or diminished in vigour because of the long interval without fire, or have characters such as seed dormancy that is only broken by particular cues, or have special requirements for re-establishment that are met at a later stage of community development (Frost 1984).

Where *Protea laurifolia* re-established from seeds after the fire (Figure 7.24), *P. nitida* resprouted in sample plot 15 (Figure 7.32). Although showing a decrease in cover abundance, *Erica inaequalis* (an important shrub in community 9, Chapter 4) showed prolific flowering in the year after the fire. Most *Erica* species in the Cape Floristic Region are reseederers with resprouting after fire being uncommon (Ojedae 1998). *E. inaequalis* is known to be a reseeding species (Dr E.G.H Oliver¹ pers. comm.), but some of the *E. inaequalis* shrubs were found to have resprouted in areas where the fire intensity was low (Figures 7.33 & 7.34). *Passerina truncata* also resprouted in the first season following the fire (Figure 7.35).

According to Kruger and Bigalke (1984) fire intensity influences vegetation structure and dynamics in the following way: High intensity fires would likely cause an abnormally high mortality among sprouting plants, be advantageous to seeding species. The germination of hard-seeded species (such as

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Aspalathus and *Anthospermum* spp., but also other members of the Fabaceae, Rutaceae and Thymelaeaceae) will be favoured as scarification by fire could decrease the water-resistance of the seed coat to facilitate water uptake for germination (Bond and Van Wilgen 1996).



Figure 7.32: *Protea nitida* (sample plot 15) was found resprouting after the fire.



Figure 7.33: Although *Erica inaequalis* re-established from seeds after the fire, several resprouting shrubs were also found.



Figure 7.34: *Erica inaequalis* and *Indigofera* sp. nov. cf. *angustifolia* resprouted after the fire.



Figure 7.35: *Passerina truncata* resprouting during the growing season following the fire.

Abnormally high fire intensities could change plant composition toward an increased woody component, especially seeding shrubs, where abnormally low

intensities would likely favour the graminoid and restioid component over woody elements. The effects of a fire with average intensity would be intermediate between these extremes (Kruger and Bigalke 1984). In this study, *Anthospermum spathulatum* (Rubiaceae) increased markedly as many established seedlings were found in the first year after the fire (Annexure 3). Dormancy of *Anthospermum* species relates to the inability of the seed to take up water due to an impermeable seed coat. The seeds need some form of scarification to reduce impermeability and promote water uptake for germination (Bond and Van Wilgen 1996, Kruger and Bigalke 1984). The abundance of *A. spathulatum* seedlings after the fire can in all probability be ascribed to the intensity of the fire. that recruitment of other members of the Fabaceae, Rutaceae and Thymelaeaceae occurs by seed, resprouting was also found in *Drosanthemum hallii*, *Indigofera* sp. nov. cf. *angustifolia* (Figure 32), *Agathosma* species, and *Passerina truncata* (Figure 7.35), especially where fire in the study area was of low intensity.

Kruger and Bigalke (1984) also noted that in addition to the graminoid- and restioid component, the recruitment of seeding shrubs is promoted by fire of intermediate intensity. *Agathosma* (Rutaceae), *Aspalathus* and *Indigofera* (Fabaceae), *Passerina* and *Struthiola* (Thymelaeaceae), together with recruitment of grasses and restios (Figures 7.14 & 7.15), in the study area, support the fact that the fire was of intermediate intensity. In contrast with the statement of Kruger and Bigalke (1984)

Dr Koos Roux² examined the abnormal leaves of resprouting *Passerina truncata* shrubs (Figure 7.36). A possible explanation for abnormal new growth may be a result of callus forming due to the cambium being exposed to heat and smoke from the fire. A result of such influences may be that the growth develops exceptionally fast and is then atypical of normal growth. The new atypical growth does not last very long and dies off rapidly as it uses available

² Former curator: Compton Herbarium (NBG & SAM), South African National Biodiversity Institute, Private Bag X7, Claremont, 7735Cape Town, South Africa.

moisture and nutrients in the damaged plants so that further development does not occur (Figure 7.36) (Dr K Roux, pers. comm.).



Figure 7.36: Abnormal resprouting growth was found in *Passerina truncata* after the fire



Figure 7.37: The abnormal growth on *Passerina truncata* does not develop further.

Two genera, *Satyrium* and *Holothrix*, represent the Orchidaceae in the study area. Members of the Orchidaceae are classified as plants that flower shortly after fire and rarely at other times (Kruger and Bigalke 1984). This statement somewhat relates to the findings for *Satyrium erectum*, *S. coriifolium* (Figure 7.29) and *S. candidum* (Figure 7.39), but not to findings for the *Holothrix* species (Annexures 1 & 3). The absence of *Holothrix* may however relate to the dry growing season (Figure 7.28) and may not be a result of the effects of fire.

The density of a reseeded species, *Protea laurifolia* (Figure 7.19) increased while relative area covered by the species stayed the same due to the high number of young plants (established seedlings) present in the post-fire environment. Although most of the dead material in the study area was

removed by the fire, not all *P. laurifolia* shrubs were killed. An adaptation to scorching avoidance is apparent in the growth form of this species where shoots and foliage are most likely protected by the shape of the crown which appears to deflect the heat of a fire while the cambium is protected by thick bark (Bond and Van Wilgen 1996; Frost 1984; Kruger and Bigalke 1984).



Figure 7.38: *Satyrium candidum* flowering abundantly after the fire in community 4, September 2011.

The relationship between plant height and flame height is one of the factors relating to the extent to which a plant is damaged by fire (Frost 1984). The fact that not all *P. laurifolia* shrubs were killed by the fire, along with the prevalence of burned stumps of those that were killed, is symptomatic of the relative low-intermediate intensity of the fire.

Post-fire recruitment of *P. restionifolia* occurred from regrowth as well as from seeds which were released within days following the fire (Figure 7.39). Prolific regrowth was noticed for *P. restionifolia* already in the first growing season after the fire, and established seedlings were noticed, mostly not far from parent

plants, one year after the fire (Figure 7.40). The plants flowered abundantly in the years following the fire (Figure 7.41).



Figure 7.39: *Protea restionifolia* seeds just after the fire in April 2009.



Figure 7.40: *Protea restionifolia* had resprouted and re-established from seeds at the end of 2010.



Figure 7.41: *Protea restionifolia* flowering abundantly in October 2013.

The serotinous fruits of *P. laurifolia* are retained within the flowerheads on the plant after the ripening period and are released when water supply to the stem stops. This happens when the plant dies or is killed by fire (Bond and Van Wilgen 1996; Frost 1984; Rebelo 2001). Carpets of seeds, released from *P. laurifolia* cones was found to cover the soil at the feet of parent plants within eight days after the fire (Figures 7.42 & 43). Some of the newly released *Protea* seeds were collected by termites and carried to underground nests in adjacent unburned vegetation (Figure 7.44). Established seedlings of *P. laurifolia* were noticed in the second growing season (September 2010) following the fire (Figure 7.45).



Figure 7.43: Carpets of seeds released from *Protea laurifolia* flowerheads were noticed within eight days after the fire in April 2009.



Figure 7.42: *Protea laurifolia* seeds.



Figure 7.44: Some of the newly released *Protea* seeds were carried to underground nests by termites in an unburned patch of vegetation adjacent to sampling plot 17.



Figure 7.45: Seedlings of *Protea laurifolia* were well established in November 2012.

In a study of seed biology and co-existence of two obligate reseeding fynbos species (with recruitment from hard-coated and soil stored seeds) in Dune Asteraceous Fynbos near Cape Agulhas, Kilian and Cowling (1992) found that *Passerina paleacea* produced much more seeds and maintained considerably larger soil seed banks than *Phylica ericoides*. The seeds of both species showed a high degree of dormancy, although germination was found to be stimulated by direct fire-related cues for the *Phylica* only (Kilian and Cowling 1992). Seeds of both species germinated after fire, “but approximately 4 x more *Passerina* seedlings than the *Phylica* seedlings were counted at the end of the winter germination period after a mild autumn fire” (Kilian and Cowling 1992). The authors furthermore suggest that *Phylica ericoides* demonstrated fire-stimulated germination and greater drought tolerance, while germination of the *Passerina* was cued to the removal of vegetation cover and exposure of the soil surface. In contrast with the post-fire response noted for *Phylica ericoides* (Kilian and Cowling 1992), no seedlings of *Phylica rogersii* were noticed in the study area one year after the fire (Annexure 3). According to Kilian and Cowling (1992), hot summer fires would promote *Phylica* seed germination, while cool spring fires result in the almost complete disappearance of *P. ericoides*. The low-intermediate intensity of the fire in this study, together with probability of myrmecochory (seed dispersal by ants), could possibly explain the absence of *P. rogersii* seedlings soon after the fire (Annexure 3). Seed predation in Fynbos is generally high (Kilian and Cowling 1992; Pierce and Cowling 1991). Amongst other species, germination of *Phylica* seeds in the burned area could be influenced by seed reduction/removal if preyed on by rodents that find shelter in the unburned patch adjacent to the study area, or if carried from the burned area to the unburned patches by termites or ants, as myrmecochory is known to occur in elaiosome-bearing *Phylica* species (Kilian and Cowling 1992; Pierce and Cowling 1991).

Hard-seededness, where dormancy is due to an impermeable seed coat, is found in species of the Rhamnaceae (Bond and Van Wilgen 1996, Kilian and Cowling 1992). The trait is not considered to be a unique adaptation to fire as other means of scarification may also break seeds. Here however, low-intermediate fire intensity could have played a role in the delay of re-

establishment of *P. rogersii* which possibly needs a hotter fire, or have requirements for germination that are met at later stage of community development. The establishment of a high number of seedlings of *P. rogersii* species was observed following an accidental summer fire in an adjacent part of the study area (personal observation, A. le Roux unpublished data).

Although Kilian and Cowling (1992) found that germination of *Passerina paleacea* was not stimulated by direct fire-related cues, the authors observed that seed germination was favoured by cool fires. If *Passerina truncata* possesses similar re-establishment traits than those found for *P. paleacea* by Kilian and Cowling (1992), the low- intermediate intensity of the fire in this study could relate to the abundance of *P. truncata* seedlings together with the absence of *Phyllica rogersii* seedlings (Figure 7.24). In contrast with the reseeding trait of *P. paleacea* (Kilian and Cowling 1992), resprouting *P. truncata* plants were furthermore found in areas where the fire burned at low intensities (Figure 7.35).

The dominance of *Passerina truncata* before the fire could possibly have contributed to the flammability of this plant community (Annexure 1). Van Wyk and Gericke (2000) make mention of the use of *P. filiformis* to heat up ovens. The vernacular name, “windmakerbos”, is said to be derived from the remarkable blaze produced when the bush is set alight. *P. vulgaris* (bakkersbos) was similarly used for rapidly heating up outside ovens (Van Wyk and Gericke 2000). Mucilaginous cell walls are common in the Thymelaeaceae, but in an advanced state especially in *Passerina* species where the phenomenon is considered an adaptation to survive the dry warm summers typical of the Mediterranean climate of the Cape Floristic Region (Bredenkamp and Van Wyk 1999). In the dry season, apart from having small ericoid leaves, the flammability of the above mentioned *Passerina* species, as well as the one growing in the study area, *P. truncata*, (personal observation), may possibly indirectly relate to the presence of mucilage (a gelatinous substance which absorbs water and increases in bulk). Fahn (1988) state that carbohydrate mucilages and gums have been suggested to play a role in the secretion of lipophilic substances.

Although they were noticed in the surrounding area before, four species of the Aizoaceae, two annuals *Cleretum papulosum* subsp. *papulosum* and *Cleretum bellidiforme* as well as the shrubs *Drosantherum parvifolium* (known to grow in disturbed places – Goldblatt and Manning 2000) and *Ruschiella lunulata* were only noticed in the sampling plot after the fire, with a considerable increase in relative canopy cover (Annexures 1 & 3). As seed of most genera of the Aizoaceae are stored in hyrochastic capsules, seed dispersal is usually limited to wet conditions and closely related to the opening of the capsule through moisture as seeds are in most cases expelled from open capsules by raindrops (Smith *et al.* 1998). Seeds dispersed by ballistic means are not moved long distances from the parent plants (McDonald 1995) and recruitment of *Drosantherum parvifolium* (which flowered prolifically after the fire) most likely occurred from the soil seed bank, where the post-fire environment likely provided optimum conditions to facilitate re-establishment.

Another succulent that resprouted fairly quickly after the fire is *Tylecodon paniculatus*. The burnt succulent stems had already resprouted after the first growing season after the fire in 2009 (Figure 7.46).



Figure 7.46: *Tylecodon paniculatus* (with *Haemanthus coccineus* flowering) in the week after the fire, April 2009 (a) and already resprouting in September that same year (b).

Bond *et al.* (1984) state that natural fire behaviour is difficult to replicate in small areas as fire intensity may differ. They also mention that “replicated plots are invariably smaller than natural burnt areas so that processes such as seed dispersal from adjacent unburned sites and post-dispersal predation will differ from those in larger fires”. The reality that some patches in the larger burned area did not burn completely, could probably relate to sparse vegetation cover and lack of adequate fuel such as restios and grasses or other fine dry material to carry the fire in those areas. In this study these unburned patches seemed to have an important effect on the re-establishment of some species as they provide shelter for predators and insects who may either feed on, or carry seed away from the burned site. Unburned patches may however also supply seeds to the burned area as is probably the case for *Erica inaequalis*.

Mucina and Rutherford (2006) note various controversies regarding the use of the Braun Blanquet approach in Fynbos vegetation. The authors state the following:

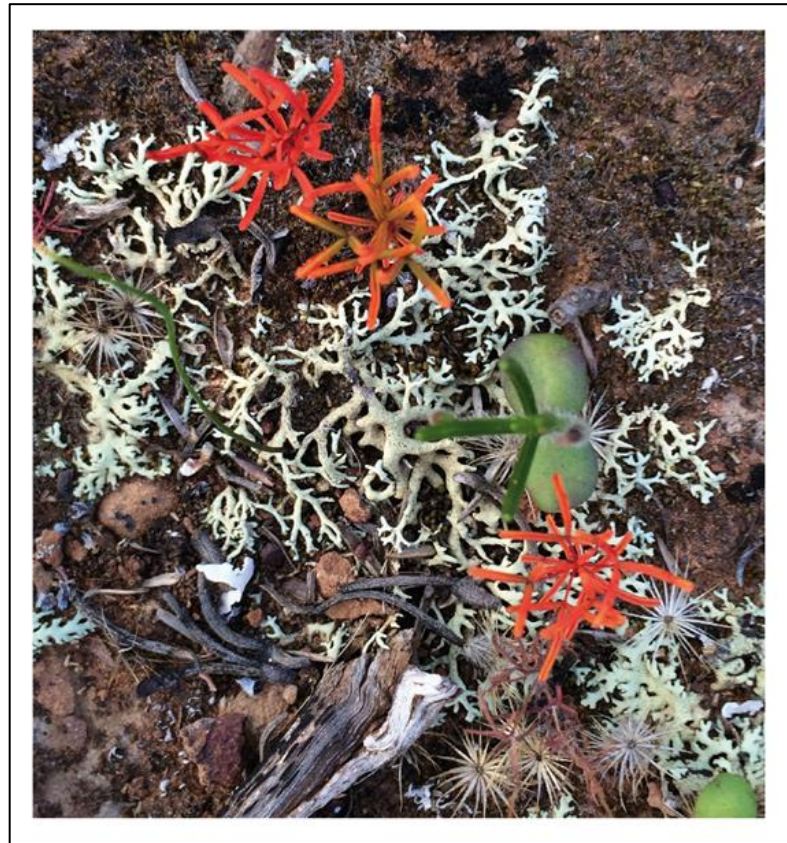
- “The composition of many communities is determined by fire.”
- “The same community may vary in species composition and abundance between fires.”
- “This results in different community classifications for the same site.”

The fact that data analysis with pre- as well as post-fire data grouped pre- and post-fire relevés within the same plant community (Annexure 3), proves that the Braun Blanquet method can be successfully applied in the winter rainfall vegetation system at all times because analyses of data from as early as the first year following a fire, shows that although minor changes in composition, and more drastic changes in density and cover (Annexures 1 & 3), the species composition does not differ adequately to be classified as a different community.

Lessons learned from this study and from the wealth of literature concerning fire confirm the uniqueness of every fire with its ensuing consequences. Not only the season or environmental conditions, but also the nature and history of the plant community have important influences on the behaviour of the fire at the time. These unique characteristics of a specific fire, together with environmental conditions and events in the seasons following the fire, influence the re-establishment and survival of individual species which are part of the regeneration process and future plant community. This study does however, prove that no major changes in the vegetation in terms of plant community classification based on floristic composition have occurred.

CHAPTER 8

CONCLUSION



Ouhangsberg se
bamboesblaartjies,
stokkies en ligene.

Asbossiekorale,
gombosanemone
en suringpraal.

haumannskloof september 2015

Eduard Haumann

The aims set down for this study were satisfactorily achieved.

1. Identify, classify and describe the vegetation of the study area.
2. Examine how the vegetation in the region of the Brandvlei Dam relates to similar geological areas between the Brandvlei Dam and the Rooiberg near Robertson.
3. To determine the influence of soil and environmental factors on the vegetation.
4. Investigate post-fire regeneration of two plant communities within the study area by comparing the vegetation structure and species composition with pre-fire data.

Although only parts of the study area (or similar vegetation in the larger Worcester - Robertson area) have been surveyed and studied in the past (Acocks 1979; Boschhoff 1989; Chesselet 1985; Chesselet *et al.* 2003; Cowling and Heijnis 2001; Helme 2007; Joubert 1968; Midgley and Musil 1990; Norton 1977; Olivier 1966; Smitheman and Perry 1990; Van Wyk and Smith 2001; Wood 1990), no complete and detailed study has been done of the hills underlain by the Witteberg Group around the Greater Brandvlei dam, on Hammansberg, Droogeriviersberg, Gannaberg, Gemsbokkop and Rooiberg near Robertson.

Endeavours to comprehend, appreciate and classify a vegetation system, require attentiveness to habitat physiognomies together with detailed studies of geology and soil characteristics. The study area is a complex system of different geological groups and formations which, as a consequence of acute folding in most places created a beautiful landscape of mountain plateaus, ridges, slopes, intermontane valleys and drainage lines (Figures 1.1, 1.2, 3.16). The great variety of substrates which is influenced by different mudrock- and sandstone formations, colluvium, aeolian sand (of alluvium origin) together with microclimates shaped as a result of folding, support a just as complex, but interesting and diverse specialised fauna and flora (Chapter 3).

The study identified more than a 1000 species within 324 genera and 79 families (Chapter 6). An analysis of the floristic data classified the vegetation of the mountains and foothills of the study area into 5 major communities, 15 communities with various sub-communities and several variants (Chapter 4).

The vegetation of the study area can be described as a mosaic of fynbos-, renosterveld- and succulent karoo vegetation units sustained by a winter-rainfall pattern where a steep moisture gradient occurs from west to east, with the western part receiving more winter rains than the eastern part of the study area (Figures 3.4 – 3.10). Precipitation is affected by the rain-shadow effect created by the mountains to the west (winter-rainfall) and to the east (summer rainfall). The differences in vegetation communities are mainly based on geology with consequent soil characters and degree of rockiness, as well as topography, moisture availability and the water holding capacity of the soil. Although slope, aspect and elevation can sometimes be associated with specific plant communities, geology, soil pH and rock cover are the principal elements responsible for shaping the vegetation mosaic.

The vegetation of the study area is a diverse mosaic of medium to low *Elytropappus rhinocerotis* (renosterbos) dominated plant communities on finer grained soils derived from the various mudrock-dominated formations of the Witteberg Group, a medium to tall *Passerina truncata* (gonnabos) dominated shrubland with large *Protea* shrubs and / or small *Protea* trees where the substrate is largely influenced by the sandstone-dominated formations of the Witteberg Group, a medium to low grass dominated *Capeochloa arundinacea* (Olifantgras) shrubland where both mudrock-dominated and sandstone-dominated formations influence the substrate as a result of folding, a low karoo *Hirpicium integrifolium* (Haarbossie) dominated shrubland where succulents are in abundance on the Dwyka tillite, and a distinct *Thamnochortus bachmannii* restio-dominated sandveld in areas where deep aeolian sand had accumulated. The inconsiderate and excessive mining of these sands holds a threat for this diverse community as sources of such sands does not exist anymore. Braided river networks and former floodplains which experienced seasonal floods in the past, are now either inundated by damming, or channelled to a large extent and the dynamic character of former floodplains permanently changed to facilitate

farming in the area (compare Figure 3.1 with the picture on the cover page of chapter 3).

In a study regarding determinants of the Fynbos/Succulent Karoo biome boundary, Esler *et al.* (2015) included an area close to the contact of the Bokkeveld- and Table Mountain Groups in the southern part of this study area. Several sources of literature describe contributing factors such as moisture availability, soil types, nutrients, geology and altitude accountable for creating a boundary between the Succulent Karoo and the Fynbos biomes. Furthermore is the intermingling of fynbos and succulent karoo elements described by various authors as a broad ecotonal band (Bond 1981; Campbell 1986; Ellis & Lambrechts 1986; Esler *et al.* 2015; Lechmere-Oertel and Cowling 1999; Lechmere-Oertel and Cowling 2001).

Because of the geological variation in the study area, encompassing over almost two hundred million years of sediment accumulation as well as an ice age (Table 3.1) and the predominant underlying formations of the study area (the Witteberg Group) consisting of alternating sandstone- and mudrock dominated layers together with intense folding, the steep precipitation gradient and different influences of winter rain (in the west) and summer rain (in the east) (Figures 3.4 -3.10) are factors contributing to the mosaic character of the vegetation of these mountains. Rather than a broad ecotone, the vegetation of the study area is understood as a complex mosaic mountain vegetation entity (Chapter 4).

Similarities between detailed sampled vegetation on the hills around the Greater Brandvlei Dam and on Hammansberg, were found with the vegetation (not sampled in such detail) on Ouhangsberg, Gannaberg, Gemsbokkop and Rooiberg. Although differences related to moisture availability occur, it was found that the vegetation supported by similar geology can within this Worcester- Robertson Karoo system be extrapolated.

Before long-term inundation of two floodplains of the Upper Breede River due to the construction of the Greater Brandvlei Dam (Figure 1.3), it is expected that the clayed soils derived from the basal mudrock layer of the Witteberg Group (exposed on the northern perimeter of the dam) as well as upper mudrock

layers of the Bokkeveld Group (exposed at the eastern perimeter of the dam) (Figure 3.11) supported alluvium renosterveld vegetation rather than Breede Sand Fynbos as mapped by Mucina *et al.* (2005). Sub-communities 2.1 and 6.2 (Major community 1) are most probably remnants of larger tracts of Breede Alluvium Renosterveld that had been destroyed through the construction, and later enlargement, of the Greater Brandvlei Dam.

Numerous literatures exist on post-fire regeneration in fynbos and renosterveld communities, but in this study post-fire data was compared to pre-fire data from precise marked sample plots (Chapter 7). From this comparison it was found that the Braun Blanquet method can successfully be applied in the winter rainfall vegetation system at all times because analyses of data from as early as the first year following a fire, shows that although minor changes in composition, and more drastic changes in density and cover (Annexures 1 & 3), the species composition and dominance do not differ adequately to be classified as a different community.

Because of the preliminary findings of this study, the north-eastern boundary of the Cape Winelands Biosphere Reserve was re-evaluated so that the reserve extends to the Breede River and includes the hills between the river and the Greater Brandvlei Dam.

The vegetation of these mountains is not understood as a transitional broad ecotone, but a unique winter rainfall mosaic vegetation predominantly determined by geology and climate, where geology is put before climate as differences on major community and community level often occur within the same broad climatic area but on different substrates. Microhabitats and -climates do occur, but are responsible for differences on sub-community- and variant levels.

No previous study of this scale and detail have been undertaken in the area. This study contributes greatly to the knowledge and understanding of these unique ecosystems and how they are influenced by the environment. The number of new species identified within this large system is further proof of the unique plant communities and plant species occurring in this area. This is supported by the high diversity found in all plant communities compared to

similar ecosystems elsewhere. It is important that the large natural areas within this region is conserved and sustainably managed.

Further studies of this unique natural system are recommended. This study continues with more detailed sampling in the mountains as well as sampling of the intermontane drainage lines which were not yet covered in this study. This would enable more detailed mapping of the vegetation of the region. More taxonomic studies regarding problematic and indeterminate plant taxa, not only focussing on red data species alone, but also the various undescribed species, should be undertaken.

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dankie dankie vir

waar melkbos aan hemel raak

en wonders gaan haal

Droogeriviersberg 6 Oktober 2017



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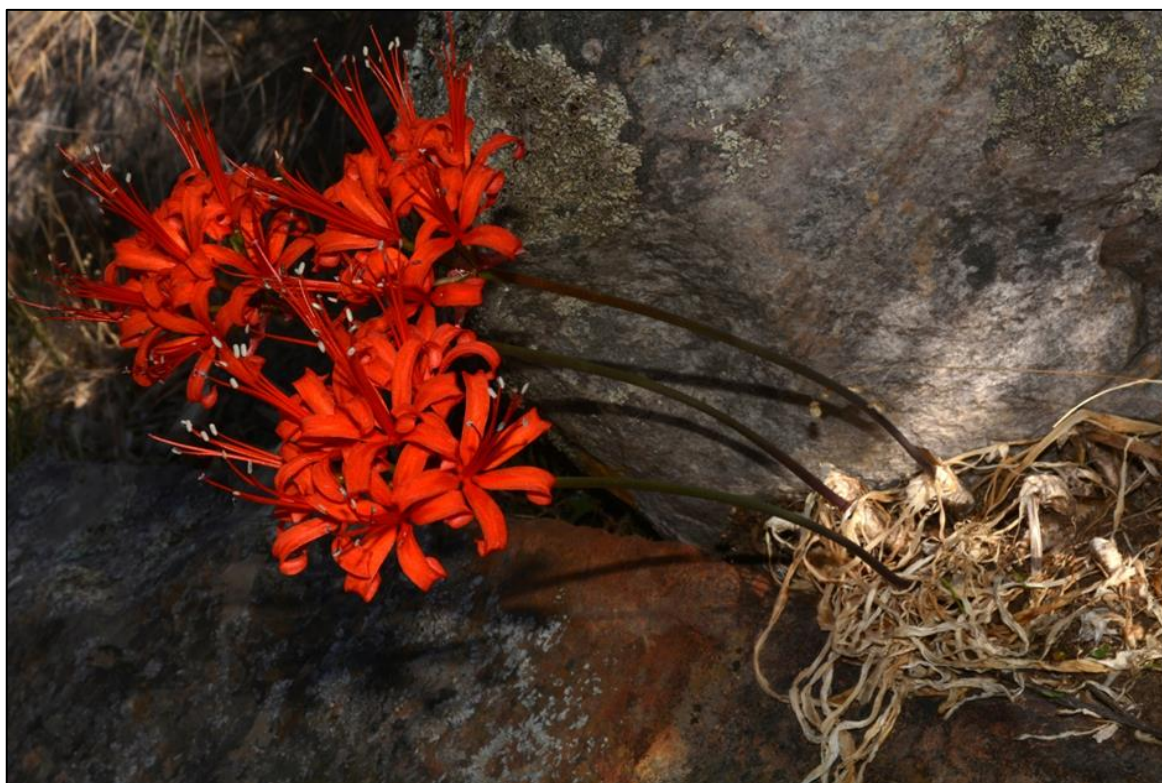
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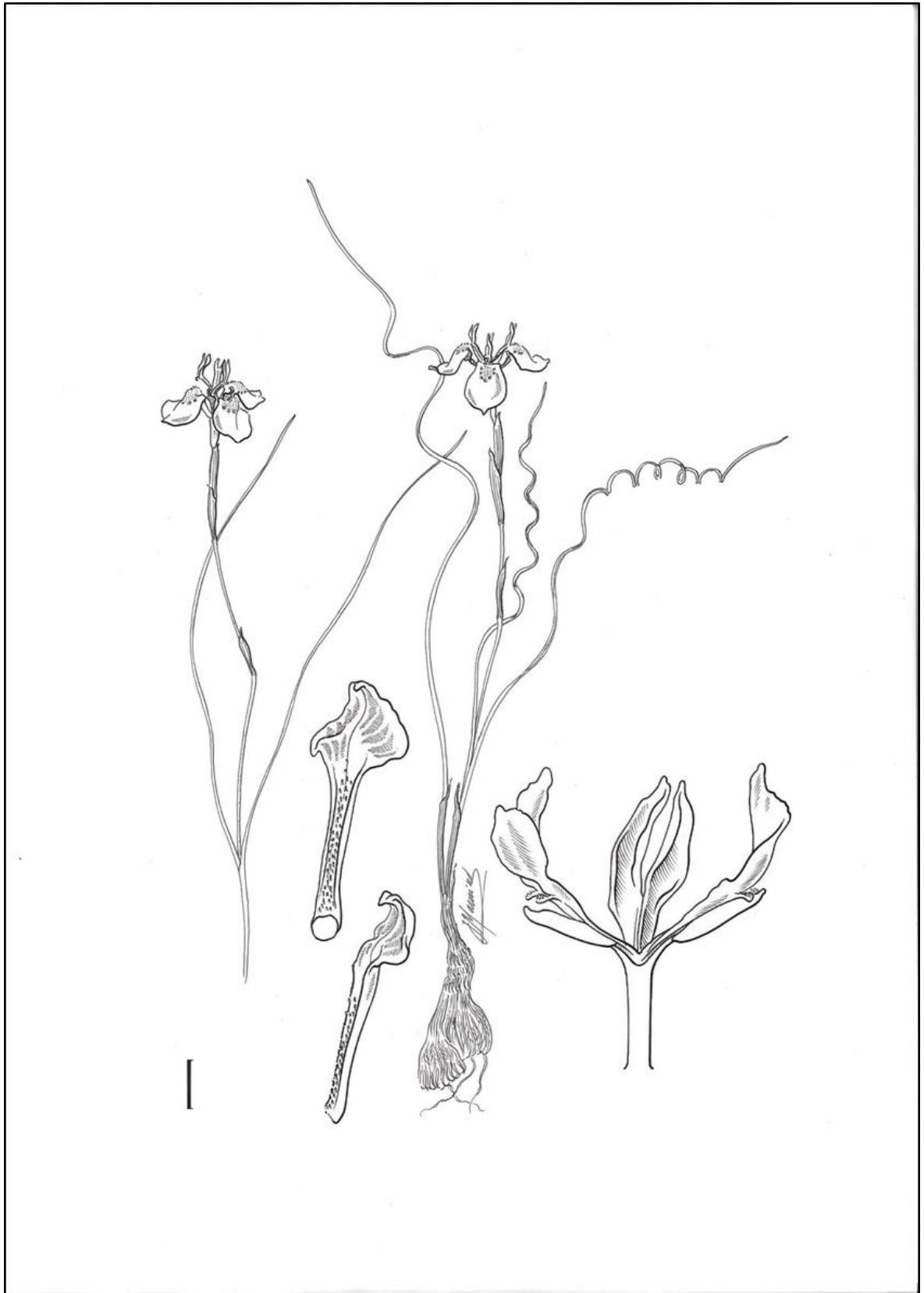
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ANNEXURES



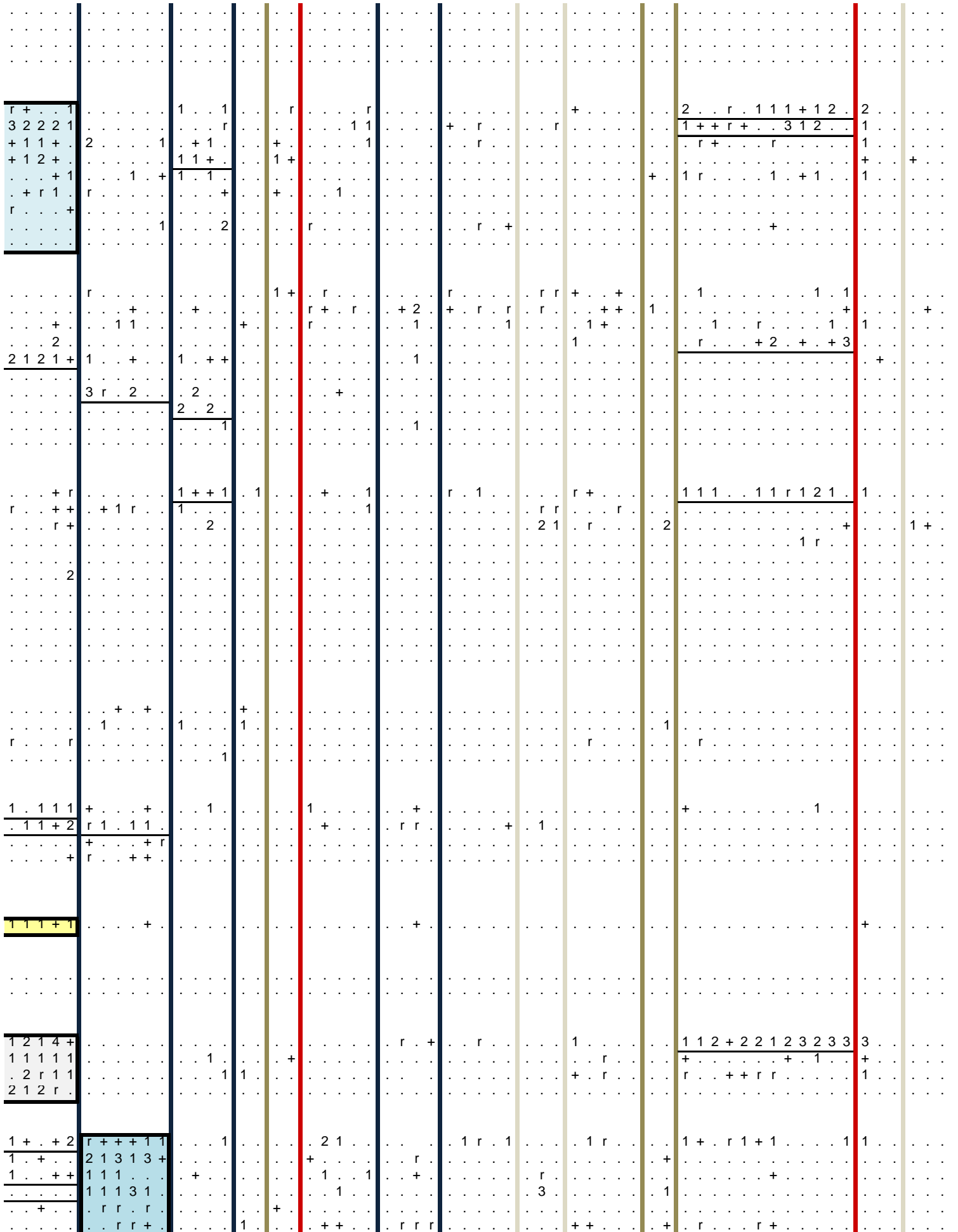
Moraea helicoidea, by John Manning at the type locality – September 2015.

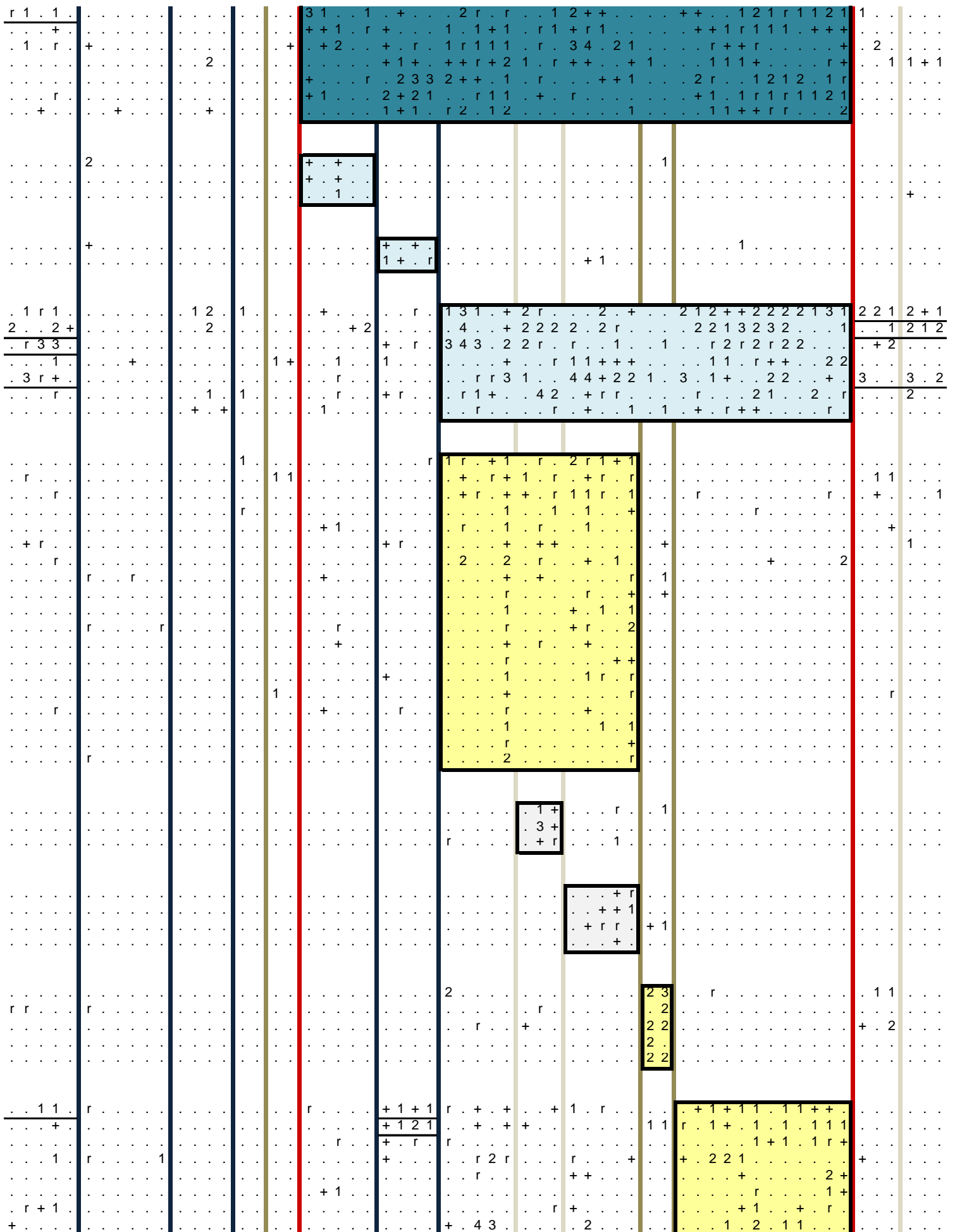
Species group AO: Important species for Major Community 5	
16	<i>Thamnochortus bachmannii</i> + 1 . r
13	<i>Gladiolus carinatus</i> 1 r r
11	<i>Gymnodiscus capillaris</i> 1
9	<i>Stipagrostis zeyheri</i> subsp. <i>zeyheri</i> r
5	<i>Aristida diffusa</i> subsp. <i>diffusa</i>
3	<i>Rafnia angulata</i> subsp. <i>montana</i>
3	<i>Brunsvigia orientalis</i>

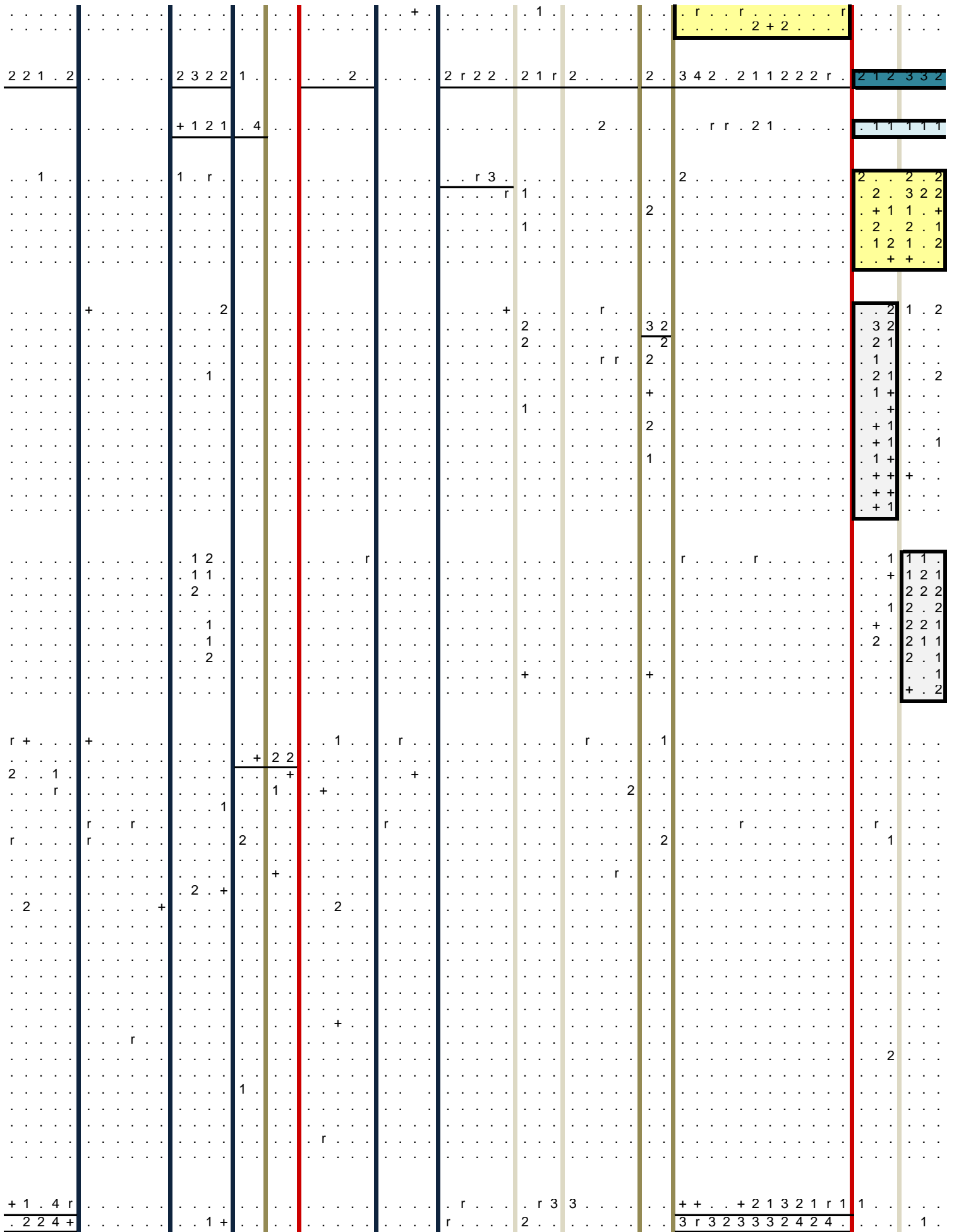
Species group AP: Important species for Community 14	
5	<i>Stoebe cinerea</i> .
15	<i>Diospyros glabra</i> .
8	<i>Trachyandra revoluta</i> .
6	<i>Euchaetis pungens</i> .
5	<i>Polpoda capensis</i> .
5	<i>Trichogyne repens</i> .
5	<i>Acrosanthes teretifolia</i> .
5	<i>Trachyandra chlamydophylla</i> .
4	<i>Aristea dichotoma</i> .
4	<i>Babiana ringens</i> .
4	<i>Pelargonium radulifolium</i> .
3	<i>Leucospermum rodolentum</i> .
3	<i>Phylla stipularis</i> .
3	<i>Oxalis commutata</i> .
3	<i>Lotononis involucrata</i> 1
3	<i>Elytropappus glandulosus</i> .
3	<i>Cyphia bulbosa</i> .
3	<i>Rumex cordatus</i> .
3	<i>Arctotis incisa</i> . 1
3	<i>Erica plumosa</i> .
2	<i>Chenopodiopsis hirta</i> .
2	<i>Nenax hirta</i> subsp. <i>hirta</i> .
2	<i>Stoebe nervigera</i> .

Species group AQ: Important species for Community 15	
20	<i>Willdenowia incurvata</i> 2 4 2 2 + 1
12	<i>Moraea fugax</i> 1 1 1 +
11	<i>Ficinia bulbosa</i> . + r
11	<i>Ferraria variabilis</i> + . 1 r 1 . 1
9	<i>Ornithoglossum viride</i> . +
8	<i>Eragrostis curvula</i> . + 1
8	<i>Aspalathus heterophylla</i> 1 +
7	<i>Lapeirousia anceps</i> . r +
7	<i>Hermannia cuneifolia</i> var. <i>cuneifolia</i> 1 2
7	<i>Albuca cooperi</i> . r . +
6	<i>Silene clandestina</i> .
6	<i>Wahlenbergia capensis</i> . r
6	<i>Lyperia tristis</i> . +
5	<i>Ursinia nana</i> . +
5	<i>Monoculus monstrosus</i> . +
4	<i>Microcodon glomeratum</i> . r . +
3	<i>Annesorhiza laticostata</i> . +
2	<i>Caesia contorta</i> .

Species group AR: General species for Major Communities 1 – 5 (frequency > 10)	
113	<i>Elytropappus rhinocerotis</i> 4 3 3 2 4 4 3 2 3 3 4 3 4 2 4 4 3 4 4 4 4 3 2 4 3 4 1 5 5 4 4 3 + + 2 + 1
99	<i>Oedera squarrosa</i> 1 2 1 2 1 3 + 2 1 + 1 2 2 + . 1 + 4 1 1 3
97	<i>Felicia filifolia</i> subsp. <i>schaeferi</i> 1 2 3 3 2 r r 1 2 1 2 + . + 2 2 2 1 2 . + 3 1 . 2 2 3 4 2
96	<i>Anthospermum spathulat</i> 2 1 1 . r r 1 2 . 1 1 2 2 . 1 . 2 + . + 2 2 3 3 . + . . . 2
91	<i>Satyrium erectum</i> 1 + 1 + 1 1 1 1 r 1 1 + r 1 + 1 2 + 1 + 1 1 1 1 1 1 + 1 + . 1 1 2 1 + 2
90	<i>Crassula atropurpurea</i> + 1 + + 2 1 2 2 2 1 1 + 2 + 1 . + 2 + . 1 + . + 1
87	<i>Ischyrolepis sieberi</i> 2 2 . 1 2 . r 1 3 r 3 1 + 2 r . + . . 1 . . 4
85	<i>Chrysocoma ciliata</i> 2 1 2 + + + 2 1 + 1 + 1 1 1 1 . . + 1 1 . . 1 + 2 1 . . . + r .
82	<i>Eriocephalus africanus</i> 3 2 3 2 2 2 2 2 2 1 1 . + . 2 2 2 2 1 2 1 1 1 2 . 1 . 1 3 1 1 4 . r . r 2
82	<i>Merxmuellera stricta</i> 1 . . 1 3 . 2 r 3 3 1 2 . 3 3 2 3 2 2 2 + + 2 . 2 . + r
81	<i>Pentsthis eriotoma</i> + r . . 2 + + r . 2 . 2 3 . 1 . 2 . 1 2 3 2 3
80	<i>Ursinia anthemoides</i> + 1 1 2 4 3 4 1 3 2 2 2 2 1 1 2 1 1 2 + . 1 1 2 + . 1 2 1 1 . 1 1 1 .
79	<i>Passerina species</i> r r 1 3 1 2
78	<i>Pentsthis airoides</i> subsp. <i>airoides</i> 2 3 3 1 2 + . 1 2 + 1 . 1 2 . . . 2 1 2 3 . 2 3 3 2 1 1 2 2 3 3 4 1
75	<i>Mesembryanthemum longistylum</i> 2 + 2 1 1 2 . 1 r 3 1 + + . r . 2
73	<i>Helichrysum rutilans</i> 2 + . 2 2 3 1 2 1 + 2 1 r + + + . 2 2 + 1 . 1 r +
64	<i>Troglophyton parvulum</i> 1 . 1 1 1 1 1 + r 1 + 1 2 + 1 1 + 1 . 1 1 . 3 3 3 3 + 1 . . + 1 1 2 .
64	<i>Pelargonium radiatum</i> + . 1 . + r 1 . 2 2 1 1 1 1 2 2 + 1







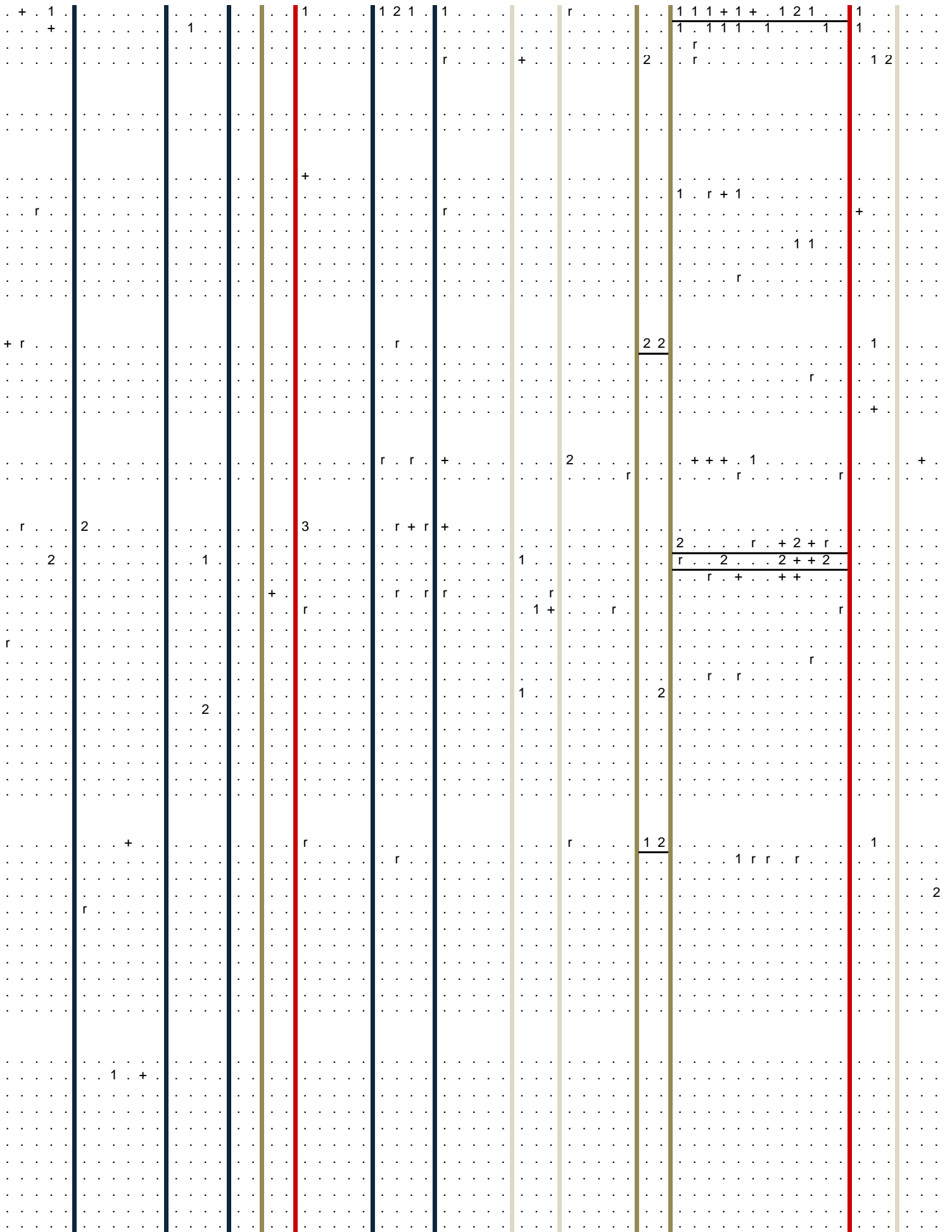
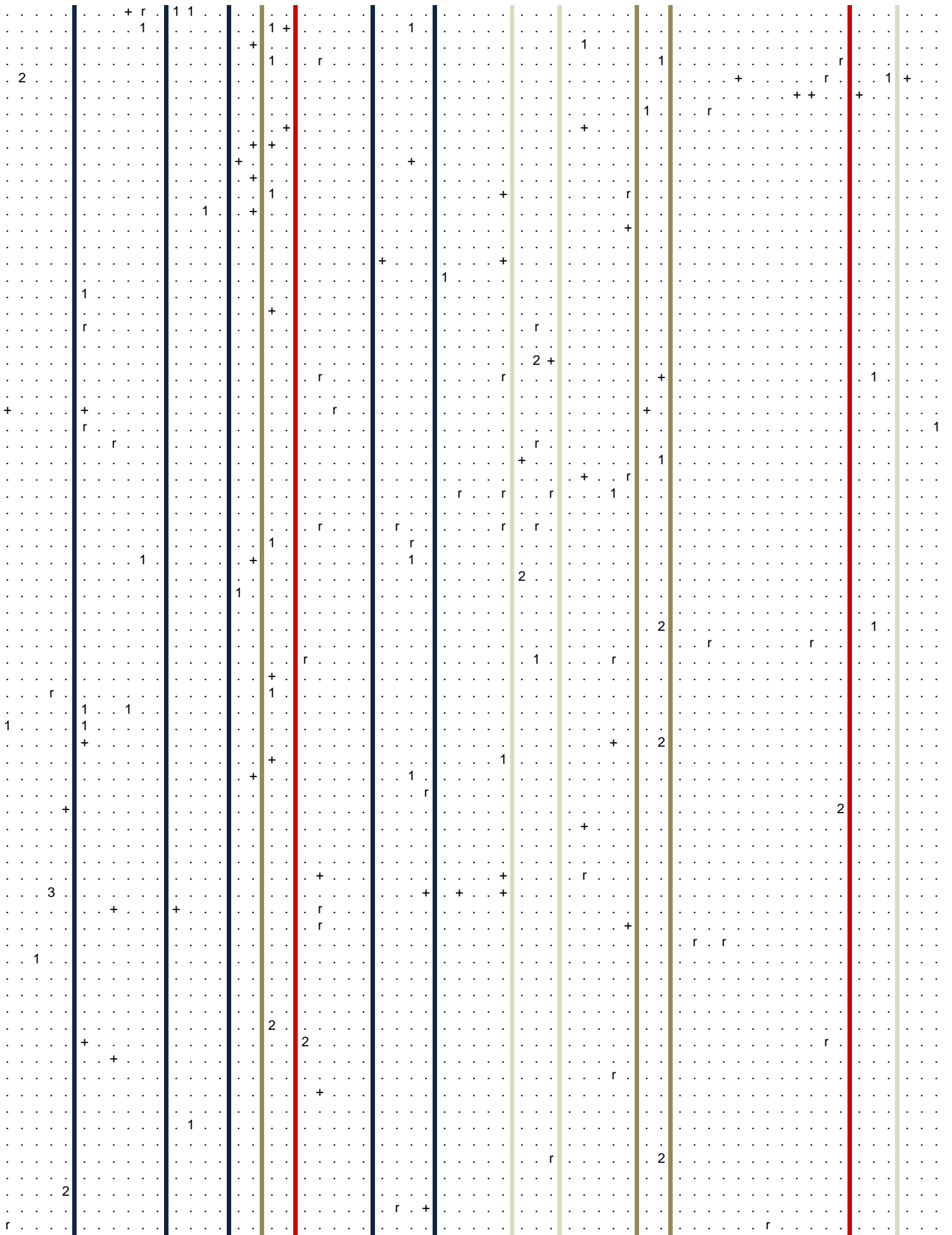
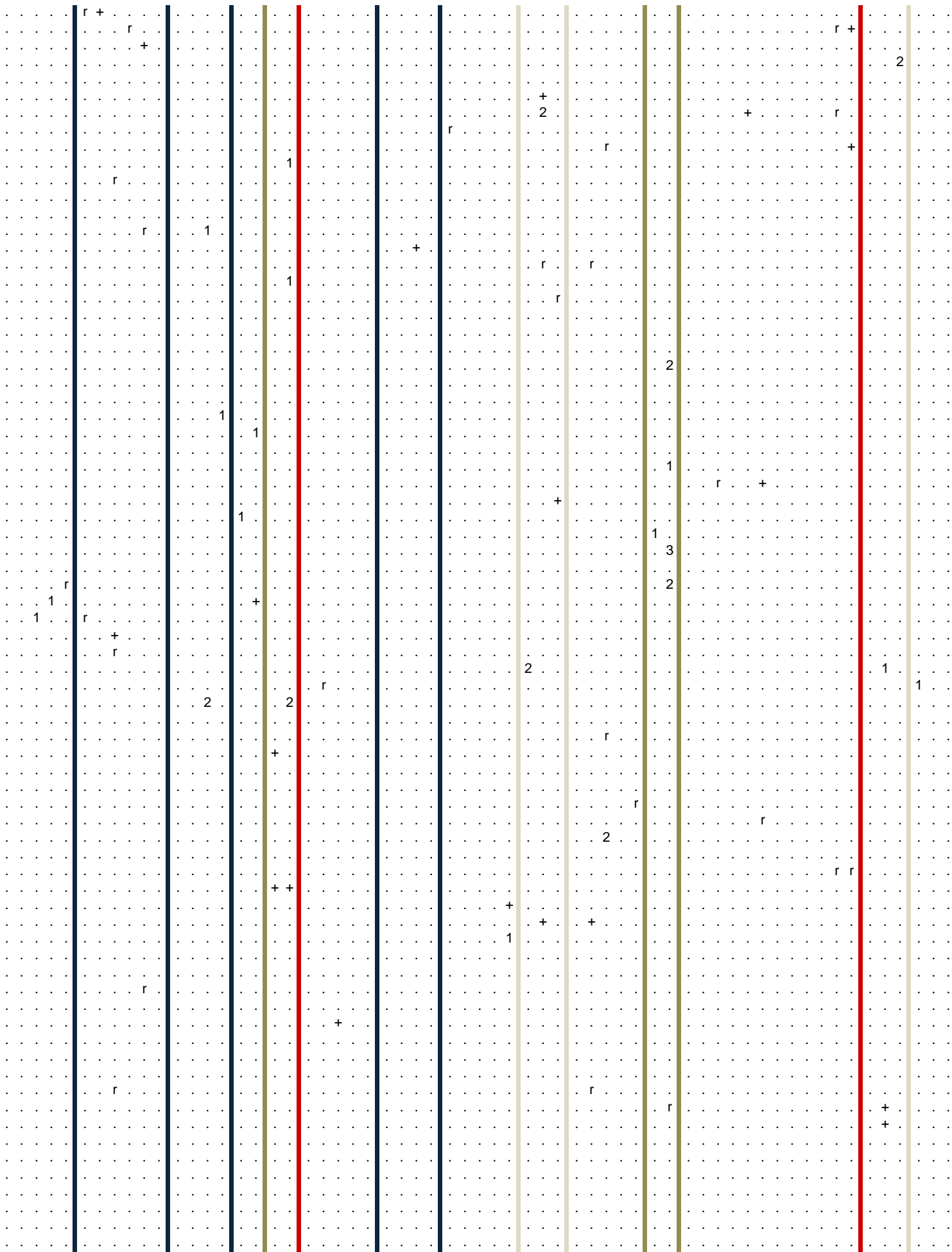
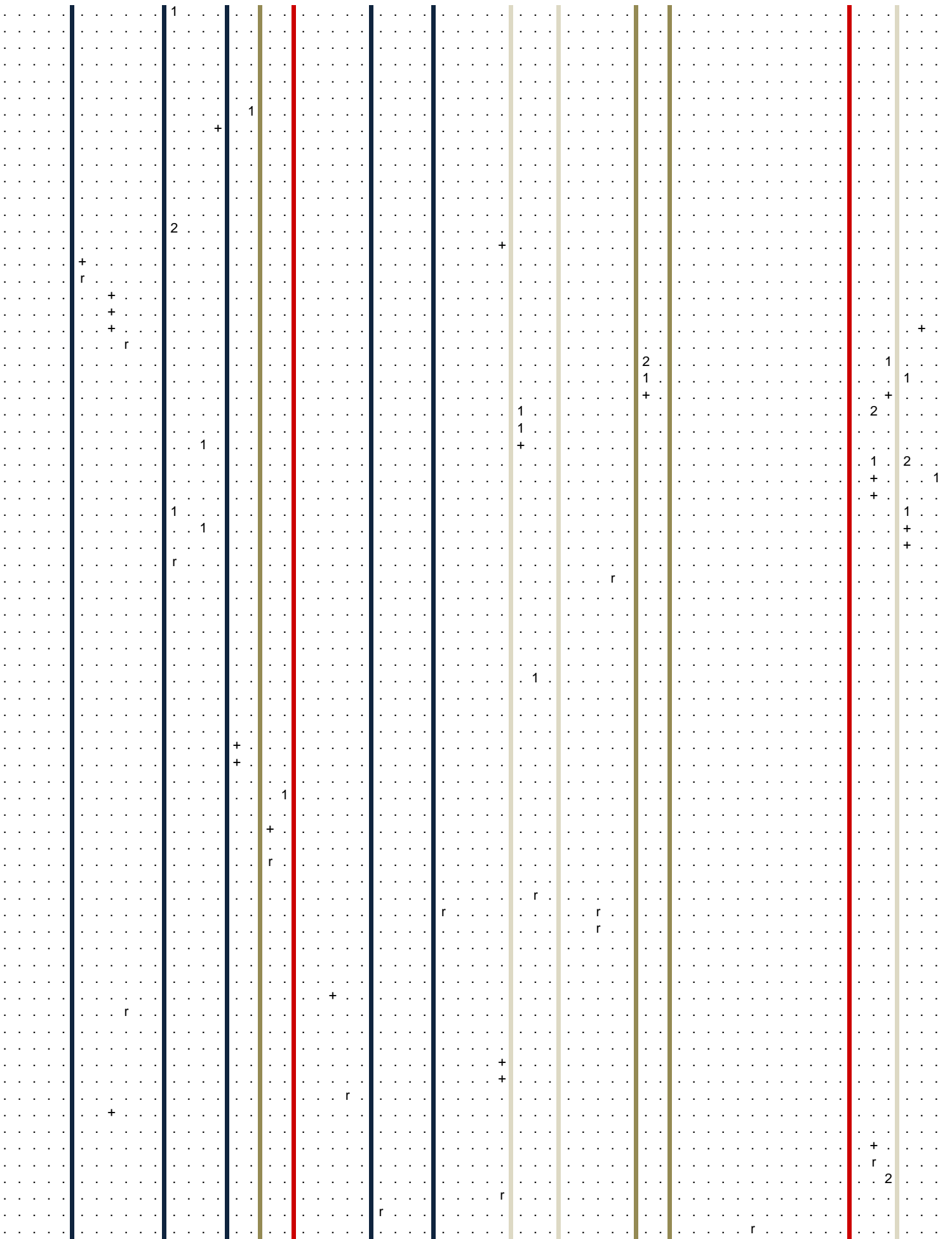
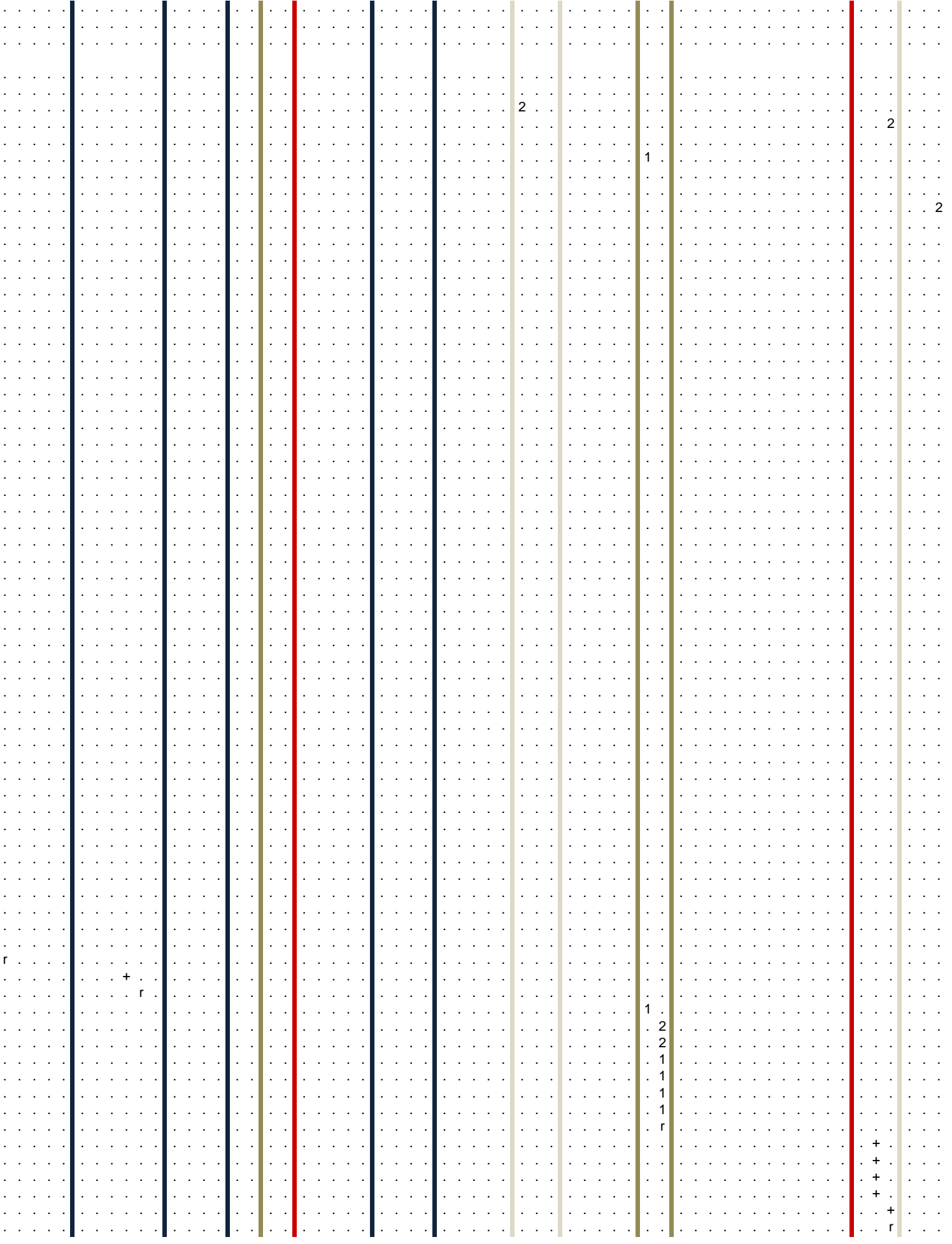


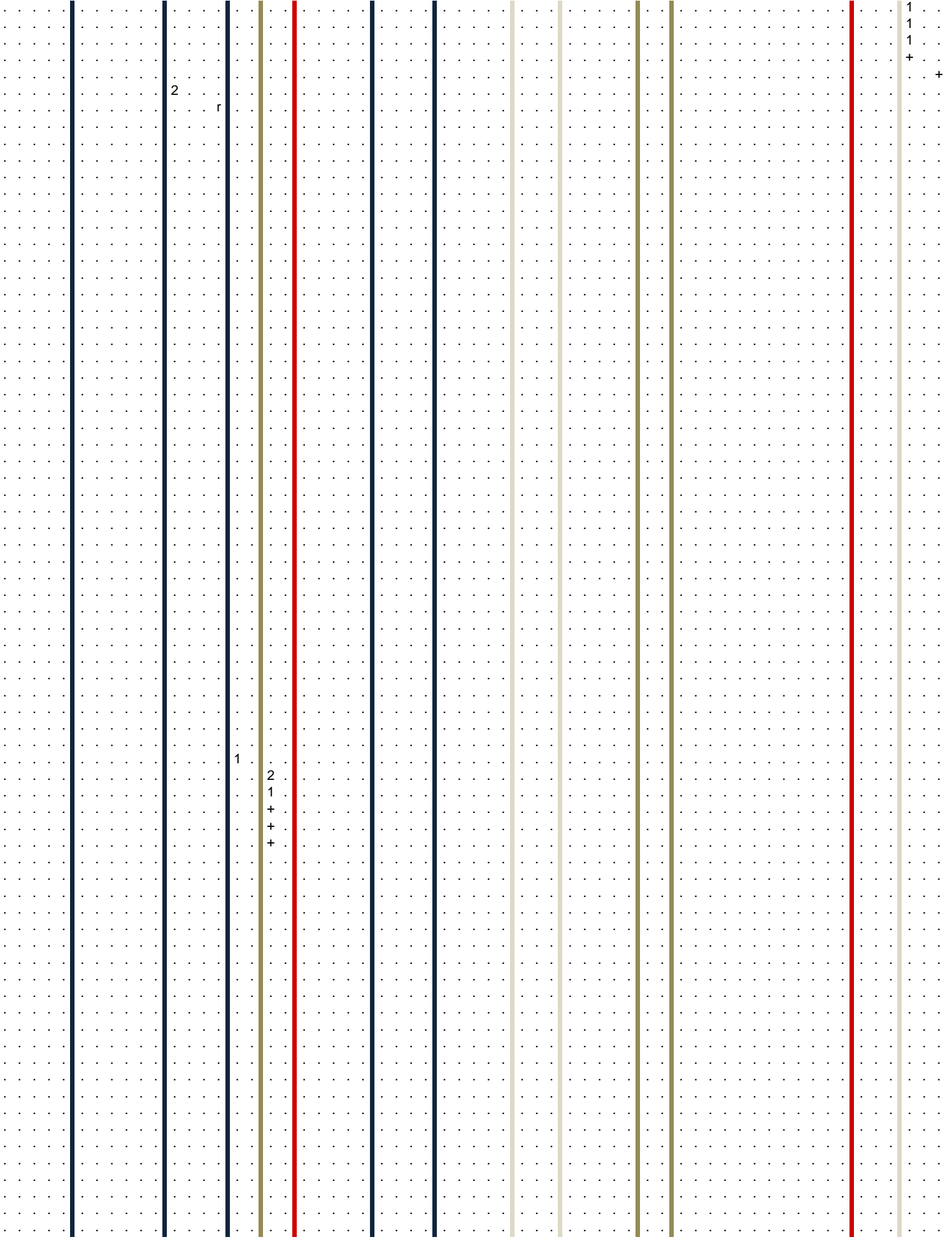
Table with multiple columns and rows. Columns are grouped by vertical lines: dark blue, red, and olive green. The content consists of mathematical expressions and numbers.











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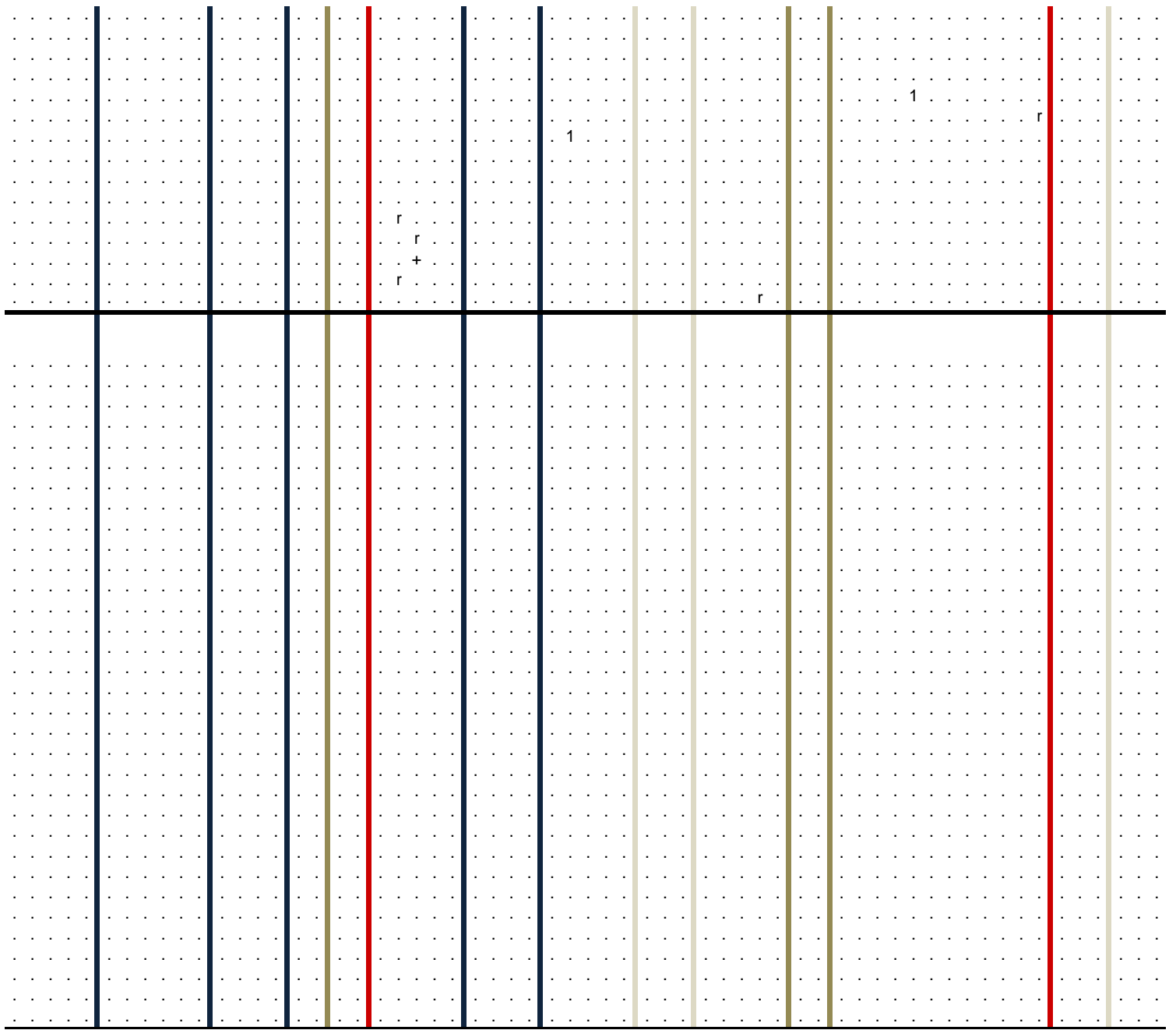
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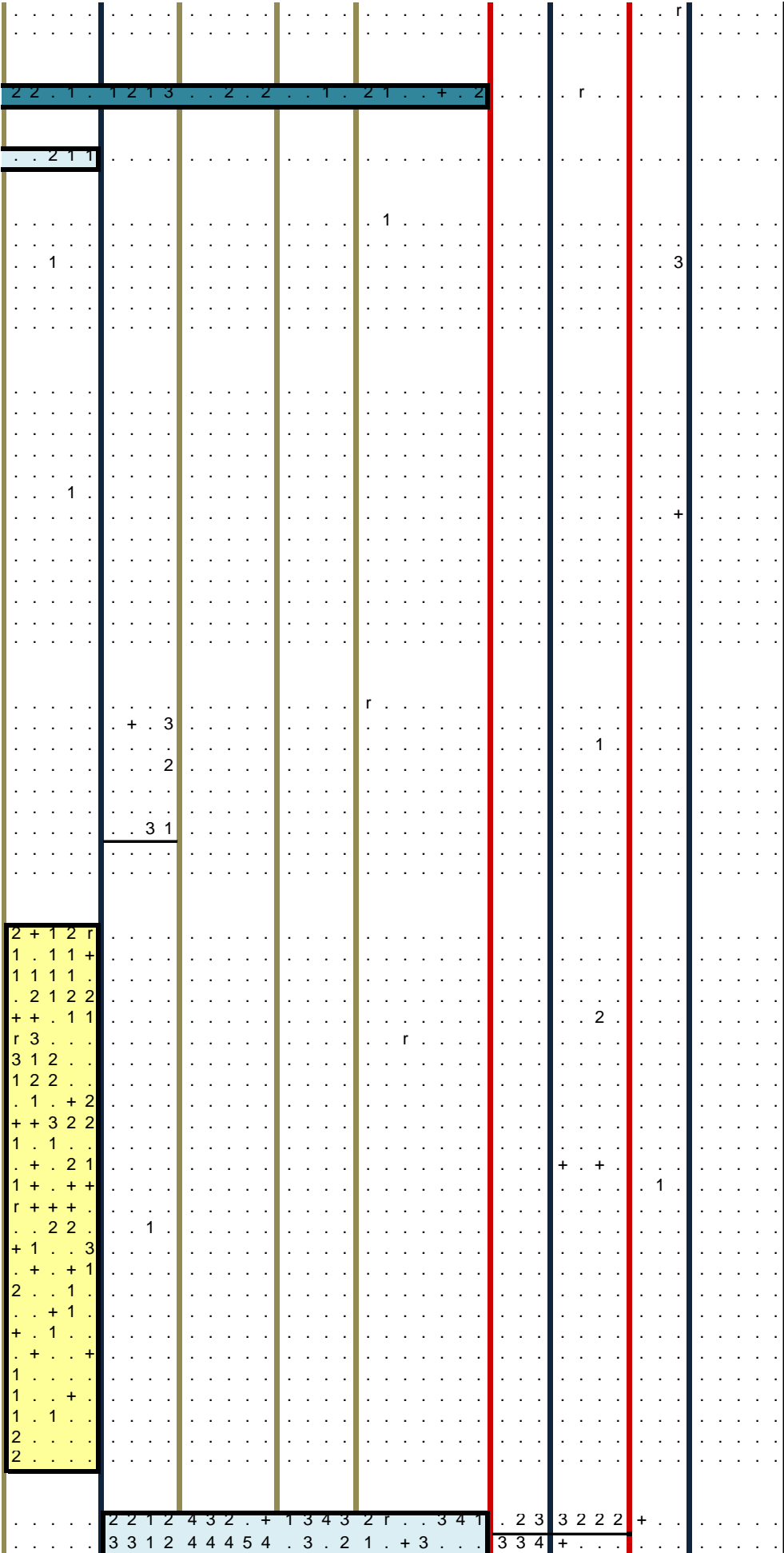
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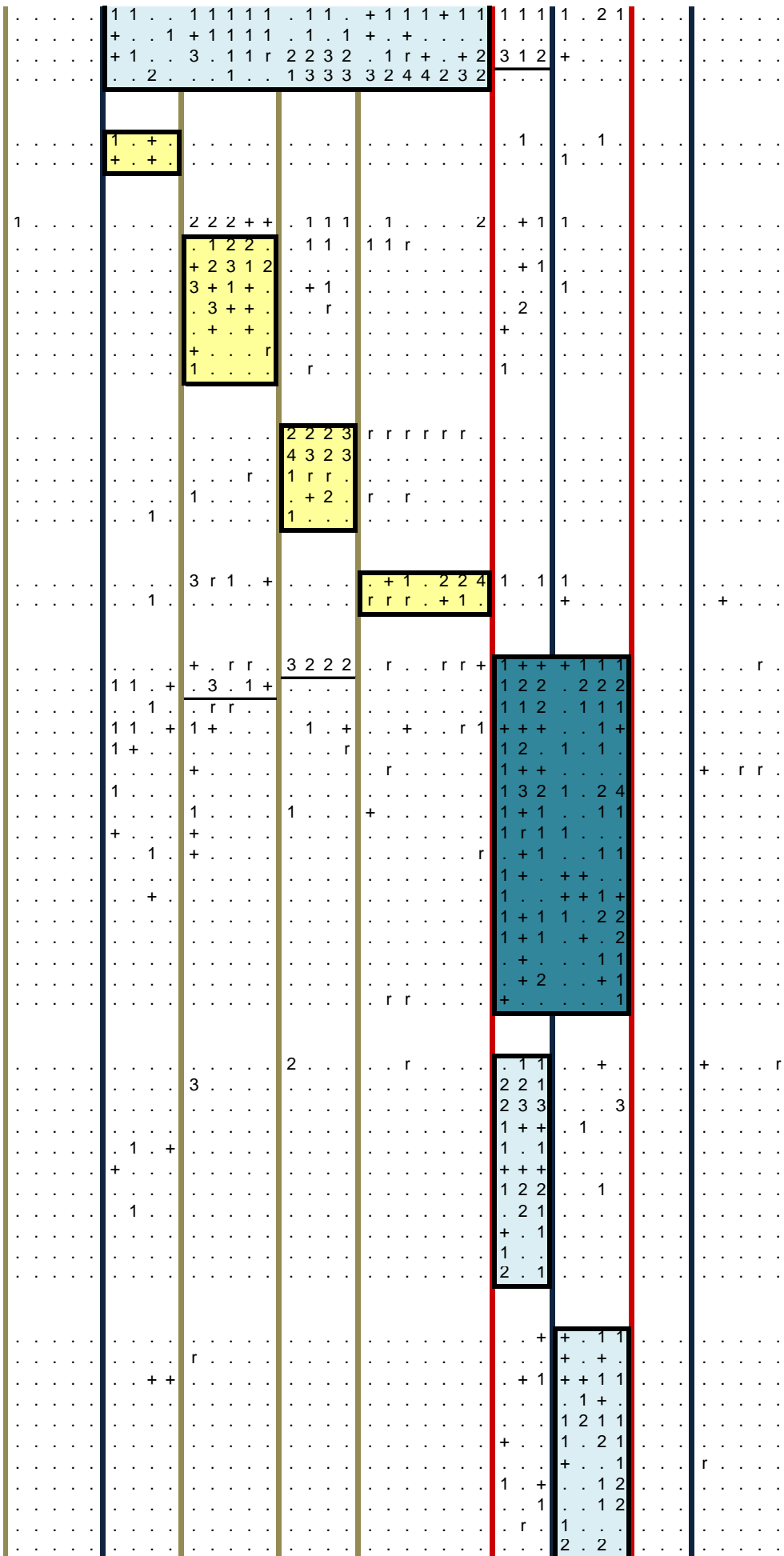
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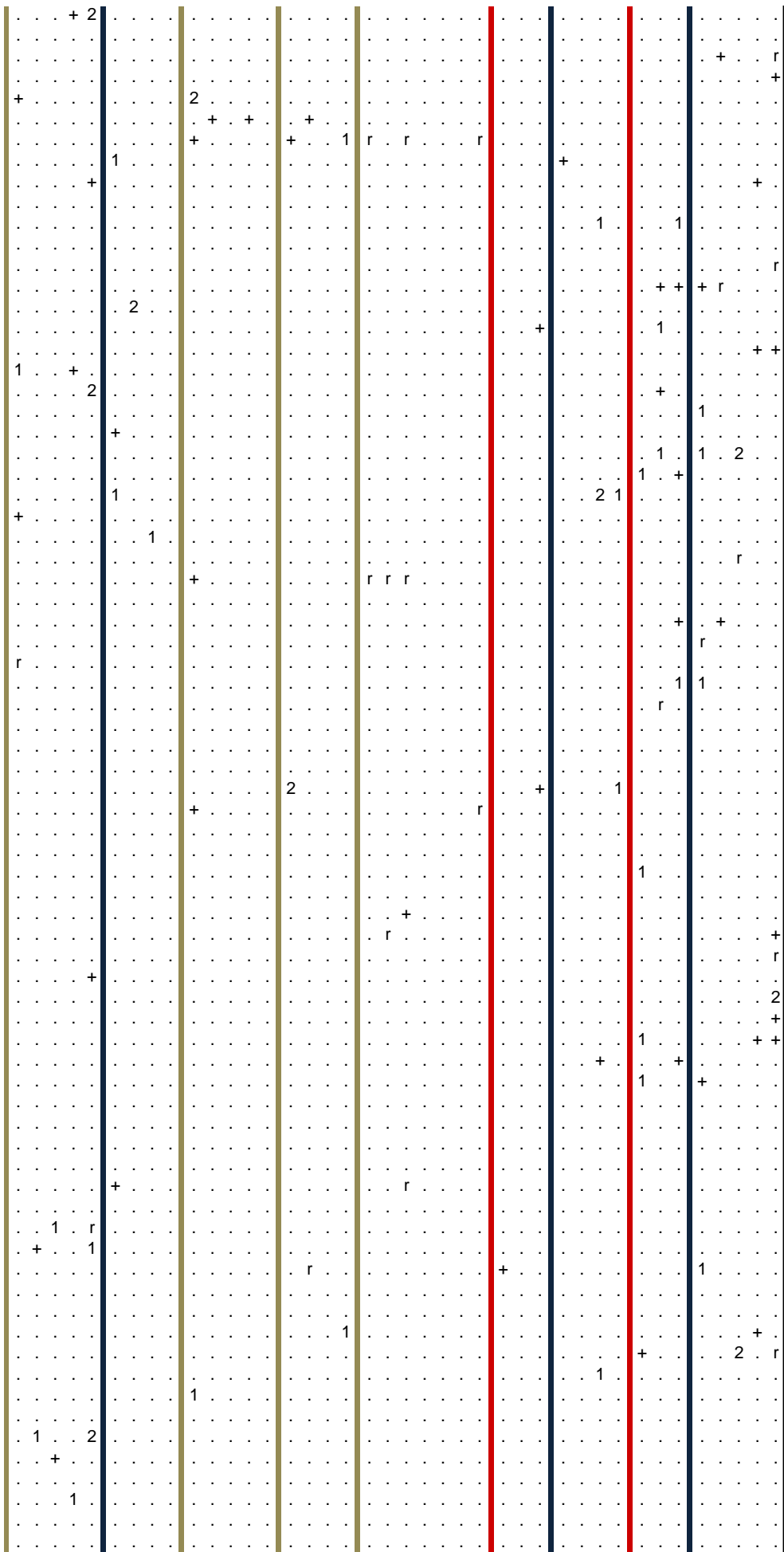
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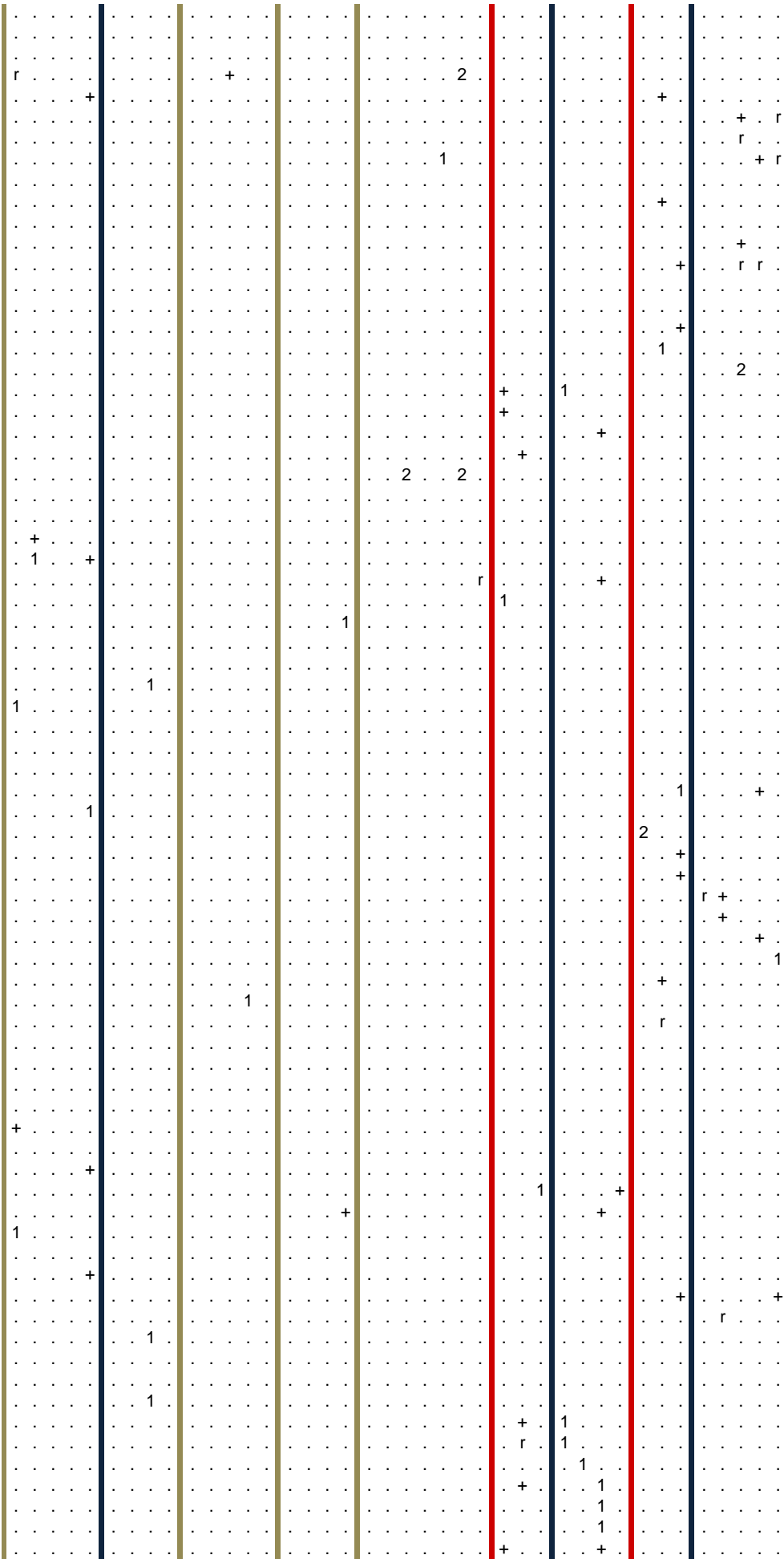


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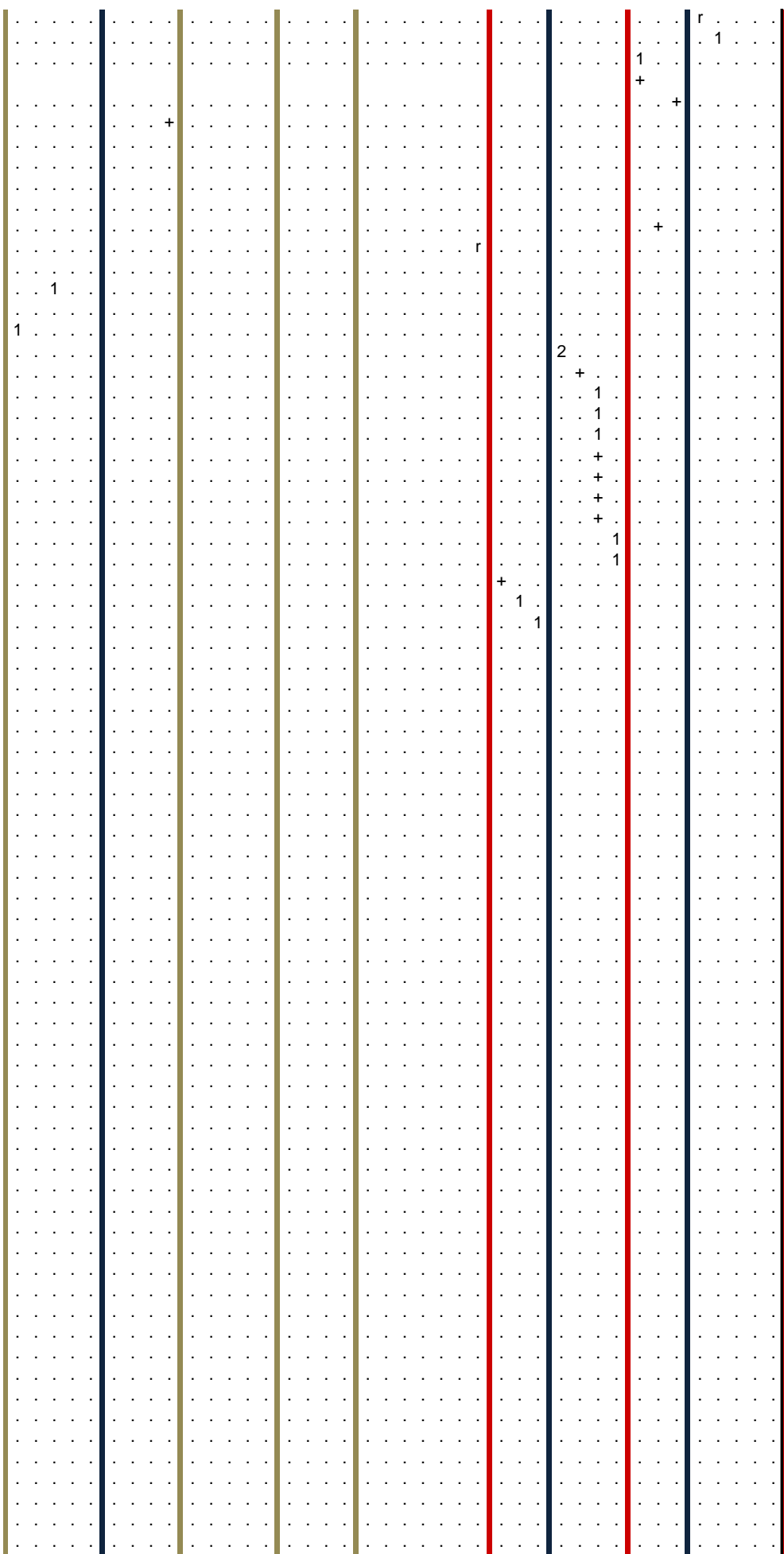






The image displays a grid of 10 columns of dot paper. Each column is bounded by vertical lines. The lines are colored as follows: the first three columns have olive green lines, the fourth and fifth have dark blue lines, the sixth and seventh have red lines, and the eighth, ninth, and tenth have dark blue lines. The grid contains several mathematical symbols and numbers:

- Column 1: A '1' is located in the 4th row from the top.
- Column 2: A '+' is in the 1st row, '1' in the 2nd, and another '+' in the 3rd.
- Column 3: A '2' is in the 6th row.
- Column 4: A '1' is in the 18th row.
- Column 5: A '+' is in the 20th row.
- Column 6: A '1', '+', 'r', '+', and '+' are in the 1st, 2nd, 3rd, 4th, and 5th rows respectively.
- Column 7: A '+' is in the 40th row.
- Column 8: A '1' is in the 52nd row.
- Column 9: A '+' is in the 47th row, 'r' in the 48th, '+ r' in the 49th, '1' in the 50th, '+ +' in the 51st, 'r' in the 52nd, 'r' in the 53rd, 'r' in the 54th, '+' in the 55th, '+' in the 56th, '3' in the 57th, '1' in the 58th, '1' in the 59th, '+' in the 60th, '1' in the 61st, and '+' in the 62nd.
- Column 10: A '2' is in the 74th row.



1

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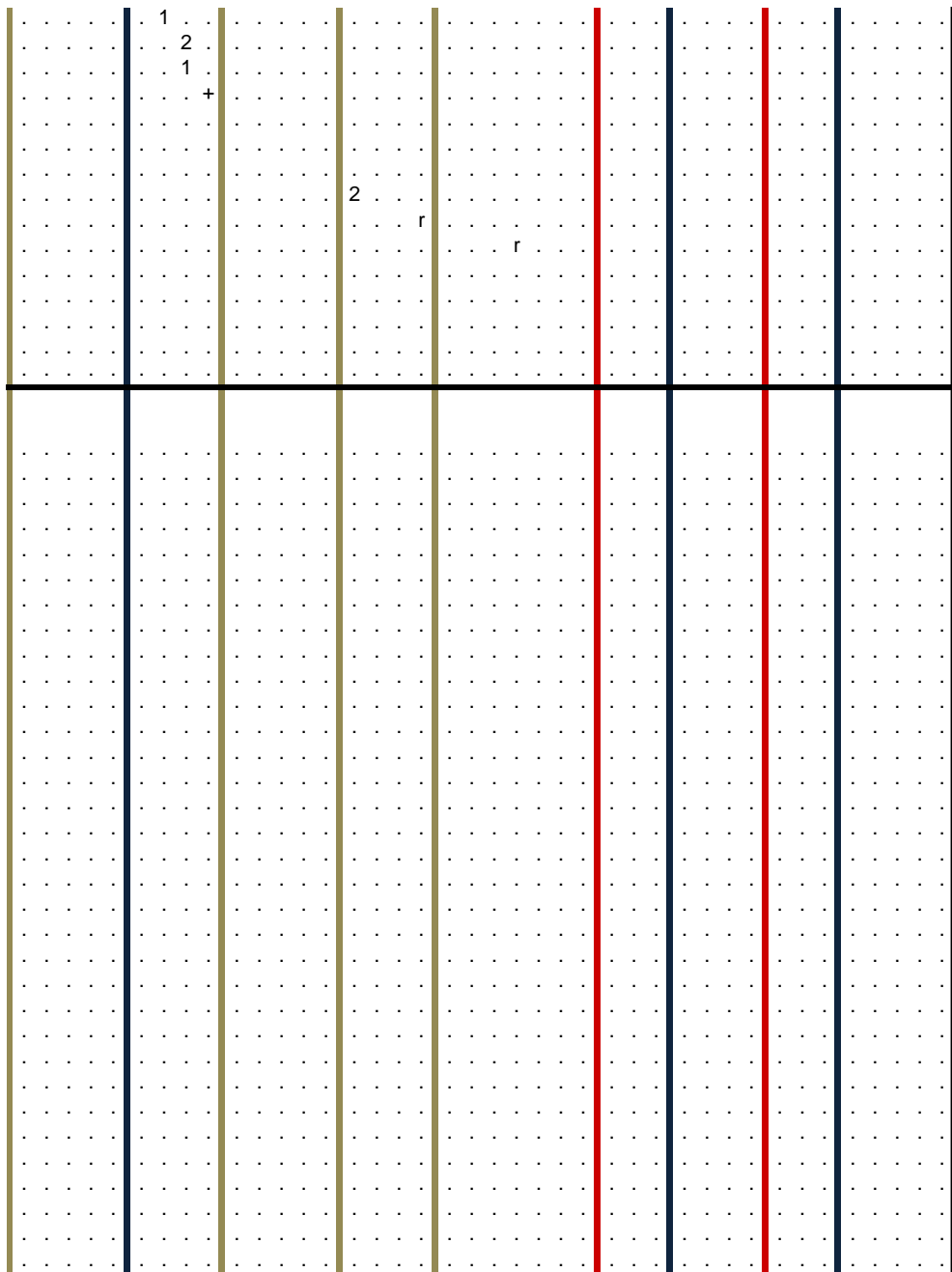
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ANNEXURE 2

Synoptic table with percentage, frequency and modified fidelity index phi coefficient (3)

Group No.	1	2	3	4
No. of relevé	4	3	6	3
<i>Elytropappus rhinocerotis</i>	100	100	100	100
<i>Oedera squarrosa</i>		100	33	100
<i>Anthospermum spathulat</i>	25	33	67	67
<i>Felicia filifolia s. schaeferi</i>	100		67	
<i>Satyrium erectum</i>	100	100	100	
<i>Chrysocoma ciliata</i>		100	100	100
<i>Crassula atropurpurea</i>	50	33	17	100
<i>Drosanthemum parvifolium</i>	25	100	50	67
<i>Ischyrolepis capensis</i>	25	100	67	
<i>Ehrharta capensis</i>	75	100	50	33
<i>Pelargonium radicum</i>	25	33		
<i>Ficinia nigrescens</i>	25	33	50	
<i>Rhus dissecta</i>	50	67	33	
<i>Oxalis obtusa</i>	100		67	67
<i>Pteronia incana</i>	25			100
<i>Mesembryanthemum longistylum</i>		33	17	100
<i>Ischyrolepis sieberi</i>		67	33	33
<i>Pentaschistis eriostoma</i>	25			33
<i>Passerina species</i>		33	33	
<i>Oedera genistifolia</i>	75	33	17	100
<i>Troglophyton parvulum</i>	75		100	100
<i>Tribolium hispidum</i>	100	100	100	67
<i>Merxmuellera stricta</i>	50	67	17	33
<i>Ursinia anthemoides</i>	100	100	100	100
<i>Pentaschistis airoides s. airoides</i>		100	83	67
<i>Eriocephalus africanus</i>	100	100	83	67
<i>Helichrysum rutilans</i>	50	100	100	33
<i>Babiana patula</i>	50	100	83	
<i>Phyllobolus grossus</i>		33	50	
<i>Drosanthemum hallii</i>		33	33	
<i>Protea laurifolia</i>				
<i>Bulbine praemorsa</i>			33	33
<i>Ruschia diversifolia</i>				
<i>Aspalathus tuberculata</i>			17	
<i>Erica species</i>				
<i>Eriospermum pubescens</i>	25		17	67
<i>Tribolium utriculosum</i>	100	67	50	67
<i>Muraltia trinervia</i>		33	33	
<i>Cyphia digitata</i>	50	67	83	
<i>Heliophila pendula</i>	50	100	83	67

Microloma sagittatum	50	---	100	---	100	---	67
Hesperantha acuta	25	---	67	---	50	---	33
Antimima species	100	30,6	100	---	17	---	.
Nenax hirta	100	---	67	---	17	---	.
Aspalathus muraltioides	75	---	33	---	33	---	.
Tylecodon ventricosus	100	45,1	.	---	.	---	67
Geissorhiza ornithogaloides s.ornitho	100	35,2	.	---	67	---	.
Oxalis pes-caprae	100	44,5	.	---	33	---	33
Struthiola confusa	75	---	67	---	83	---	.
Wurmbea marginata	.	---	100	---	33	---	.
Hesperantha radiata	.	---	100	---	.	---	.
Afrolimon amoenum	.	---	100	84	.	---	.
Adenogramma glomerata	25	---	67	---	100	33,1	.
Pharnaceum aurantium	50	---	67	---	100	24,7	33
Gladiolus venustus	75	---	.	---	83	33,7	.
Spiloxene flaccida	50	---	67	---	67	---	67
Nylandtia spinosa	.	---	33	---	83	---	67
Lachenalia unifolia	.	---	67	---	100	39,9	33
Selago triquetra	.	---	100	---	100	36	.
Lampranthus spiniformis	25	---	67	---	100	40,9	.
Crassula bergioides	.	---	67	---	100	35,6	33
Albuca flaccida	25	---	67	---	83	---	.
Senecio arenarius	25	---	67	---	83	---	33
Pelargonium rapaceum	50	---	67	---	83	---	.
Helichrysum incarnatum	50	---	67	---	83	---	33
Heliophila coronopifolia	.	---	100	---	50	---	.
Moraea inconspicua	.	---	100	54	67	---	.
Wachendorfia parviflora	.	---	67	---	83	43,4	.
Itasina filifolia	.	---	100	---	50	---	.
Moraea virgata	25	---	100	---	67	---	.
Ruschia species	.	---	100	---	83	---	.
Thamnochortus bachmannii	.	---	.	---	50	---	.
Diascia capensis	50	---	.	---	67	---	.
Wahlenbergia ramulosa	.	---	.	---	83	33,2	.
Willdenowia incurvata	25	---	.	---	83	34	.
Crassula strigosa	.	---	.	---	100	46,8	.
Gladiolus virescens	.	---	.	---	83	47,7	.
Ischyrolepis gaudichaudiana	.	---	.	---	67	---	.
Helichrysum asperum	.	---	33	---	83	39	.
Gladiolus alatus	25	---	.	---	67	34,9	.
Wiborgia mucronata	.	---	.	---	67	32,5	.
Rumex lativalvis	.	---	33	---	83	52	.
Dorotheanthus bellidiformis	.	---	.	---	83	55	.
Cotula turbinata	.	---	.	---	50	---	33
Albuca longipes	.	---	.	---	50	---	.
Aspalathus spinosa s. flavispina	.	---	67	---	67	46,8	.
Corycium orobanchoides	.	---	.	---	50	48,9	.
Athanasia trifurcata	.	---	.	---	50	49,9	.
Ornithogalum polyphyllum	.	---	.	---	33	---	.

<i>Drimia haworthioides</i>	.	---	.	---	50	46,7	.
<i>Thesium dissitiflorum</i>	25	---	33	---	83	28,6	100
<i>Ehrharta calycina</i>	25	---	33	---	67	---	100
<i>Sebaea exacoides</i>	25	---	.	---	50	---	100
<i>Tetragonia verrucosa</i>	.	---	.	---	.	---	100
<i>Ornithogalum dubium</i>	50	---	.	---	.	---	100
<i>Tripteris aghillana</i>	.	---	.	---	.	---	67
<i>Zygophyllum pygmaeum</i>	.	---	.	---	.	---	67
<i>Gloveria integrifolia</i>	.	---	.	---	.	---	67
<i>Ficinia trichodes</i>	.	---	.	---	.	---	67
<i>Ruschia intrusa</i>	.	---	.	---	.	---	67
<i>Sparaxis maculosa</i>	50	---	.	---	.	---	.
<i>Cineraria platycarpa</i>	.	---	.	---	.	---	67
<i>Pelargonium carneum</i>	25	---	.	---	.	---	33
<i>Drosanthemum speciosum</i>	.	---	.	---	.	---	100
<i>Sutera glabrata</i>	50	---	.	---	.	---	100
<i>Euphorbia burmannii</i>	.	---	.	---	17	---	100
<i>Antimima stokoei</i>	.	---	.	---	.	---	67
<i>Wiborgia tenuifolia</i>	.	---	.	---	.	---	67
<i>Oxalis engleriana</i>	25	---	.	---	.	---	67
<i>Drosanthemum species</i>	50	---	67	---	.	---	.
<i>Hesperantha falcata</i>	25	---	.	---	17	---	33
<i>Oxalis species</i>	.	---	.	---	.	---	33
<i>Indigofera heterophylla</i>	50	---	.	---	50	---	100
<i>Bulbine frutescens</i>	25	---	100	---	33	---	.
<i>Xenoscapa fistulosa</i>	50	---	.	---	.	---	33
<i>Merxmuellera arundinacea</i>	.	---	.	---	.	---	.
<i>Nerine humilis</i>	.	---	.	---	.	---	.
<i>Drimia anomala</i>	.	---	.	---	.	---	.
<i>Othonna retrofracta</i>	50	---	.	---	17	---	.
<i>Syncarpha canescens</i>	.	---	.	---	17	---	.
<i>Crassula saxifraga</i>	75	---	67	---	.	---	33
<i>Heliophila descurva</i>	.	---	.	---	.	---	.
<i>Polycarena pubescens</i>	50	---	.	---	17	---	.
<i>Phyllopodium cordatum</i>	.	---	.	---	33	---	.
<i>Lotononis rigida</i>	.	---	67	---	.	---	33
<i>Oxalis glabra</i>	25	---	.	---	33	---	.
<i>Aspalathus recurva</i>	.	---	33	---	.	---	.
<i>Phyllopodium heterophyllum</i>	.	---	.	---	.	---	.
<i>Moraea species</i>	25	---	33	---	17	---	.
<i>Tripteris tomentosa</i>	25	---	.	---	.	---	.
<i>Agathosma serpyllacea</i>	.	---	33	---	33	---	.
<i>Schoenoxiphium ecklonii</i> v. <i>ecklonii</i>	25	---	.	---	.	---	.
<i>Pentaschistis glandulosa</i>	.	---	.	---	.	---	.
<i>Satyrium coriifolium</i>	.	---	.	---	.	---	.
<i>Corymbium glabrum</i> v. <i>glabrum</i>	.	---	.	---	17	---	.
<i>Berkheya heterophylla</i>	.	---	.	---	.	---	.
<i>Agathosma virgata</i>	.	---	.	---	.	---	.
<i>Bulbinella triquetra</i>	25	---	.	---	.	---	33

Pterygodium catholicum	.	---	.	---	.	---	.
Pterygodium pentherianum	.	---	.	---	.	---	.
Printzia polifolia	.	---	.	---	.	---	.
Muraltia ononidifolia	.	---	.	---	17	---	.
Ficinia indica	25	---	.	---	17	---	.
Hermannia confusa	25	---	.	---	.	---	.
Sonderina tenuis	.	---	.	---	.	---	.
Carpobrotus edulis	.	---	.	---	.	---	.
Themeda triandra	.	---	.	---	.	---	.
Perdicium capense	.	---	.	---	.	---	.
Corybium africanum s. scabridum v. sc.	.	---	.	---	.	---	.
Pelargonium pillansii	.	---	.	---	.	---	.
Euphorbia silenifolia	.	---	.	---	.	---	.
Othonna digitata	25	---	.	---	.	---	.
Selago aspera	.	---	.	---	.	---	33
Protea restionifolia	.	---	.	---	.	---	.
Psammotropha species	.	---	.	---	17	---	.
Prismatocarpus pedunculatus	.	---	.	---	.	---	.
Leucadendron teretifolium	.	---	.	---	.	---	.
Muraltia heisteria	.	---	.	---	.	---	.
Selago thomii	.	---	.	---	.	---	.
Drosanthemum micans	.	---	.	---	.	---	33
Erica bolusiae	.	---	.	---	.	---	.
Dicoma spinosa	.	---	.	---	.	---	.
Thesium imbricatum	.	---	.	---	.	---	.
Pteronia hirsuta	25	---	.	---	.	---	.
Erica setacea	.	---	.	---	.	---	.
Ixia atrandra	50	---	.	---	.	---	.
Prismatocarpus fruticosus	.	---	.	---	.	---	.
Aspalathus latifolia	.	---	.	---	.	---	.
Oedera capensis	.	---	.	---	.	---	.
Ischyrolepis gossypina	.	---	.	---	.	---	.
Drosera cistiflora	25	---	33	---	.	---	.
Wachendorfia paniculata	25	---	.	---	.	---	.
Heliophila pusilla	25	---	.	---	.	---	.
Lampranthus aurantiacus	.	---	.	---	.	---	.
Euphorbia tuberosa	.	---	.	---	.	---	.
Lampranthus scaber	50	---	.	---	.	---	.
Senecio anthemifolius	.	---	.	---	.	---	.
Ficus mutantifolia	.	---	.	---	.	---	.
Aizoon sarmentosum	.	---	.	---	.	---	.
Oxalis flava	50	---	33	---	50	---	.
Romulea hirsuta v. cuprea	.	---	.	---	17	---	.
Oxalis depressa	.	---	.	---	50	---	.
Rhynchopsidium sessiliflorum	25	---	.	---	67	35,7	33
Ehrharta melicoides	.	---	.	---	.	---	33
Cleretum papulosum s. papulosum	.	---	.	---	.	---	.
Albuca species	25	---	.	---	.	---	100
Gladiolus floribundus	25	---	.	---	33	---	.

Helichrysum hebelepis	.	---	.	---	.	---	.
Lapeirousia pyramidalis	.	---	.	---	50	---	.
Othonna lingua	.	---	.	---	17	---	.
Oxalis convexula	.	---	.	---	17	---	33
Drimia species	.	---	.	---	.	---	.
Oxalis pulchella v. tomentosa	25	---	.	---	50	---	.
Helichrysum moesianum	50	---	.	---	50	---	.
Thesium subnudum	25	---	100	---	.	---	.
Rhus rosmarinifolia	.	---	.	---	.	---	.
Thesium strictum	.	---	.	---	.	---	.
Geissorhiza confusa	.	---	.	---	.	---	.
Babiana ambigua	.	---	.	---	33	---	.
Lachenalia pustulata	.	---	.	---	17	---	.
Corymbium glabrum	50	---	.	---	.	---	.
Gladiolus carinatus	.	---	.	---	50	---	.
Cullumia ciliaris	.	---	.	---	33	---	.
Ficinia bulbosa	.	---	.	---	33	---	.
Agathosma capensis	.	---	.	---	.	---	.
Manulea cheiranthus	.	---	.	---	.	---	.
Struthiola ciliata	.	---	.	---	17	---	.
Lapeirousia micrantha	.	---	.	---	.	---	.
Indigofera brachystachya	.	---	.	---	.	---	.
Caesia contorta	.	---	.	---	.	---	.
Moraea neglecta	.	---	.	---	.	---	.
Albuca juncifolia	.	---	.	---	.	---	.
Silene cretica	.	---	.	---	.	---	.
Watsonia spectabilis	.	---	.	---	.	---	.
Gazania ciliaris	.	---	.	---	.	---	.
Arctotis acaulis	.	---	.	---	17	---	.
Hypodiscus striatus	.	---	.	---	.	---	.
Zygophyllum sessilifolium	.	---	.	---	.	---	.
Eriospermum proliferum	.	---	.	---	17	---	.
Elytropappus gnaphaloides	.	---	.	---	33	---	.
Ehrharta villosa	25	---	67	---	67	---	.
Cliffortia ruscifolia	.	---	.	---	83	---	.
Crassula subulata v. subulata	50	---	67	---	33	---	33
Senecio radicans	.	---	.	---	.	---	.
Phylica rogersii	.	---	33	---	17	---	.
Bulbine mesembryanthemoides	.	---	.	---	.	---	.
Pelargonium luteolum	.	---	.	---	.	---	33
Viscum capense	.	---	67	---	17	---	.
Crassula nudicaulis	25	---	33	---	.	---	100
Euryops rehmannii	.	---	.	---	.	---	33
Pteronia paniculata	50	---	33	---	.	---	100
Mohria caffrorum	75	---	100	---	.	---	100
Berkheya armata	25	---	.	---	.	---	.
Montinia caryophyllacea	25	---	.	---	.	---	.
Cyphia volubilis	25	---	33	---	50	---	.
Satyrium candidum	.	---	.	---	.	---	.

Cyanella lutea	50	---	.	---	50	---	67
Wurmbea variabilis	50	---	.	---	.	---	.
Oxalis pardalis	25	---	.	33	33	---	.
Cyanella hyacinthoides	.	---	.	100	.	---	.
Cheilanthes hastata	50	---	.	---	.	---	33
Pterygodium alatum	25	---	.	33	17	---	.
Eriospermum dielsianum s. dielsianum	25	---	.	---	.	---	.
Aspalathus submissa	.	---	.	100	17	---	.
Stipa capensis	.	---	.	100	33	---	67
Helichrysum rosum	.	---	.	---	.	---	67
Moraea gawleri	.	---	.	33	50	---	67
Moraea unguiculata	75	---	.	67	.	---	33
Lichensteinia interrupta	25	---	.	---	.	---	.
Metalasia acuta	.	---	.	---	67	---	.
Holothrix secunda	.	---	.	---	50	---	.
Ruschia caroli	.	---	.	---	.	---	100
Adromischus filicaulis s. marlothii	.	---	.	---	.	---	67
Pteronia fasciculata	.	---	.	---	.	---	33
Crassula rupestris	.	---	.	---	.	---	33
Tylecodon paniculatus	.	---	.	---	.	---	67
Gladiolus orchidiflorus	.	---	.	---	33	---	.
Crassula tetragona s. tetragona	50	---	.	67	83	---	100
Rhus incisa	50	---	.	---	.	---	.
Aspalathus spicata	.	---	.	---	33	---	.
Pelargonium alternans	.	---	.	---	.	---	33
Tetragonia fruticosa	50	---	.	---	17	---	.
Ursinia pilifera	.	---	.	---	.	---	33
Euclea undulata	.	---	.	---	.	---	33
Selago eckloniana	.	---	.	---	.	---	67
Euphorbia mauritanica	.	---	.	---	.	---	33
Crassula muricata	.	---	.	---	.	---	.
Haworthia herbacea	.	---	.	---	.	---	33
Leipoldtia schultzei	.	---	.	---	.	---	33
Carissa bispinosa	.	---	.	---	.	---	33
Crassula subaphylla	.	---	.	---	.	---	.
Sutherlandia frutescens	.	---	.	---	.	---	.
Selago scabrida	.	---	.	---	.	---	.
Ruschia lineolata	.	---	.	---	.	---	67
Duvalia caespitosa	.	---	.	---	.	---	.
Euphorbia hamata	.	---	.	---	.	---	.
Hirpicium integrifolium	25	---	.	---	.	---	67
Polygala scabra	75	41,6	.	---	.	---	67
Cotyledon orbiculata v. orbiculata	.	---	.	---	.	---	100
Cissampelos capensis	.	---	.	---	.	---	.
Aspalathus heterophylla	25	---	.	---	17	---	.
Elytropappus species	.	---	.	---	.	---	.
Relhania relhanioides	.	---	.	---	.	---	.
Oxalis polyphylla	.	---	.	---	.	---	.
Drimia capensis	50	---	.	---	.	---	33

Anginon swellendamensis	.	---	.	---	.	---	33
Asparagus retrofractus	.	---	.	---	.	---	.
Galenia africana	.	---	.	---	17	---	33
Pelargonium karoocicum	25	---	.	---	.	---	67
Sarcostemma viminale	.	---	.	---	.	---	.
Gasteria disticha	.	---	.	---	.	---	33
Lotononis leptoloba	.	---	.	---	.	---	.
Drosanthemum striatum	.	---	.	---	.	---	.
Babiana species	.	---	.	---	.	---	67
Cannomois species	.	---	.	---	.	---	.
Thamnochortus lucens	.	---	.	---	.	---	.
Acrodon bellidiflorus	.	---	.	---	.	---	.
Tribolium uniolae	25	---	.	---	33	---	.
Asparagus rubicundus	.	---	33	---	17	---	.
Bulbinella cauda-felis	50	---	.	---	.	---	33
Cheilanthes capensis	.	---	.	---	.	---	33
Briza minor	.	---	.	---	.	---	.
Helichrysum cylindriflorum	.	---	.	---	.	---	.
Geissorhiza delicatula	.	---	.	---	.	---	67
Serruria acrocarpa	.	---	.	---	.	---	.
Osteospermum polygaloides	.	---	.	---	.	---	.
Erica pillansii	.	---	.	---	.	---	.
Oxalis microdonta	.	---	.	---	.	---	.
Ornithogalum graminifolium	25	---	33	---	17	---	.
Tulbaghia capensis	.	---	.	---	.	---	.
Erepsia anceps	.	---	.	---	.	---	.
Oxalis livida	25	---	.	---	.	---	.
Gymnodiscus capillaris	.	---	.	---	17	---	.
Senecio pinifolius	25	---	.	---	.	---	.
Agathosma ovata	.	---	.	---	.	---	.
Maytenus oleoides	.	---	.	---	.	---	.
Haworthia maculata	.	---	.	---	.	---	.
Albuca aurea	.	---	.	---	.	---	33
Centella capensis	.	---	.	---	.	---	.
Cephalophyllum purpureo-album	50	---	.	---	.	---	.
Drimia elata	75	69	.	---	.	---	.
Babiana stricta	50	---	.	---	33	---	.
Disperis villosa	50	---	.	---	50	48,5	.
Lampranthus elegans	50	---	.	---	.	---	.
Manochlamys albicans	.	---	33	---	33	---	.
Protea nitida	.	---	.	---	.	---	.
Selago micradenia	.	---	.	---	17	---	.
Lobelia capillifolia	.	---	.	---	.	---	.
Syncarpha species	.	---	.	---	.	---	.
Leucospermum calligerum	.	---	.	---	.	---	.
Pelargonium senecioides	.	---	.	---	17	---	.
Othonna arbuscula	.	---	.	---	.	---	.
Scopelogenia veruculata	.	---	.	---	.	---	.
Tribolium echinatum	.	---	100	85,3	.	---	.

Polpoda capensis	.	---	.	---	.	---	.	---
Ornithogalum hispidum	25	---	33	---	33	---	100	---
Oxalis fergusonae	75	---	.	---	67	---	.	---
Dodonaea viscosa	25	---	.	---	17	---	33	---
Oxalis purpurea	50	---	.	---	83	---	33	---
Holothrix villosa	25	---	.	---	17	---	33	---
Othonna pinnata	.	---	33	---	33	---	.	---
Taraxacum officinale	.	---	67	---	67	---	.	---
Lampranthus leipoldtii	50	---	.	---	17	---	.	---
Heliophila elata	.	---	.	---	.	---	100	---
Pelargonium triste	25	---	33	---	.	---	.	---
Lachenalia orchoides	25	---	67	---	67	---	.	---
Chamarea gracillima	75	---	.	---	.	---	33	---
Cyanella species	50	---	.	---	67	---	33	---
Senecio crassulaefolius	.	---	.	---	.	---	33	---
Crassula muscosa	.	---	.	---	.	---	67	---
Holothrix cernua	25	---	.	---	17	---	33	---
Trachyandra muricata	25	---	100	---	33	---	.	---
Holothrix aspera	25	---	.	---	33	---	.	---
Wahlenbergia androsacea	.	---	33	---	33	---	.	---
Stoebe cinerea	.	---	.	---	.	---	.	---
Senecio species	.	---	.	---	.	---	67	---
Othonna auriculifolia	25	---	.	---	.	---	.	---
Senecio laxus	50	---	.	---	33	---	33	---
Rumex sagittatus	50	---	.	---	67	---	.	---
Crassula tetragona	.	---	.	---	.	---	.	---
Othonna amplexifolia	.	---	.	---	.	---	67	---
Diospyros glabra	.	---	.	---	.	---	.	---
Eriospermum graminifolium	75	---	.	---	.	---	.	---
Tetragonia spicata	.	---	.	---	17	---	33	---
Rhus undulata	.	---	.	---	.	---	33	---
Othonna bulbosa	25	---	.	---	.	---	.	---
Helichrysum hamulosum	.	---	.	---	.	---	33	---
Tetragonia nigrovaginata	.	---	.	---	17	---	.	---
Phyllopodium capillare	.	---	.	---	33	---	.	---
Freesia refracta	.	---	.	---	.	---	67	---
Arctopus echinatus	75	36,8	.	---	.	---	.	---
Eriospermum nanum	.	---	33	---	50	---	.	---
Hemimeris racemosa	50	---	.	---	.	---	33	---
Oxalis pocockiae	.	---	.	---	.	---	.	---
Chamarea capensis	25	---	.	---	.	---	.	---
Leucadendron salignum	.	---	.	---	33	---	.	---
Ferraria species	.	---	67	---	50	---	.	---
Eriospermum bowieanum	.	---	.	---	33	---	.	---
Bulbine species	.	---	.	---	.	---	.	---
Cheilanthes contracta	25	---	.	---	.	---	.	---
Isolepis incomptula	.	---	.	---	17	---	.	---
Moraea fugax	.	---	33	---	50	---	.	---
Stipagrostis zeyheri s. zeyheri	.	---	.	---	17	---	.	---

Phylica constricta	.	---	.	---	.	---	.
Empodium plicatum	25	---	.	---	17	---	.
Moraea longistyla	50	---	33	---	50	---	.
Aloe microstigma	.	---	.	---	.	---	67
Cymbopappus adenosolen	.	---	33	---	17	---	.
Haworthia pumila	.	---	.	---	.	---	67
Aspalathus hirta s. hirta	50	---	.	---	33	---	.
Asparagus capensis	25	---	.	---	.	---	33
Dimorphotheca nudicaulis	25	---	.	---	.	---	67
Polygala umbellata	.	---	.	---	.	---	.
Helichrysum excisum	.	---	33	---	.	---	.
Hyobanche sanguinea	.	---	.	---	.	---	.
Lobostemon gracilis	.	---	.	---	.	---	.
Pentaschistis patula	.	---	.	---	17	---	.
Protea humiflora	.	---	.	---	.	---	.
Albuca namaquensis	.	---	.	---	.	---	.
Hermannia alnifolia	25	---	.	---	17	---	33
Clutia polifolia	.	---	.	---	.	---	.
Oxalis ciliaris	25	---	.	---	33	---	.
Crossyne guttata	50	---	.	---	.	---	.
Ehrharta ramosa	.	---	.	---	.	---	.
Albuca cooperi	.	---	.	---	33	---	.
Eragrostis curvula	.	---	.	---	33	---	.
Senecio erosus	50	---	.	---	.	---	.
Syringodea longituba	.	---	.	---	.	---	.
Lachenalia mutabilis	.	---	.	---	17	---	.
Festuca scabra	.	---	.	---	.	---	.
Silene clandestina	.	---	.	---	.	---	.
Massonia depressa	.	---	.	---	.	---	.
Pentameris species	25	---	.	---	17	---	.
Moraea tripetala	.	---	.	---	17	---	.
Nemesia affinis	25	---	.	---	33	---	.
Microcodon glomeratum	.	---	.	---	33	---	.
Eriospermum capense	25	---	.	---	.	---	67
Zygophyllum fulvum	.	---	.	---	.	---	33
Ornithoglossum viride	.	---	.	---	17	---	.
Haemanthus coccineus	.	---	.	---	.	---	.
Lycium ferocissimum	.	---	.	---	.	---	33
Eriocephalus species	.	---	.	---	17	---	.
Koeleria capensis	.	---	.	---	.	---	.
Geissorhiza scillaris	.	---	.	---	.	---	.
Erica plukenetii	.	---	.	---	.	---	.
Trachyandra revoluta	.	---	.	---	.	---	.
Wahlenbergia capensis	.	---	.	---	17	---	.
Drosanthemum hispidum	25	---	.	---	17	---	33
Lampranthus haworthii	.	---	.	---	.	---	100
Albuca spiralis	.	---	.	---	.	---	33
Gazania krebsiana s. arctotoides	25	---	.	---	.	---	.
Ornithogalum pilosum	.	---	.	---	.	---	33

Senecio bulbinifolius	.	---	.	---	.	---	.
Pelargonium longifolium	.	---	.	---	.	---	.
Phyllobolus caudatus	25	---	33	---	17	---	.
Polycarena rariflora	25	---	.	---	.	---	.
Aspalathus neglecta	25	---	.	---	.	---	.
Schizodium cornutum	.	---	.	---	.	---	.
Pollichia campestris	.	---	.	---	.	---	.
Pelargonium ovale	.	---	.	---	.	---	.
Trachyandra flexifolia	25	---	.	---	50	36	.
Cyphia incisa v. incisa	25	---	.	---	50	---	.
Limeum africanum	.	---	33	---	17	---	.
Psammotropha quadrangularis	.	---	.	---	.	---	.
Geissorhiza inflexa	25	---	.	---	.	---	.
Lotononis hirsuta	50	---	.	---	.	---	.
Dianthus caespitosus	.	---	67	---	17	---	67
Agathosma species	.	---	.	---	.	---	.
Hermannia cuneifolia v. cuneifolia	25	---	33	---	.	---	.
Ficinia tristachya	.	---	.	---	.	---	.
Lessertia herbacea	25	---	67	---	.	---	.
Silene gallica	25	---	.	---	.	---	.
Gethyllis villosa	25	---	67	---	.	---	.
Senecio burchellii	.	---	.	---	.	---	.
Ornithogalum nanodes	50	---	.	---	33	---	.
Aspalathus acuminata s. acuminata	.	---	.	---	17	---	.
Syncarpha gnaphaloides	.	---	.	---	.	---	.
Willdenowia arescens	.	---	.	---	.	---	.
Pentaschistis curvifolia	.	---	33	---	17	---	.
Pelargonium ternifolium	.	---	.	---	.	---	.
Annesorhiza species	.	---	.	---	17	---	.
Chlorophytum undulatum	25	---	.	---	.	---	.
Lapeirousia anceps	.	---	.	---	33	---	.
Euchaetis pungens	.	---	.	---	.	---	.
Rhus pallens	.	---	.	---	.	---	.
Lycium afrum	.	---	.	---	.	---	.
Ischyrolepis triflora	.	---	.	---	.	---	.
Oxalis pseudo-hirta	25	---	.	---	.	---	.
Muraltia macrocarpa	.	---	.	---	.	---	33
Asparagus declinatus	25	---	.	---	.	---	.
Albuca maxima	.	---	.	---	.	---	.
Acrosanthes teretifolia	.	---	.	---	.	---	.
Microloma tenuifolium	.	---	.	---	.	---	.
Adromischus maculatus	.	---	.	---	.	---	.
Senecio rosmarinifolius	.	---	.	---	17	---	33
Moraea miniata	.	---	.	---	17	---	.
Eriospermum cernuum	25	---	.	---	.	---	.
Prismatocarpus crispus	.	---	.	---	.	---	.
Bulbine lagopus	.	---	.	---	.	---	.
Solanum tomentosum	.	---	.	---	.	---	.
Erepsia bracteata	.	---	.	---	.	---	.

Hebenstretia ramosissima	.	---	.	---	33	---	.
Aristida diffusa s. diffusa	.	---	.	---	.	---	.
Metalasia brevifolia	.	---	.	---	.	---	.
Lyperia tristis	.	---	.	---	17	---	.
Gorteria personata s. gracilis	50	---	33	---	33	---	.
Lichtensteinia obscura	25	---	.	---	.	---	.
Ruschia multiflora	.	---	.	---	.	---	.
Rhynchosidium pumilum	.	---	.	---	17	---	33
Pteronia ovalifolia	.	---	.	---	.	---	33
Oxalis annae	.	---	.	---	.	---	.
Antimima peersii	50	---	.	---	.	---	.
Nenax acerosa	.	---	.	---	17	---	.
Lyperia antirrhinoides	.	---	.	---	.	---	.
Zaluzianskya divaricata	.	---	.	---	.	---	.
Heliophila crithmifolia	50	---	.	---	.	---	.
Crassula umbella	.	---	.	---	.	---	.
Pelargonium carnosum	.	---	.	---	.	---	.
Lobostemon laevigatus	.	---	.	---	.	---	.
Trachyandra chlamydophylla	.	---	.	---	.	---	.
Oncosiphon suffruticosum	.	---	.	---	.	---	.
Erepsia gracilis	.	---	.	---	.	---	.
Galium capense s. capense	.	---	.	---	17	---	.
Hermannia althaeifolia	.	---	.	---	.	---	.
Geissorhiza juncea	.	---	.	---	.	---	.
Tritoniopsis antholyza	.	---	.	---	.	---	.
Aspalathus pachyloba	.	---	.	---	.	---	.
Phylica parviflora	.	---	.	---	.	---	.
Centella villosa	.	---	.	---	.	---	.
Watsonia aletroides x laccata	.	---	.	---	.	---	.
Gladiolus grandiflorus	.	---	.	---	.	---	.
Romulea flava	.	---	.	---	33	---	.
Heliophila arenaria	.	---	.	---	33	---	.
Boophane disticha	.	---	.	---	.	---	.
Ursinia nana	25	---	.	---	17	---	.
Tripteris clandestina	.	---	.	---	17	---	.
Babiana ringens	.	---	.	---	.	---	.
Trichogyne repens	.	---	.	---	.	---	.
Wiborgia obcordata	.	---	.	---	.	---	.
Pteronia divaricata	.	---	.	---	.	---	.
Phyllobolus splendens	.	---	.	---	.	---	33
Pteronia flexicaulis	.	---	.	---	.	---	.
Quaqua mammillaris	.	---	.	---	.	---	33
Sceletium species	.	---	.	---	.	---	.
Tritonia flabellifolia	.	---	.	---	.	---	.
Helichrysum indicum	25	---	33	---	.	---	.
Eriocephalus ericoides	.	---	.	---	.	---	.
Conophytum ficiforme	.	---	.	---	.	---	33
Schismus barbatus	.	---	.	---	.	---	33
Delosperma asperulum	.	---	.	---	.	---	33

Annesorhiza nuda	25	---	.	---	.	---	.
Felicia amelloides	.	---	.	---	.	---	.
Crassula capensis	.	---	.	---	.	---	.
Selago glabrata	.	---	.	---	.	---	.
Clutia pubescens	.	---	.	---	.	---	.
Drosanthemum globosum	.	---	.	---	.	---	33
Triglochin bulbosa	.	---	.	---	17	---	.
Crassula pubescens s. pubescens	.	---	.	---	.	---	67
Androcymbium capense	.	---	.	---	.	---	.
Wahlenbergia nodosa	.	---	.	---	.	---	33
Albuca acuminata	.	---	.	---	.	---	.
Atriplex semibaccata v. appendiculata	.	---	.	---	.	---	.
Metalasia densa	.	---	.	---	.	---	.
Astephanus triflorus	.	---	.	---	.	---	.
Aspalathus tridentata s. tridentata	.	---	.	---	.	---	.
Gethyllis afra	.	---	.	---	17	---	.
Disperis bolusiana s. bolusiana	.	---	.	---	.	---	.
Pelargonium alchemilloides	.	---	.	---	.	---	.
Aspalathus cephalotes s. cephalotes	.	---	.	---	.	---	.
Phylica excelsa v. excelsa	.	---	.	---	.	---	.
Disa harveiana s. harveiana	.	---	.	---	.	---	.
Heeria argentea	.	---	.	---	.	---	.
Pelargonium crispum	.	---	.	---	.	---	.
Macrostylis tenuis	.	---	.	---	.	---	.
Erica anomala	.	---	.	---	.	---	.
Erica toringbergensis	.	---	.	---	.	---	.
Euclea tomentosa	.	---	.	---	.	---	.
Phaenocoma prolifera	.	---	.	---	.	---	.
Agathosma bifida	.	---	.	---	.	---	.
Cyphia phyteuma	25	---	.	---	.	---	.
Oxalis truncatula	25	---	.	---	.	---	.
Aspalathus cephalotes s. violaceae	.	---	.	---	.	---	.
Arctotis undulata	25	---	.	---	.	---	.
Spiloxene capensis	.	---	67	---	.	---	.
Dischisma capitatum	25	---	.	---	17	---	.
Heliophila pinnata	25	---	.	---	.	---	.
Brunsvigia orientalis	.	---	.	---	.	---	.
Pelargonium lobatum	.	---	.	---	.	---	.
Lachenalia pusilla	.	---	.	---	17	---	.
Trachyandra falcata	.	---	.	---	.	---	.
Oftia africana	.	---	.	---	.	---	.
Phylica stipularis	.	---	.	---	.	---	.
Oxalis commutata	.	---	.	---	.	---	.
Lotononis involucrata	25	---	.	---	.	---	.
Aristea dichotoma	.	---	.	---	.	---	.
Drimia burchellii	.	---	.	---	33	---	.
Pentzia incana	.	---	.	---	.	---	33
Leysera tenella	.	---	.	---	33	---	.
Anacampseros lanceolat	.	---	.	---	.	---	33

Pelargonium tetragonum	.	---	.	---	.	---	.
Bulbine inflata	.	---	.	---	.	---	33
Othonna parviflora	.	---	.	---	.	---	.
Schizobasis intricata	.	---	.	---	.	---	.
Euphorbia caterviflora	.	---	.	---	.	---	.
Anacampseros retusa	.	---	.	---	.	---	.
Ehrharta delicatula	.	---	.	---	.	---	33
Chrysanthemoides monilifera	.	---	.	---	.	---	33
Bulbine longifolia	.	---	.	---	.	---	33
Crassula ciliata	.	---	.	---	.	---	.
Prenia pallens v. pallens	.	---	.	---	.	---	.
Aspalathus species	.	---	.	---	.	---	33
Osteospermum spinosum	.	---	.	---	.	---	.
Aspalathus cliffortioides	.	---	.	---	.	---	.
Ixia capillaris	.	---	.	---	.	---	.
Torilis arvensis	.	---	.	---	.	---	.
Sebaea micrantha v. intermedia	25	---	.	---	.	---	.
Holothrix villosa v. villosa	.	---	.	---	.	---	.
Pelargonium fergusoniae	.	---	.	---	.	---	.
Romulea atrandra	.	---	.	---	.	---	.
Gladiolus hyalinus	.	---	.	---	.	---	.
Tetragonia decumbens	.	---	.	---	.	---	.
Merxmuellera species	.	---	.	---	.	---	.
Rhus lucida	.	---	.	---	.	---	.
Prismatocarpus lycioides	.	---	.	---	.	---	.
Cassytha ciliolata	.	---	.	---	.	---	.
Cliffortia crenata	.	---	.	---	.	---	.
Agathosma leptospermoides	.	---	.	---	.	---	.
Hymenolepis speciosa	.	---	.	---	.	---	.
Microdon dubius	.	---	.	---	.	---	.
Stayneria neilii	.	---	.	---	.	---	.
Elegia flacea	.	---	.	---	.	---	.
Aspalathus acanthoclada	.	---	.	---	.	---	.
Pterothrix perotrichoides	.	---	.	---	.	---	.
Euryops tenuissimus	25	---	.	---	.	---	.
Pauridia minuta	.	---	33	---	.	---	.
Elytropappus glandulosus	.	---	.	---	.	---	.
Gladiolus guthriei	.	---	.	---	.	---	.
Cyphia incisa v. cardamines	.	---	.	---	.	---	.
Heliophila scoparia	.	---	.	---	.	---	.
Ficinia deusta	.	---	.	---	.	---	.
Helichrysum litorale	.	---	.	---	.	---	.
Senecio pubigerus	.	---	.	---	.	---	.
Trichogyne paronychioides	.	---	.	---	17	---	.
Dianthus bolusii	.	---	.	---	17	---	.
Leysera gnaphalodes	.	---	33	---	.	---	.
Rafnia angulata	.	---	.	---	.	---	.
Eustegia minuta	.	---	.	---	17	---	.
Athanasia scabra	.	---	.	---	33	---	.

Asparagus undulatus	.	---	33	---	17	---	.
Leucospermum rodolentum	.	---	.	---	.	---	.
Arctotis incisa	25	---	.	---	.	---	.
Cyphia bulbosa	.	---	.	---	.	---	.
Rumex cordatus	.	---	.	---	.	---	.
Micranthus junceus	25	---	.	---	17	---	.
Lachnaea capitata	.	---	.	---	17	---	.
Oxalis pulchella	25	---	.	---	.	---	.
Stoebe spiralis	.	---	.	---	33	---	.
Galenia sarcophylla	.	---	33	---	33	---	.
Hypochaeris radicata	.	---	.	---	17	---	.
Convolvulus capensis	.	---	.	---	.	---	.
Drosanthemum bellum	.	---	.	---	.	---	.
Ursinia nudicaulis	.	---	.	---	.	---	.
Delosperma pageanum	.	---	.	---	.	---	33
Crassula expansa s. expansa	.	---	.	---	.	---	.
Sutera caerulea	.	---	.	---	.	---	.
Atriplex cinerea s. bolusii v.adamson	.	---	.	---	.	---	.
Wahlenbergia cinerea	.	---	.	---	.	---	.
Ballota africana	.	---	.	---	.	---	.
Ixia latifolia	.	---	.	---	.	---	.
Senecio junceus	.	---	.	---	.	---	.
Zygophyllum foetidum	.	---	.	---	.	---	.
Androcymbium eucomoides	25	---	.	---	.	---	.
Wiborgia sericea	.	---	.	---	.	---	.
Bulbinella nutans	.	---	.	---	.	---	.
Polycarena aurea	.	---	.	---	.	---	.
Indigofera meyeriana	.	---	.	---	.	---	.
Pteronia elongata	.	---	.	---	.	---	.
Otholobium candicans	.	---	.	---	.	---	33
Aizoon karooicum	.	---	.	---	.	---	.
Chironia baccifera	.	---	.	---	.	---	.
Gnaphalium pauciflorum	.	---	.	---	.	---	.
Heliophila subulata	.	---	.	---	.	---	.
Adromischus caryophyllaceus	.	---	.	---	.	---	.
Pelargonium articulatum	.	---	.	---	.	---	.
Lactuca serriola	.	---	.	---	.	---	.
Mesembryanthemum nodiflorum	.	---	.	---	.	---	.
Atriplex lindleyi s. inflata	.	---	.	---	.	---	.
Lebeckia cytisoides	.	---	.	---	.	---	.
Aspalathus nigra	.	---	.	---	.	---	.
Phyllobolus species	.	---	.	---	.	---	.
Polygala fruticosa	.	---	.	---	.	---	.
Cotula coronopifolia	.	---	.	---	.	---	.
Chamarea species	.	---	.	---	.	---	.
Ursinia anthemoides s. anthemoides	.	---	.	---	.	---	.
Dovyalis caffra	.	---	.	---	.	---	.
Hymenogyne glabra	.	---	.	---	17	---	.
Gethyllis ciliaris	.	---	.	---	.	---	33

Cysticapnos vesicaria	.	---	.	---	.	---	.
Annesorhiza grandiflora	.	---	.	---	.	---	.
Romulea cruciata v. intermedia	.	---	.	---	.	---	.
Dianthus albens	.	---	.	---	.	---	.
Briza maxima	.	---	33	---	.	---	.
Cotula sororia	.	---	.	---	.	---	.
Diascia elongata	.	---	.	---	.	---	.
Androcymbium crispum	.	---	.	---	.	---	.
Ischyrolepis species	.	---	.	---	.	---	.
Pelargonium multicaule s. multicaule	.	---	.	---	.	---	.
Indigofera gracilis	.	---	.	---	.	---	.
Ficinia secunda	.	---	.	---	.	---	.
Helichrysum teretifolium	.	---	.	---	.	---	.
Gladiolus recurvus	.	---	.	---	.	---	.
Secamone alpini	.	---	.	---	.	---	.
Colpoon compressum	.	---	.	---	.	---	.
Ficinia species	.	---	.	---	.	---	.
Stoebe plumosa	.	---	.	---	.	---	.
Tetaria species	.	---	.	---	.	---	.
Crassula species	.	---	.	---	.	---	.
Arctotis species	.	---	.	---	.	---	.
Carpobrotus mellei	.	---	.	---	.	---	.
Wahlenbergia neorigida	.	---	.	---	.	---	.
Staavia capitella	.	---	.	---	.	---	.
Erica woodii	.	---	.	---	.	---	.
Wahlenbergia rubioides	.	---	.	---	.	---	.
Pteronia camphorata	.	---	.	---	.	---	.
Zyrphelis montana	.	---	.	---	.	---	.
Poa species	.	---	.	---	.	---	.
Pelargonium nanum	.	---	.	---	.	---	.
Cullumia sulcata	.	---	.	---	.	---	.
Aspalathus lactea s. breviloba	.	---	.	---	.	---	.
Annesorhiza thunbergii	.	---	.	---	.	---	.
Drosanthemum ambiguum	25	---	.	---	.	---	.
Corymbium species	.	---	.	---	.	---	.
Corymbium africanum	.	---	.	---	.	---	.
Senecio tuberosus	.	---	.	---	.	---	.
Rafnia species	.	---	.	---	.	---	.
Aristea africana	.	---	.	---	.	---	.
Moraea barnardiella	.	---	.	---	.	---	.
Heliophila meyeri	25	---	.	---	.	---	.
Trachyandra jacquiniana	.	---	.	---	.	---	.
Centella macrocarpa	.	---	.	---	.	---	.
Romulea setifolia v. aggregata	.	---	.	---	.	---	.
Rhus angustifolia	.	---	.	---	.	---	.
Gomphocarpus cancellatus	.	---	.	---	.	---	.
Arctotheca calendula	.	---	.	---	17	---	.
Lachenalia juncifolia	.	---	.	---	.	---	.
Cynanchum africanum	.	---	.	---	.	---	.

Hermannia trifurca	.	---	.	---	.	---	.
Bromus diandrus	.	---	.	---	.	---	.
Crassula thunbergiana	.	---	.	---	.	---	.
Lebeckia sepiaria	.	---	.	---	.	---	.
Conicosia elongata	.	---	.	---	17	---	.
Aspalathus quinquefolia s. virgata	.	---	.	---	.	---	.
Pelargonium radulifolium	.	---	.	---	.	---	.
Manulea leiostachys	.	---	.	---	.	---	.
Hermannia filifolia	.	---	.	---	.	---	.
Grisebachia plumosa	.	---	.	---	.	---	.
Ursinia chrysanthemoides	.	---	.	---	.	---	.
Aspalathus ciliaris	.	---	.	---	.	---	.
Leucadendron brunioides v. brunioides	.	---	.	---	17	---	.
Eriospermum capense s. stoloniferum	.	---	.	---	.	---	.
Eriospermum lanceifolium	.	---	.	---	17	---	.
Nenax hirta s. hirta	.	---	.	---	.	---	.
Chenopodiopsis hirta	.	---	.	---	.	---	.
Stoebe nervigera	.	---	.	---	.	---	.
Nemesia barbata	.	---	.	---	.	---	.
Othonna carnosa	.	---	.	---	17	---	.
Muraltia divaricata	.	---	.	---	.	---	.
Pelargonium myrrhifolium	50	70,2	.	---	.	---	.
Chrysocoma tridentata	.	---	.	---	17	---	.
Ornithogalum suaveolens	.	---	.	---	17	---	.
Cannomois scirpoides	.	---	.	---	.	---	.
Disperis circumflexa	.	---	.	---	.	---	.
Crassula orbicularis	.	---	.	---	.	---	.
Disa triloba	.	---	.	---	.	---	.
Pelargonium heterophyllum	.	---	.	---	.	---	.
Ixia vanzyliae	.	---	.	---	.	---	.
Athanasia humilis	.	---	.	---	.	---	.
Helichrysum species	.	---	.	---	.	---	.
Nemesia pageae	.	---	.	---	.	---	.
Cineraria lobata	.	---	.	---	.	---	.
Berkheya rigida	.	---	.	---	.	---	.
Cotyledon orbiculata v. spuria	.	---	.	---	.	---	.
Pelargonium ternatum	.	---	.	---	.	---	.
Limeum aethiopicum	.	---	.	---	.	---	.
Euphorbia nesemannii	.	---	.	---	.	---	.
Lebeckia leptophylla	.	---	.	---	.	---	.
Delosperma inconspicuum	.	---	.	---	.	---	33
Moraea polyanthos	.	---	.	---	.	---	33
Ixia collina	.	---	.	---	.	---	33
Lepidium africanum	.	---	.	---	.	---	33
Anisodonteia species	.	---	.	---	.	---	33
Bulbine favosa	.	---	.	---	.	---	33
Pelargonium abrotanifolium	.	---	.	---	.	---	33
Asterella marginata	.	---	.	---	.	---	.
Felicia hyssopifolia	.	---	.	---	.	---	.

<i>Ixia stricta</i>	.	---	.	---	.	---	.
<i>Polygala microlopha</i> v. <i>microlopha</i>	.	---	.	---	.	---	.
<i>Moraea thomasiae</i>	.	---	.	---	.	---	.
<i>Bulbinella punctulata</i>	.	---	.	---	.	---	.
<i>Centella asiatica</i>	.	---	.	---	.	---	.
<i>Romulea tortuosa</i>	.	---	.	---	.	---	.
<i>Ixia rapunculoides</i>	.	---	.	---	.	---	.
<i>Romulea hirsuta</i> v. <i>hirsuta</i>	.	---	.	---	.	---	.
<i>Chenopodium mucronatum</i>	.	---	.	---	.	---	.
<i>Lachenalia latifolia</i>	.	---	.	---	.	---	.
<i>Sonchus oleraceus</i>	.	---	.	---	.	---	.
<i>Cotula tenella</i>	.	---	.	---	.	---	.
<i>Pelargonium hantamianum</i>	.	---	.	---	.	---	.
<i>Oxalis punctata</i>	.	---	.	---	.	---	.
<i>Crassula hirsuta</i>	.	---	.	---	.	---	.
<i>Pelargonium species</i>	.	---	.	---	.	---	.
<i>Nerine sarniensis</i>	.	---	.	---	.	---	.
<i>Strumaria tenella</i>	.	---	.	---	.	---	.
<i>Cotula bipinnata</i>	.	---	.	---	.	---	.
<i>Drosanthemum pulchrum</i>	.	---	.	---	.	---	.
<i>Aira cupaniana</i>	.	---	.	---	.	---	.
<i>Pharnaceum lineare</i>	.	---	.	---	.	---	.
<i>Spergularia bocconii</i>	.	---	.	---	.	---	.
<i>Cysticapnos cracca</i>	.	---	.	---	.	---	.
<i>Satyrium erectum</i> x <i>bicorne</i>	.	---	.	---	.	---	.
<i>Pseudoselago densifolia</i>	.	---	.	---	.	---	.
<i>Stellaria media</i>	.	---	.	---	.	---	.
<i>Phyllica ericoides</i> v. <i>zeyheri</i>	.	---	.	---	.	---	.
<i>Polycarpon tetraphyllum</i>	.	---	.	---	.	---	.
<i>Diascia parviflora</i>	.	---	.	---	.	---	.
<i>Grammatotheca bergiana</i>	.	---	.	---	.	---	.
<i>Ursinia punctata</i>	.	---	.	---	.	---	.
<i>Sutera decipiens</i>	.	---	.	---	.	---	.
<i>Silene undulata</i>	.	---	.	---	.	---	.
<i>Salvia africana-caerulea</i>	.	---	.	---	.	---	.
<i>Senecio vestitus</i>	.	---	.	---	.	---	.
<i>Conium sphaerocarpum</i>	.	---	.	---	.	---	.
<i>Moraea ochroleuca</i>	.	---	.	---	.	---	.
<i>Senecio paarlensis</i>	.	---	.	---	.	---	.
<i>Senecio repandus</i>	.	---	.	---	.	---	.
<i>Aspalathus linearis</i>	.	---	.	---	.	---	.
<i>Sutera uncinata</i>	.	---	.	---	.	---	.
<i>Selago venosa</i>	.	---	.	---	.	---	.
<i>Clutia alaternoides</i> v. <i>alaternoides</i>	.	---	.	---	.	---	.
<i>Anaxeton asperum</i>	.	---	.	---	.	---	.
<i>Pelargonium setulosum</i>	.	---	.	---	.	---	.
<i>Zygophyllum lichtensteinianum</i>	.	---	.	---	.	---	.
<i>Helichrysum saxicola</i>	.	---	.	---	.	---	.
<i>Drimia dregei</i>	.	---	.	---	.	---	.

Erica coarctata	.	---	.	---	.	---	.
Struthiola species	.	---	.	---	.	---	.
Moraea bellendenii	.	---	.	---	.	---	.
Aspalathus flexuosa	.	---	.	---	.	---	.
Agathosma parva	.	---	.	---	.	---	.
Senecio glutinarius	.	---	.	---	.	---	.
Corymbium villosum	.	---	.	---	.	---	.
Coleonema juniperinum	.	---	.	---	.	---	.
Osteospermum bidens	.	---	.	---	.	---	.
Lachenalia moniliformis	.	---	.	---	.	---	.
Restio distichus	.	---	.	---	.	---	.
Cliffortia sericea	.	---	.	---	.	---	.
Bolusanthus speciosus	.	---	.	---	.	---	.
Cliffortia species	.	---	.	---	.	---	.
Tenicroa fragrans	.	---	.	---	.	---	.
Cyphia linarioides	.	---	.	---	.	---	.
Romulea minutiflora	.	---	.	---	.	---	.
Micranthus species	.	---	.	---	.	---	.
Heliophila linoides	.	---	.	---	.	---	.
Chaetobromus involucratus s. dregeanu	.	---	.	---	.	---	.
Oncosiphon grandiflorum	.	---	.	---	.	---	.
Dimorphotheca sinuata	.	---	.	---	.	---	.
Lapeirousia jacquinii	.	---	.	---	.	---	.
Moraea macrocarpa	.	---	.	---	.	---	.
Wahlenbergia rubens	.	---	.	---	.	---	.
Pelargonium chamaedryfolium	.	---	.	---	.	---	.
Scabiosa columbaria	.	---	.	---	.	---	.
Cliffortia polygonifol	.	---	.	---	.	---	.
Diosma acmaeophylla	.	---	.	---	.	---	.
Metalasia adunca	.	---	.	---	.	---	.
Babiana auriculata	.	---	.	---	.	---	.
Lobostemon fruticosus	.	---	.	---	.	---	.
Indigofera procumbens	.	---	.	---	.	---	.
Leucadendron chamelaea	.	---	.	---	.	---	.
Othonna ciliata	.	---	.	---	.	---	.
Erica mammosa	.	---	.	---	.	---	.
Staberoha distachyos	.	---	.	---	.	---	.
Lachnospermum fasciculatum	.	---	.	---	.	---	.
Leucospermum hypophyllocarpode ndro	.	---	.	---	.	---	.
Lebeckia contaminata	.	---	.	---	.	---	.
Tetragonia portulacoides	.	---	.	---	.	---	.
Watsonia meriana	.	---	.	---	.	---	.
Metalasia erubescens	.	---	.	---	.	---	.
Metalasia agathosmoides	.	---	.	---	.	---	.
Oxalis hirta	.	---	.	---	.	---	.
Erica quadrangularis	.	---	.	---	.	---	.
Bassia species	.	---	.	---	.	---	.
Nemesia gracilis	.	---	.	---	.	---	.
Hebenstretia dentata	.	---	.	---	.	---	.

Bartholina burmanniana	.	---	.	---	.	---	.
Ruschia costata	.	---	.	---	.	---	.
Lobostemon argenteus	25	---	.	---	.	---	.
Apatesia species	25	---	.	---	.	---	.
Cotula macroglossa	25	---	.	---	.	---	.
Amellus species	25	---	.	---	.	---	.
Tenicroa filifolia	25	---	.	---	.	---	.
Argyrolobium argenteum	25	---	.	---	.	---	.
Tetragonia sarcophylla	25	---	.	---	.	---	.
Spiloxene gracilipes	25	---	.	---	.	---	.
Indigofera incana	25	---	.	---	.	---	.
Androcymbium hantamense	25	---	.	---	.	---	.
Pelargonium magenteum	25	---	.	---	.	---	.
Aspalathus hispida s. hispida	.	---	.	---	17	---	.
Drosanthemum calycinum	.	---	.	---	17	---	.
Moraea ciliata	.	---	.	---	17	---	.
Lampranthus debilis	.	---	.	---	17	---	.
Spergularia media	.	---	.	---	17	---	.
Crotalaria excisa	.	---	.	---	17	---	.
Spiloxene aquatica	.	---	.	---	17	---	.
Anisodonteia fruticosa	.	---	.	---	17	---	.
Plantago coronopus	.	---	.	---	17	---	.
Helichrysum simulans	.	---	.	---	.	---	.
Isolepis species	.	---	.	---	.	---	.
Trichodiadema species	.	---	.	---	.	---	.
Eriocephalus racemosus	.	---	.	---	.	---	.
Lachnospermum species	.	---	.	---	.	---	.
Olea europaea s. africana	.	---	.	---	.	---	.
Gazania krebsiana s. krebsiana	.	---	.	---	.	---	.
Viscum rotundifolium	.	---	.	---	.	---	.
Tulbaghia dregeana	.	---	.	---	.	---	.
Aloe mitriformis	.	---	.	---	.	---	.
Pelargonium plurisectum	.	---	.	---	.	---	.
Helichrysum revolutum	.	---	.	---	.	---	.
Drosanthemum vandermerwei	.	---	.	---	.	---	.
Tetragonia microptera	.	---	.	---	.	---	.
Schizodium flexuosum	.	---	.	---	.	---	.

5 columns)

4	5	6	7	8	9	10	1
3	6	7	3	4	6	4	9
---	100	100	100	100	83	100	100
---	67	57	100	---	100	25	89
---	67	71	100	25	100	25	89
---	83	86	67	100	100	50	44
---	100	100	67	100	100	100	89
---	50	71	67	50	67	75	44
---	100	57	67	75	67	---	---
---	67	71	67	25	---	---	11
---	17	43	---	---	67	100	100
---	50	57	100	50	100	100	100
---	17	86	33	100	100	100	100
---	17	---	33	---	50	25	56
---	17	57	67	---	67	---	67
---	83	14	33	75	67	25	44
---	83	71	67	75	67	---	44
---	33	57	---	50	83	---	44
---	17	100	33	25	100	---	100
---	67	57	67	75	100	50	11
---	33	14	---	---	67	50	---
---	100	100	100	100	100	75	100
---	83	86	67	100	83	100	100
---	67	100	33	50	83	75	78
---	50	100	100	50	83	100	100
---	83	86	67	25	50	100	100
---	67	86	100	100	100	100	100
---	100	71	100	50	67	100	100
---	50	86	---	25	83	100	56
---	50	71	33	50	67	100	89
---	---	14	---	75	---	---	---
---	---	29	---	75	83	---	---
---	---	---	---	---	67	---	---
---	---	43	33	25	83	25	22
---	17	29	---	25	50	---	---
---	---	---	---	---	17	50	11
---	17	14	---	---	50	---	---
---	33	43	---	---	17	50	33
---	67	71	33	25	33	100	100
---	67	86	67	50	50	100	89
---	33	57	33	25	33	100	89
---	83	14	---	---	---	100	56

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---	50	---	14	---	.	---	.	---	75	---	11		
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---	33	---	57	---	67	---	25	---	50	---	100	---	78
48,6	.	---	14	---	.	---	25	---	.	---	.	---	.
---	67	---	14	---	33	---	25	---	33	---	.	---	.
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65,7	.	---	.	---	33	---	.	---	.	---	.	---	.
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65,7	.	---	.	---	.	---	.	---	.	---	.	---	.
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81,3	.	---	.	---	.	---	.	---	.	---	.	---	.
---	100	58,9	.	---	33	---	.	---	33	---	.	---	.
---	100	43,3	.	---	33	---	.	---	.	---	.	---	.
---	100	---	14	---	67	---	.	---	.	---	.	---	22
---	50	---	14	---	.	---	25	---	33	---	.	---	.
---	100	63	.	---	.	---	.	---	.	---	.	---	.
---	67	44,3	.	---	33	---	.	---	.	---	.	---	.
---	83	31,2	.	---	33	---	25	---	100	38,9	.	---	33
---	83	35	.	---	67	---	.	---	.	---	.	---	44
---	83	39	.	---	33	---	.	---	.	---	.	---	11
---	67	58,3	.	---	.	---	.	---	.	---	.	---	.
---	67	---	43	---	33	---	25	---	17	---	.	---	11
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---	67	---	43	---	33	---	50	---	100	34	.	---	.
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---	17	---	.	---	.	---	.	---	.	---	75	---	11
---	17	---	14	---	.	---	50	---	17	---	100	49,7	11
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---	17	---	57	35,6	.	---	.	.	---	17	---	33
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---	33	---	43	---	.	---	.	25	---	.	.	11
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---	.	100	24,1	86	---	100	---	75	---	83	---	---	---	22
---	.	67	---	86	---	100	---	75	---	100	27,3	---	---	.
---	.	83	---	71	---	67	---	100	---	67	---	---	---	.
---	.	100	---	57	---	100	---	50	---	83	---	100	---	89
---	.	33	---	57	---	---	.	50	---	100	24,3	75	---	89
---	.	50	---	29	---	67	---	---	.	100	24,8	25	---	89
---	.	100	27,6	29	---	67	---	---	.	83	---	50	---	56
---	.	---	.	43	---	---	.	25	---	100	41,3	100	41,3	100

---	.	---	100	30,5	33	---	50	---	67	---	75	---	89
---	50	---	86	---	33	---	50	---	67	---	75	---	100
---	17	---	57	---	67	---	75	---	50	---	50	---	33
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---	50	---	29	---	33	---	50	---	33	---	75	---	67
---	33	---	57	---	33	---	50	---	67	---	100	---	100
---	33	---	57	---	.	---	50	---	67	---	100	---	78
---	33	---	43	---	33	---	25	---	33	---	100	---	67
---	.	---	43	---	.	---	25	---	.	---	100	---	100
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---	100	30,6	43	---	33	---	50	---	17	---	75	---	33
---	50	---	57	---	67	---	25	---	33	---	50	---	67
---	.	---	43	---	67	---	.	---	33	---	100	39,3	100
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---	100	---	43	---	.	---	25	---	83	---	.	---	.
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58,3	.	---	.	---	.	---	.	---	.	---	.	---	.
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1	12	13	14	15	16	17	1						
)	6	5	4	2	2	5	7						
---	100	---	100	---	100	---	100	---	86				
---	83	---	100	---	75	---	50	---	100				
---	67	---	100	---	100	---	50	---	50	---	80	---	86
---	33	---	80	---	100	---	50	---	50	---	20	---	100
---	100	---	100	---	50	---	100	---	100	---	80	---	86
---	33	---	20	---	75	---	50	---	100	---	60	---	29
---		---	40	---	50	---		---		---	40	---	100
---		---		---	25	---		---	100	---	60	---	86
---	83	---	80	---	75	---	100	---	100	---	40	---	29
---	83	---	100	---	100	---	50	---	100	---	40	---	
20,7	50	---	100	---	50	---		---		---	60	---	86
---	67	---	80	---	50	---	100	---	100	---	40	---	14
---	50	---	40	---	25	---		---		---	60	---	14
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---	17	---	100	---	100	---		---		---	60	---	100
---	50	---	80	---	25	---	100	---		---	100	---	86
---	50	---	100	---	50	---	50	---		---	80	---	100
---		---	80	---	75	---	100	---		---	80	---	100
19,5	50	---	20	---	100	---		---	100	---	20	---	71
---	100	---	60	---		---	50	---	50	---	60	---	71
---	83	---	100	---	50	---	100	---	100	---	60	---	43
---	100	---	100	---	100	---	50	---	100	---	100	---	86
---	100	---	100	---	25	---	50	---	100	---	60	---	71
---	100	---	100	---		---		---	50	---	80	---	86
---	100	---	60	---	75	---	100	---	50	---	80	---	57
---	100	---	80	---		---	100	---	100	---	80	---	71
---	100	---	100	---	25	---	100	---	100	---	60	---	86
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---	33	---		---		---		---		---	20	---	57
---		---		---	50	---	50	---		---	20	---	29
---	67	---	40	---	25	---	50	---		---	20	---	29
---	17	---	20	---		---		---		---	20	---	
---	33	---	60	---		---	50	---		---	20	---	14
20,5	83	---	100	---	75	---	100	---		---	40	---	43
---	100	---	100	---	75	---		---	50	---	60	---	29
22,6	83	---	40	---		---		---	50	---	20	---	
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21,1	17	---	.	---	25	---	.	---	.	---	20	---	14
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40,4	.	---	20	---	50	---	100	---	50	---	20	---	14
34,6	33	---	20	---	.	---	.	---	50	---	.	---	.
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49,9	33	---	.	---	25	---	.	---	.	---	.	---	.
73,4	.	---	.	---	.	---	.	---	.	---	.	---	.
32	17	---	60	---	.	---	.	---	.	---	20	---	.
60,9	33	---	.	---	.	---	.	---	50	---	.	---	.
48,8	67	48,8	40	---	.	---	.	---	.	---	.	---	.
32,1	50	---	40	---	75	---	.	---	100	---	.	---	.

47,6	83	38,7	.	---	.	---	50	---	50	---	.	---	.
43	67	---	.	---	.	---	.	---	.	---	.	---	.
55,4	100	62,9	.	---	.	---	.	---	.	---	.	---	.
---	67	---	60	---	50	---	.	---	.	---	20	---	.
---	100	42,8	.	---	.	---	.	---	100	---	.	---	14
---	100	79,3	.	---	.	---	.	---	.	---	.	---	.
---	67	33,3	20	---	.	---	.	---	.	---	20	---	.
---	50	51,4	20	---	.	---	.	---	.	---	.	---	.
---	50	63,2	.	---	.	---	.	---	.	---	.	---	.
38	17	---	100	59,5	25	---	.	---	.	---	20	---	.
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---	33	---	100	52,9	50	---	.	---	.	---	20	---	.
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20,3	50	---	100	---	100	---	100	---	.	---	.	---	.
20,7	83	---	100	---	50	---	50	---	100	---	40	---	43
---	100	27,6	80	---	50	---	.	---	.	---	40	---	.
41,3	.	---	20	---	.	---	.	---	.	---	20	---	.

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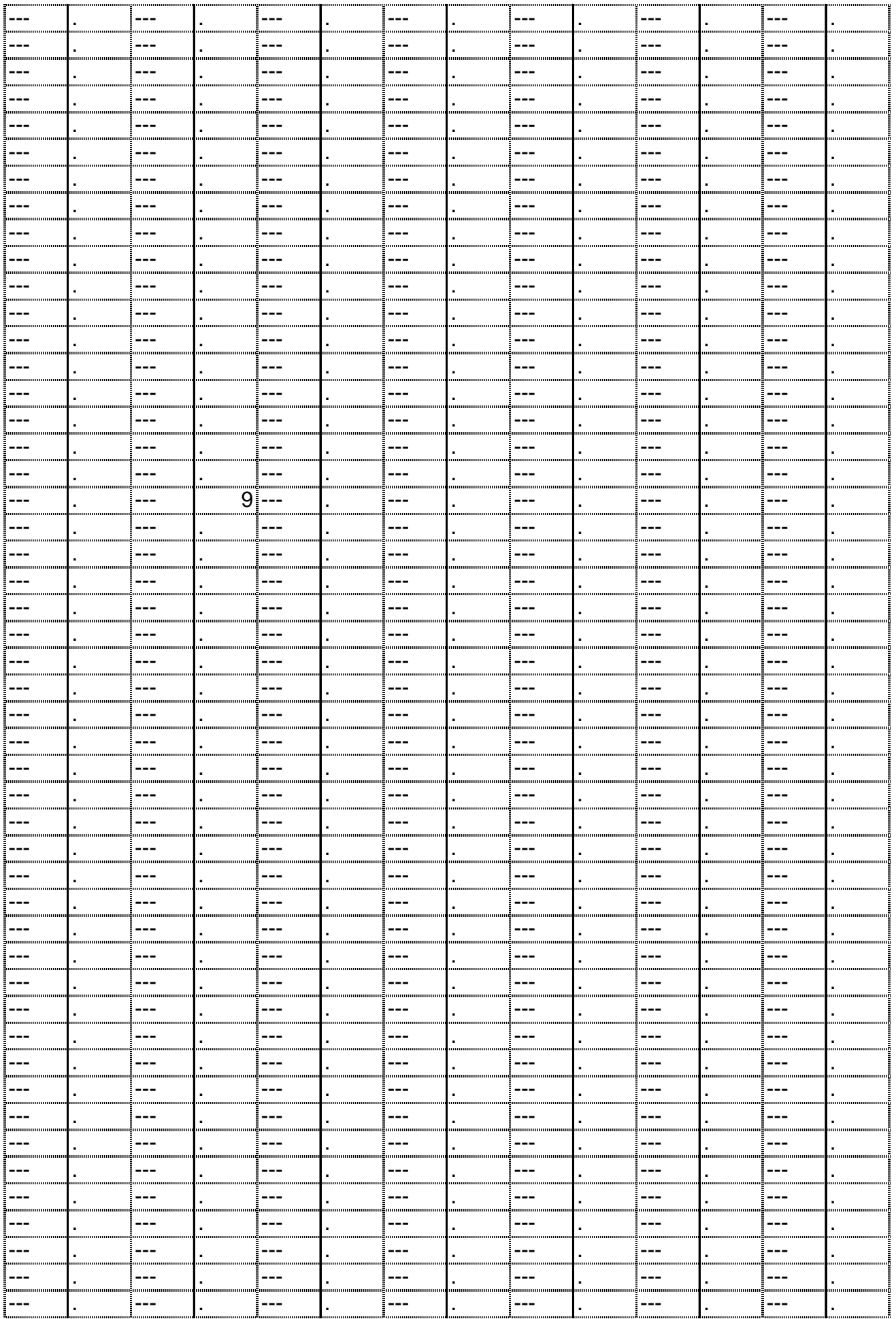
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7	4	11	3	5	6	12	3
---	100	64	67	60	67	92	67
---	75	100	100	100	83	100	100
---	75	91	33	100	100	100	100
---	100	91	67	80	83	100	33
---	75	64	67	60	17	92	33
---	75	100	100	60	50	83	.
---	100	55	100	80	83	100	67
---	100	45	67	20	67	67	67
---	25	100	17,3	100	50	58	67
---	25	82	.	.	.	25	.
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---	75	91	33	80	83	67	33
---	75	73	100	100	50	75	.
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---	75	73	67	40	67	92	67
---	100	45	100	60	67	83	100
---	100	73	33	60	83	92	100
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---	25	9	67	20	67	8	.
---	25	18	67	40	17	25	.
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---	100	100	67	100	50	25	33
---	50	100	67	60	100	50	33
---	50	64	67	100	67	92	33
---	50	100	67	100	17	58	.
---	100	82	67	100	67	42	33
---	75	91	29,5	60	67	67	.
---	75	91	20,4	60	67	83	33
---	75	100	35,1	67	40	50	67
---	25	64	33	60	50	67	33
---	75	100	26,8	67	40	100	26,8
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---	50	91	32,5	33	100	36,5	50
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---	100	---	100	30,1	67	---	60	---	17	---	50	---	33
35,2	50	---	73	---	33	---	20	---	67	---	83	28	.
---	75	---	100	36,4	.	---	20	---	33	---	58	---	.
29,1	25	---	27	---	33	---	.	---	100	35,4	67	---	.
37,3	.	---	.	---	.	---	.	---	.	---	8	---	.
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---	75	---	91	33,5	33	---	100	37,6	.	---	.	---	.
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---	50	---	100	21,7	100	---	80	---	83	---	25	---	67
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---	25	---	45	---	100	---	.	60	---	100	33,1	25	
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---	100	100	100	40	25	71	33
---	100	80	100	80	25	71	33
---	67	100	50	20	50	71	.
---	100	60	100	100	.	57	67
---	.	60	.	40	.	43	.
---	67	.	50	60	.	43	67
---	67	.	75	100	100	86	100
---	33	.	50	40	50	57	.
---	100	100	50	20	.	.	.
---	33	100	25	20	.	14	.
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---	100	80	.	20	.	.	.
---	67	60	50	40	.	43	.
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---	100	20	50	100	75	100	.
---	33	60	75	100	75	86	.
---	67	60	75	100	50	100	33
---	100	60	100	100	75	86	33
---	33	20	50	40	.	29	.
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---	100	40	75	.	.	14	.
---	33	20	75	20	.	14	33
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---	75	33	40
---	25	.	20
---	25	33	40
---	75	67	100
---	100	.	60
---	25	33	.
---	.	33	80
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---	25	---	.	---	.	---
---	25	---	.	---	.	---
---	.	---	.	---	20	---
---	25	---	33	---	100	33,1
---	25	---	.	---	100	---
---	50	---	33	---	.	---
---	.	---	.	---	.	---
---	25	---	33	---	80	---
---	.	---	.	---	20	---
---	.	---	.	---	40	---
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---	.	---	.	---	80	---
---	.	---	.	---	60	---
---	.	---	33	---	100	30,2
---	.	---	67	---	60	---
---	.	---	33	---	100	33,1
---	.	---	.	---	100	46,1
---	.	---	.	---	20	---
---	.	---	.	---	20	---
---	.	---	.	---	20	---
---	50	---	.	---	.	---
---	.	---	33	---	80	---
---	.	---	100	---	80	34,7
---	.	---	.	---	20	---
---	.	---	.	---	60	---
---	.	---	67	---	100	42,2
---	.	---	.	---	80	---
---	50	---	.	---	.	---
---	.	---	100	---	60	---
---	25	---	.	---	80	37,2
---	.	---	33	---	60	---
---	.	---	.	---	80	40,2
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---	25	---	.	---	20	---
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---	.	---	67	---	60	---
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---	.	---	.	---	100	37,6
---	25	---	67	---	40	---
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---	.	---	67	---	60	---
---	.	---	.	---	40	---
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---	.	---	67	---	80	43,3
---	.	---	.	---	60	---
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---	.	---	100	---	60	---
---	.	---	67	---	100	---
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76,5	.	---	.	---	.	---
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---	25	---	33	---	.	---
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---	75	---	.	---	.	---
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---	100	---	.	---	.	---
---	100	---	33	---	.	---
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---	75	---	.	---	.	---
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---	100	---	33	---	.	---
---	75	---	.	---	.	---
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---	100	34,8	.	---	20	---
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---	25	---	.	---	.	---
---	75	---	.	---	.	---
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---	75	---	.	---	.	---
---	50	---	.	---	.	---
---	25	---	.	---	.	---
60,6	50	---	.	---	.	---
---	50	---	.	---	.	---
68,2	75	50	.	---	.	---
---	100	66,8	.	---	.	---
72,9	50	---	.	---	.	---
78,8	25	---	.	---	.	---
---	50	---	.	---	.	---
---	50	---	.	---	.	---
---	25	---	.	---	.	---
78,8	25	---	.	---	.	---
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---	75	71,2	.	---	.	---
89,1	25	---	.	---	.	---
53,6	75	38,8	.	---	.	---
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58,3	25	---	.	---	.	---
---	50	---	.	---	.	---
---	.	---	33	---	60	42,6
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---	25	---	.	---	.	---
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---	75	41,4	.	---	.	---

---	.	---	100	84	40	---
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---	25	---	.	---	.	---
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---	50	---	.	---	.	---
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---	25	---	.	---	40	---
---	50	---	.	---	.	---
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---	.	---	100	78,4	20	---
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---	25	---	33	---	.	---
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---	.	---	.	---	60	58,3
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---	.	---	67	---	20	---
---	.	---	100	75,9	20	---
---	.	---	33	---	40	---
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---	50	---	.	---	20	---
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89,1	.	---	.	---	.	---
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Species group E: Important species for Sub-community 2.2

Crassula strigosa	1					1 1	
Restio gaudichaudiana		1	2				r
Wahlenbergia debilis	1 1 1 1						+ 1
Helichrysum asperum			+ r		+ r		
Diascia capensis					+ +		
Wiborgia mucronata							
Rumex lativalvis	1						
Gladiolus alatus							
Dorotheanthus bellidiformis							
Gladiolus virescens					+ r + +		+ .
Cotula turbinata							
Albuca longipes							
Aspalathus spinosa subsp. flavispina					+ r		
Drimia exuviata							

Species group F: Important species for Community 3

Pteronia paniculata							
Euryops rehmannii							+
Crassula nudicaulis	2		r			+ + + 1 +	
Crassula subulata var. subulata	1 + . +						
Oxalis pardalis	. + 1 .	1 . 1 1			+	. 1 + 1	
Heliophila elata	r . . . + r . .				+ + + . .	1 2 1 . 1	
Selago aspera					+ . r . r	3 2 2 1 1	. + . . .
Polygala scabra	. + + .						

Species group G: Important species for Sub-community 3.1

Indigofera heterophylla		r					r
Sutera glabrata					+ 1 2 1 1 1		1 1 1 . + 2 . +
Moraea gawleri	. + 1 +	. 1 1 . . . +		1 . . . +		+ 1	1 . .
Euphorbia burmannii							
Oxalis engleriana		1 . . + . . . 1 .					. 1 . .
Helichrysum hamulosum		3 r . 2 . . + . .		1 . . + . .			
Wiborgia tenuifolia							. 1 . .

Species group H: Important species for Sub-community 3.1 Variant i

Ornithogalum dubium							r
Sebaea exacoides	1 1 1 +	. + 1 r . 1 1 1 +			. . . 1 .		+
Ehrharta calycina					. . . 2 . . .		

Species group I: Important species for Sub-community 3.1 Variant ii

Drosanthemum papillatum		. . . + . + . . + +					+
Hesperantha falcata		. 1 +		
Pelargonium carneum							

Species group J: Important species for Sub-community 3.2

Xenoscapa fistulosa	. + . . + . . . + . .						1 + . . . + . .
Cyanella lutea	+ 1 1 .	r 1 2 1 1 1 1 2 .		1 1 1 . 1 .			. . . r r . .
Pelargonium pillansii		. . . + . . . + 1 . . .				1 . 1 r +	. . . . .

Tulbaghia capensis	. . . . .	r . . . + + . 1 1 .	1 . . . . . +	. . . . .	. . . . .
Species group K: Important species for Sub-community 3.3					
Crassula saxifraga	1 1 1 1	. . . . + . . . . +	. 1 . . 1 . .	+ + . 1	+
Species group L: Important species for Sub-community 3.3 Variant i					
Species group M: Important species for Sub-community 3.3 Variant iii					
Othonna retrofracta	. . . . .	. . . . .	. . . . .	. . . . .	r . +
Drimia anomala	. + . . . . .	. . . . . + .	. . . . .	. + . . . . .	. . . . .
Syncarpha canescens	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Species group N: Important species for Community 4					
Wurmbea variabilis	1 . 1 1	r + + + 1 1 1 2 2	+ + 1 . . .	1 1 1 1 1	. . . . .
Cheilanthes hastata	1 + . +	2 1 3 1 3 . . 1 .	. . 2 1 + .	+ . . +	r
Eriospermum dielsianum subsp. dielsianu	1 1 1 1	1 1 1 . . 1 1 1 1	1 1 1 . 1 1	1 1 1 . 1	+
Stipa capensis	1 2 5 3	1 1 1 3 1 4 4 1 1	2 5 2 1 2 2	. . . . .	+ 1
Moraea unguiculata	1 . 1 .	. r r . r 1 + 1 .	1 1 . 1 1 +	. + + . + . . . . .	. . . . .
Cyanella hyacinthoides	1 1 1 .	. . r r + + . . .	1 1 1 + 1 .	. . +	r r r
Satyrion candidum	1 2 1 2	1 1 1 + 2 2 1 1 1	. . . . .	. 1 . . . . .	. . . . .
Lichtensteinia interrupta	2 2 3 2	3 2 1 1 3 2 2 2 1	1 1 2 1 2 .	1 1 . 1	+ . 1
Helichrysum rosum	1 + + .	4 1 3 4 2 1 3 3 2	3 4 3 3 2 2	r . . . + . . . . .	. . . . .
Asparagus rubicundus	. . . 1	r 1 r . . .	2 1 2 2 . . . . .	. . . . .	. . . . .
Species group N (1): Important species for Sub-com 4.1					
Aspalathus recurva	2 4 3 4	. . r . . . . .	. . . . .	. . . . .	. . . . .
Phyllopodium heterophyllum	1 1 r 1	. . . . . + . . . . .	. . . . .	. . . . .	. . . . .
Moraea vuvuzela	2 2 2 2	. . . . . 1 + 1 +	. . . . .	. . . . .	. . . . .
Polycarena pubescens	. 1 + 1	. . . . .	. 1 . . . . .	. . . . .	. . . . .
Phyllopodium cordatum	1 1 . 1	. . . . . 1	+ 1 1 . . . . .	. . . . .	. . . . .
Heliophila descurva	+ r 1 +	. . . . .	+ 1 . . . . .	. . . . .	. . . . .
Oxalis glabra	. 2 3 2	. . . . .	. . . . .	. . . . .	. . . . . 1
Merxmüllera species	. 2 . 3	. . . . .	1 . . . . .	. . . . .	. . . . .
Species group N (2): Important species for Sub-com 4.2					
Bulbinella triquetra	1 . . . .	. + + r r 2 1 2 1	. 1 1 . 1 . .	. + . . 1 . . . . .	. . . . .
Agathosma serpyllacea	. . . +	. . + r + 1 1 1 1	1 1 . . . . .	. + . . . . .	. . . . .
Muraltia ononidifolia	. . . . .	. . . . r 1 1 1 1	+ + + + . . . . .	+ + . + . . . . .	. . . . .
Pterygodium catholicum	+	r + 1 1 1 2 1 1 1	2 2 2 1 . 1 . . . . .	. . . . .	. . . . .
Pterygodium pentherianum	. . . 1	r + . + 1 1 1 + .	1 1 1 . 1 . . . . .	. . . . .	. . . . .
Tribolium uniolae	. . . . .	. . . . r 1 + 1 2	1 + + . . . . .	. . . . .	. . . . .
Printzia polifolia	. . . . .	. 1 2 + 2 3 4 3 3	1 1 1 2 2 2 . . . . .	. . . . .	. . . . .
Schoenoxiphium ecklonii var. ecklonii	. . . . .	. . + r 2 . 2 . .	. 1 . . + . . . . .	. . . . .	. . . . .
Berkheya heterophylla	. . . . .	. + + + + 2 1 2 2	. + . . + . . . . .	. . . . .	. . . . .
Agathosma virgata	. . . . .	. + 1 . 1 1 2 1	1 1 2 . + . + . . . .	. . . . .	. . . . .
Cheilanthes capensis	. . . . .	1 1 1 . 1	2 . . + . + . . . . .	. . . . .	. . . . .
Briza minor	. . . . .	. . . + . . . + +	1 1 . . 1 . . . . .	. . . . .	. . . . .
Species group N (2i): Important species for Sub-com 4.2, Vari					
Osteospermum tomentosum	. . . . .	+ + 1 . + 2 2 2 2	. . . . .	+ . . . . .	. . . . . r

Corymbium glabrum var. glabrum	. . . . .	. . . + 1 1 . 2 1	. . . +	1 1 . 2 .	. . . . .	. . . . .
Pentaschistis glandulosa	. . . . .	. . . + + 2 + 2 1	. . . . .	1 +	. . . . .	. . . . .
Satyrium coriifolium	. . . . .	. . . + . 1 1 + 1 1	. . . . .	. . . . .	. . . . .	. . . . .
Species group N (2ii): Important species for Sub-com 4.2, Varii						
Hermannia confusa	. . . . .	. . . . . 1 + . . .	r 1 + 1 + 1	. . . . .	. . . . .	. . . . .
Ficinia indica	+ 1 + . . . . .	. . . . . +	+ 1 1 1 1 2	. . . . .	+ . . . . .	. . . . .
Sonderina tenuis	1 + 1 . . . . .	. 1 1 + 1 .	. 1 1 . 2 2	1 . . . . .	. . . . .	. . . . .
Carpobrotus edulis	. . . . .	. . . . .	2 1 . 1 . . . .	. . . . .	+ . . . . .	. . . . .
Themeda triandra	. . . . .	. . . r . . . . .	. + + + . . . . .	. . . . .	. . . . .	. . . . .
Species group N (3): Important species for Sub-com 4.3						
Protea restionifolia	. . . . .	r . . . . .	. . . . .	1 1 1 1 1	. . . + . . . . .	. . . . .
Euphorbia silenifolia	. . . . .	. . . 1 . . . . .	. . . . .	+ + 1 1 +	. . . . .	. . . . .
Prismatocarpus pedunculatus	. . . . .	. . . . . r . . . . .	. + + . . . . .	2 1 3 + 1	. . . . .	. . . . .
Perdicium capense	. . . . .	. + 1 . 1 2 . 2 1	. . +	2 1 2 2 1	. . . . .	. . . . .
Corymbium africanum subsp. scabridum var.	. . . . .	. . . . . + . 1 . . . . .	. . . . .	1 + 1 + +	. . . . .	. . . . .
Othonna digitata	. . . . .	. . . . .	. . . . .	. . 1 1 1	. . . . .	. . . . .
Species group O: Important species for Community 5						
Thesium imbricatum	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Muraltia heisteria	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Pteronia hirsuta	1 . . . . .	. + . r + . . . . .	. . . . .	+ +	. . . . .	. . . . .
Species group P: Important species for Community 6						
Struthiola confusa	+ . . . . .	. . . . .	. . + . . . . .	. . . . .	. . . . .	. . . . .
Oxalis flava	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Drosera cistiflora	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	+ . . . . .
Species group Q: Important species for Sub-community 6.2						
Euphorbia tuberosa	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Gazania krebsiana subsp. arctotoides	. . . . .	. . . . .	. . . . .	. . . . .	r . . . . .	. . . . .
Mesembryanthemum caudatum	. + . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Romulea hirsuta var. cuprea	. . . . .	. . . 1 . r . . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Lessertia herbacea	. . + . . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Cyphia incisa var. cardamines	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Species group R: Important species for Major Community 2						
Albica species	1 + . + . . . . .	. . . . .	. . . . .	. . . + .	1 1 1 1 1 1 .	r
Drosanthemum hallii	. . . . .	. . . . .	. . . . .	+ 1 + 2 1	4 3 2 + 2 3 2 .	. . . . .
Bulbine praemorsa	+ . . . . .	+ . . + . . . . .	. + 1 . . . . .	. . . . .	. + . . + 1 1	2
Bulbine frutescens	. . . . .	. . . . .	. 1 . . . . .	. . . . .	. . . + . . . . .	. . . . .
Gladiolus floribundus	. . . . .	. . . . .	. . . . .	. + . . . . .	1 + + +	1
Elytropappus gnaphaloides	. . . . .	+ . . . . . + . . . . .	1 + 1 2 . . . . .	. 1 1 . +	+ 1 + . r	1
Helichrysum hebelepis	. . . . .	. . . . .	. . . . .	. . . . .	+ . 1 + 1 +	+
Mesembryanthemum grossum	. . . . .	. . . . .	. . . . .	. . . . .	1 2 . . 2 3 3	2
Lapeirousia pyramidalis	. + . . . . .	. . . . .	. . . . .	. . . . .	2 1 1 2 + 2 1 . . . . .	. . . . .
Othonna lingua	. . . . .	. . . + . . . . .	. . . . .	. . . . .	2 2 1 1 + 1	r
Species group S: Important species for Community 7						

Wahlenbergia capensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polycarena rariflora	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Watsonia spectabilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gazania ciliaris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Willdenowia arescens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pentaschistis curvifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Silene gallica	.	+	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Annesorhiza laticostata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gladiolus grandiflorus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Albica acuminata	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heliophila scoparia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gladiolus guthriei	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lapeirousia jacquini	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centella macrocarpa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group W: Important species for Sub-community 9.2 (Sub-community 9.1 Variant ii)																						
Hermannia alnifolia	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Drosanthemum hispidum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Psammotropha quadrangularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r
Species group X: Important species for Sub-community 9.3 (Sub-community 9.1 Variant iii)																						
Selago micradenia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lobelia capillifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group Y: Important species for Sub-community 9.4 (Sub-community 9.2)																						
Protea nitida	.	.	.	r	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	r	.
Ehrharta ramosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Elytropappus intricata	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
Syncarpha staelhelina	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.
Heeria argentea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group Z: Important species for Sub-community 9.5 (Sub-community 9.3)																						
Holothrix secunda	.	.	.	.	r	.	.	.	.	.	.	.	.	.	1	.	+	1	+	1	r	.
Oxalis convexula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	+	1	2	1	.
Viscum capense	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	r	r
Phylla rogersii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriospermum nanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhynchosidium sessiliflorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eriospermum bowieanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phylla constricta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Haemanthus coccineus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Drosanthemum bellum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Species group AA: Important species for Major Community 3																						
Capeochloa arundinacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Species group AB: Important species for Community 10																						
Metalasia acuta	.	+	.	.	.	.	.	.	.	2	+	2	2	.	.	.	+	.	+	.	.	.
Species group AC: Important species for Sub-community 10.1																						

Species group AK: Important species for Sub-community 11.4										
Manocharisma albicans	.	.	.	.	.	.	.	.	.	.
Species group AL: Important species for Major Community 4										
Pelargonium alternans	.	.	.	.	.	.	.	.	.	.
Tylecodon paniculatus	.	2	.	.	.	.	.	.	r + r	+
Searsia incisa	.	.	.	.	.	.	.	.	.	.
Crassula muscosa	.	.	.	.	.	.	.	.	.	.
Tetragonia fruticosa	.	.	.	.	.	.	.	.	r . r	r
Galenia africana	.	.	.	.	.	.	.	.	.	.
Cotyledon orbiculata var. orbiculata	.	.	.	.	.	.	.	.	.	.
Cissampelos capensis	.	.	.	.	.	.	.	.	.	.
Selago eckloniana	.	.	.	.	.	.	.	.	.	.
Species group AM: Important species for Community 12										
Asparagus retrofractus	.	.	.	.	.	.	.	.	.	+
Curio radicans	.	.	.	.	.	.	.	.	.	r .
Adromischus maculatus	.	.	.	.	.	.	.	.	.	r .
Species group AN: Important species for Community 13										
Ornithogalum graminifolium	.	.	.	1	.	+	.	.	.	+
Ornithogalum pilosum	.	.	.	.	.	.	.	+	.	.
Species group AO: Important species for Major Community 5										
Thamnochortus bachmannii	.	.	.	.	.	.	.	.	.	.
Gymnodiscus capillaris	.	.	.	.	.	.	.	.	.	.
Stipagrostis zeyheri subsp. zeyheri	.	.	.	.	.	.	.	.	.	r
Aristida diffusa subsp. diffusa	.	.	.	.	.	.	.	.	.	.
Species group AP: Important species for Community 14										
Diospyros glabra	.	.	.	.	.	.	.	.	.	r . r .
Trachyandra revoluta	.	.	.	.	.	.	.	.	.	r
Euchaetis pungens	.	.	.	.	.	.	.	.	.	.
Acrosanthes teretifolia	.	.	.	.	.	.	.	.	.	+
Trachyandra chlamydophylla	.	.	.	.	1	.	.	.	.	.
Species group AQ: Important species for Community 15										
Willdenowia incurvata	.	.	.	.	.	.	.	.	.	2 .
Moraea fugax	.	.	.	.	.	.	.	.	.	.
Ferraria variabilis	.	.	.	.	.	.	.	.	.	.
Ornithoglossum viride	.	.	.	.	.	.	.	.	.	.
Eragrostis curvula	.	.	.	.	.	.	.	.	.	.
Aspalathus heterophylla	.	.	.	.	.	.	.	.	.	r
Lapeirousia anceps	.	.	.	.	.	.	.	.	.	.
Silene clandestina	.	1	.	1	.	.	.	.	.	.
Monoculus monstrosus	.	.	.	.	.	.	.	.	.	.
Species group AR: General species for Major Communities 1 – 5										
Elytropappus rhinocerotis	4	4	3	3	4	5	5	4	4	4
	4	2	4	4	4	4	4	4	4	4
	4	3	4	4	4	4	4	4	4	4
	1	2	1	.	+	r	4	2	.	.

Pentaschistis airoides subsp. airoides	2 1 5 2	4 3 4 4 4 3 1 1	2 4 2 1 2 2	1 2 2 1 3	2 2 1 2 . 3 3	.
Babiana patula	1 1 2 1	. 1 1 1 1 1 + 1 1	1 1 1 + 1 1	1 1 1 1 1	++ . 1 + 1 1	+
Helichrysum rutilans	1 ++ 1	. + . + + + . + .	1 + 1 1 2 2	+ + 1 r .	+ . . 2 r + r	2
Ursinia anthemoides	1 1 2 2	+ 2 2 1 4 2 2 1 2	2 2 2 2 2 2	2 2 2 2 2	. 2 1 . r r r	1
Tenaxia stricta	3 2 3 3	1 4 2 3 2 3 1 3 1	2 1 3 2 2 2	2 3 1 3 2	3 . 2 3 3 2 3	2
Oedera squarrosa	. . . +	+ 1 2 2 . + + + +	. + 1 + 1 2	1 1 2 2 1	1 2 1 2 2 2 4	1
Felicia filifolia subsp. schaeferi	2 + . .	1 1 1 r . . . . .	. . . . + 1	+ . 1 + 1	+ 2 1 1 2 + 4	2
Anthospermum spatulatum	. + . .	1 . 1 1 1 2 2 2 1	3 2 2 1 . .	3 3 3 + 2	+ + 1 1 1 . r	+
Satyrium erectum	1 1 1 1 1	r 1 1 + 1 1 + . 1	1 + 1 1 1 1 1	1 1 1 1 +	. + + 1 r 2 r	+
Crassula atropurpurea	. . . . .	. . . . . . . . . .	. . . . . . . . . .	+ . + . .	1 2 1 3 1 3 1	2
Restio sieberi	. . . . .	2 + r 1 2 1 + 2 1	. . 2 1 1 .	2 . 1 4 2	. 4 1 3 3 4 r	3
Chrysocoma ciliata	+ + . 1	+ 1 1 r . . . . .	. . . . . 1 1	. . + . .	. . . . . r . +	1
Eriocephalus africanus	2 + 2 2	2 1 1 4 2 1 + 1 1	2 2 2 2 3 3	2 2 2 . .	+ 1 + . . r . .	.
Pentaschistis eriostoma	2 . . 2	. . . . . . . r . .	. . r . 1 1	3 2 3 1 2	1 4 2 3 1 2 2	2
Passerina truncata subsp. truncata	r . . +	. . . . . . . . . .	. . . . . . . . . .	+ . r + +	2 3 2 4 2 2 r	3
Mesembryanthemum longistylum	. . . . .	. . . . . 1 + + r	. . +	1 2 1 1 2	4 3 3 2 3 4 2	2
Restio capensis	2 2 2 2	1 + 1 3 3 2 2 2 2	2 2 3 2 2 .	2 2 2 + . .	. . 1 . . r . .	.
Ehrharta capensis	2 1 3 2	+ 3 2 1 3 3 2 2 2	1 2 2 . 2 2	2 2 2 + 1 . . . . .	. . . . . . . . . .	.
Tribolium hispidum	2 2 2 .	r 2 1 . . 2 3 1 1	1 1 . 1 1 2	1 1 1 2 2	. . + . r . r . .	.
Troglophyton parvulum	2 1 2 2	+ 3 3 4 1 2 2 2 1	1 2 2 1 2 2	1 1 . . 1	1 2 1 . . + 1	r
Pelargonium radiatum	1 1 + 1	+ r + + 1 + + 1 +	+ 1 . . 1 .	1 1 1 1 1	+ r . + 1 r 1 .	.
Oedera genitifolia	1 + . +	+ 2 3 r 2 + 1 2 +	. . . r 1 1	. . + . .	+ r . . r r + .	.
Searsia dissecta	. . . . .	. . . r r 2 + + 1	2 1 1 . . . .	. . + + . .	. . . . . r . . +	.
Drosanthemum parvifolium	. . . . .	. . . . . + . . . . .	. . . . . . . . . .	. . . . .	1 2 2 . 2 1 r	1
Pteronia incana	. . . . .	1 1 r r . . . . .	. . . . . . . . . .	. . . . .	+ 1 . r r + . .	.
Hesperantha acuta	1 . 1 .	. 1 . . . 1 1 1 1	1 1 . + 1 1	. 1 1 + 1	+ r	r
Tribolium utriculosum	1 + 2 +	+ 2 1 1 1 3 2 2 1	1 + 1 . 1 1	2 1 1 2 2	+ . + . . + . .	.
Ficinia nigrescens	. . 1 .	r 2 + 1 +	2 + 2 . 1 .	2 2 2 . 1 . . . . .	. . . . . r . . . .	.
Ehrharta villosa	. . . 1	r r . 2	2 . 1 + . . . .	. . . + . . . . .	. . . . . 1 . . 1	.
Oxalis obtusa	. . 1 .	1 . . 1 . 2 1 . .	. . . . . . . . . .	. . . . . 1 . . . . .	. . . 1 . . . . .	.
Ornithogalum hispidum	. . . . .	. . . r . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	1 1
Muraltia trinervia	2 1 2 1	r . + r + 2 2 2 2	2 1 2 1 1 +	2 2 2 2 2	1 1 . . . . . . .	.
Montinia caryophyllacea	. + . .	2 r + . 2 3 3 3 3	2 2 2 3 r .	1 1 1 1 +	+ r . r	r
Pharnaceum aurantium	2 1 + 1	. . . . . . . . . .	. . . . . . . . . .	. . . . .	+ . . . . . r . .	.
Crassula tetragona ssp. acutifolia	. . . . .	. . . . . . . . . .	. . . . . . . . . .	+ + 1 . +	. . . . . . . . . .	.
Spiloxene flaccida	. 1 + .	. 1 + 1 . 1 1 . .	1 1 . . . . .	. . . . . +	. . . . . . . . . .	.
Oxalis depressa	. . . . .	+ . . + . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . + . . . .	.
Microloma sagittatum	1 + + +	. + . + . 1 + + +	. + 1 . 1 +	+ + 1 . +	+ . + . . + . .	1
Oxalis fergusonae	. . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . + . . . .	.
Cyphia digitata	1 1 + 1	r 1 1 1 . 1 1 1 1	1 1 1 + . 1	1 1 . . . . .	. . . . . . . . . .	.
Oxalis purpurea	. . . . .	. . . 1 . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . + + . . . .	.
Holothrix villosa	. . . . .	. + . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	r .
Pelargonium luteolum	. . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	+ . . . . . + . . . .	.
Dodonaea viscosa	. . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . 1 . . . . .	.
Heliophila pendula	1 + 2 +	. 1 + . + 1 1 . .	1 2 1 1 1 1	1 + 1 . 1	1 1 + . . r + .	.
Aspalathus submissa	2 1 1 2	. + . 1 . 3 2 4 3	4 3 4 4 4 4	3 2 3 1 2	. . . . . . . . . .	r .
Lampranthus leipoldtii	. . . . .	r . . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	. . . . . . . . . .	.
Cliffortia ruscifolia	. + + 1	. . . r	2 1 1 . . . .	. . . . . . . . . .	. . . . . . . . . .	r
Othonna pinnata	. . . . .	r . 1 . . . . . . . . .	. . . . . . . . . .	. . . 1 + 1	. . . . . . . . . .	.
Adenogramma glomerata	1 1 1 1	. . . +	1 1 1 1 . . . . .	. . . . . . . . . .	. . . . . . . . . .	.

Senecio burchellii		r r		r	+
Ornithogalum nanodes			+		
Pelargonium ternifolium					r
Pelargonium senecioides					
Pelargonium ovale					
Aspalathus acuminata subsp. acuminata			r 2		r
Chlorophytum undulatum					r
Microloma tenuifolium	+				
Senecio rosmarinifolius	r				
Moraea miniata		r			
Eriospermum cernuum		1		+	1
Prismatocarpus crispus	+ +		1		
Bulbine lagopus			+		
Solanum tomentosum					
Hebenstretia ramosissima					
Metalasia brevifolia					
Ruschia lineolata					
Centella capensis					
Searsia pallens					
Albuca maxima					
Lichtensteinia obscura				2	
Rhynchosidium pumilum					
Oxalis annae					
Lyperia antirrhinoides					
Zaluzianskya divaricata				3	+
Heliophila crithmifolia	1	1			
Crassula umbella	1				
Lobostemon laevigatus	+				
Erepsia gracilis		+		+	
Geissorhiza juncea			r	+	+ +
Romulea flava					
Heliophila arenaria					
Boophane disticha					
Pelargonium carnosum		+			
Oncosiphon suffruticosum		+			
Galium capense subsp. capense		r	1		
Hermannia althaeifolia		r	r		
Wiborgia obcordata					
Felicia amelloides					
Triglochin bulbosa					+
Androcymbium capense					r +
Wahlenbergia nodosa					
Atriplex semibaccata var. appendicula	r	r			
Metalasia densa		r			
Astephanus triflorus		r	+		
Gethyllis afra			r		
Disperis bolusiana subsp. bolusiana			+		
Pelargonium alchemilloides			1	+	+
Aspalathus cephalotes subsp. cephalotes	1		2	1	
Disa harveiana subsp. harveiana		r		+	+

Dischisma capitatum					
Heliophila pinnata					
Lachenalia pusilla					
Trachyandra falcata					
Oftia africana					r
Drimia burchellii					
Selago glabrata					
Ehrharta delicatula					
Othonna parviflora					
Euphorbia caterviflora					
Prenia pallens var. pallens					
Osteospermum spinosum					
Aspalathus cliffortioides					
Torilis arvensis					
Holothrix villosa var. villosa	r				
Pelargonium fergusoniae		+			
Romulea atrandra		r			
Gladiolus hyalinus			+		
Tetragonia decumbens			1 1		+
Cassytha ciliolata					
Ficinia deusta					
Helichrysum litorale					
Senecio pubigerus					
Dianthus bolusii					
Oxalis pulchella					
Lachnaea capitata					
Stoebe spiralis					
Hypochoeris radicata					
Ursinia nudicaulis					1
Aspalathus tridentata subsp. tridentata		r			
Prismatocarpus lycioides					
Lactuca serriola					
Cotula coronopifolia					
Chamarea species					
Ursinia anthemoides subsp. anthemoides	r				+
Dovyalis caffra		+			
Hymenogyne glabra		+			
Gethyllis ciliaris		r			
Cysticapnos vesicaria			+		
Annesorhiza grandiflora			+		
Romulea cruciata var. intermedia			+	+	
Dianthus albens			+		
Briza maxima			r		
Cotula sororia		+		1	
Diascia elongata				+	
Androcymbium crispum				+	r
Ischyrolepis species					2
Pelargonium multicaule subsp. multicaul				1 1	
Indigofera gracilis				+	1
Ficinia secunda					2

Helichrysum teretifolium			r	+	
Gladiolus recurvus				+	
Secamone alpini					
Colpoon compressum					
Ficinia species					
Stoebe plumosa					
Tetradia species					
Crassula species					
Arctotis species					
Rafnia species					
Romulea setifolia var. aggregata					
Searsia angustifolia					r
Gomphocarpus cancellatus					
Bromus diandrus					
Chrysocoma tridentata					
Cannomois scirpoides					r
Disperis circumflexa					+
Cliffortia crenata					
Crassula expansa subsp. expansa					
Aira cupaniana	1				
Pharnaceum lineare	+				
Spergularia bocconii	1				
Cysticapnos cracca		+			
Satyrium erectum x bicornis			r		
Pseudoselago densifolia			+		
Stellaria media			+		
Phyllica ericoides var. zeyheri			r		
Polycarpon tetraphyllum			+		
Diascia parviflora			+		
Grammatotheca bergiana				+	
Ursinia punctata				r	
Sutera decipiens					
Silene undulata					
Salvia africana-caerulea					
Senecio vestitus					
Conium sphaerocarpum					
Moraea ochroleuca					
Senecio paarlensis					
Senecio repandus					
Heliophila linoides					
Gazania krebsiana subsp. krebsiana					
Viscum rotundifolium					
Tulbaghia dregeana					
Schizodium flexuosum					

				2	
1	+	4	3	r	3
111	11	1111	+	1	
+	+	r	r		
1++	r11	+	1r+r		r
		r	r		
1+	1rr+		r		
1	+		rr		
		r	r	+	
	+	+		+	
	+	r			1
			+		
r		r		2	r . 111 + 12
r				1	++ r + . . 3 1 2
				r	+ . . r . . .
			+	1	r . . . 1 . + 1 .
r	+	+	2 1 +		
		rr	+	+	1 1 . 1
r	+	1 . r	2 1 1	r	+. . . . +
	1+		1+		1 . . r . . . 1 .
		1			r . . . + 2 . + . + 3
1		r	+		1 1 1 . . 1 1 r 1 2 1 .
		rr	r		
	1 3 . 1 . . 1 +	2 1	r . . .	+	2 +
				1	
		r			r
	+	+	+	+	1
		1			

$$\begin{aligned}
 & \dots r \dots \dots \dots 1 \dots \dots \dots 1 \ 1 \ 2 + 2 \ 2 \ 1 \ 2 \ 3 \ 2 \ 3 \ 3 \\
 & \dots \dots \dots 1 \dots 1 \ 1 \ 1 \dots \dots r \dots \dots + \dots + \dots + \dots 1 \dots \\
 & \dots \dots \dots + r \dots \dots \dots r \dots + + r \ r \dots \dots \dots \\
 \\
 & 1 \ r \dots + + \dots + 1 \dots 1 \ 1 \ 1 + 1 \dots \dots 1 \ r \dots \dots \dots 1 + \dots r \ 1 + 1 \dots \dots 1 \\
 & \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots r \dots \dots \dots r \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots 3 \dots \dots \dots + \dots 1 \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots + \dots \dots + 1 \dots \dots + + \dots \dots + \dots r \dots r + \dots \dots \\
 & \dots \dots \dots 1 \dots \dots \dots 1 \ 2 \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots r \dots \dots \dots 2 \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots + \dots 1 \dots \dots + \dots \dots + + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots 1 \dots \dots 1 \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 \\
 & \dots \dots \dots 2 \ 2 \ 2 \ 1 \ 2 \ 1 \dots 2 \ 1 \dots 1 \dots \dots \dots \\
 & \dots \dots \dots 1 \dots + r \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots + \dots 1 + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots \\
 & \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots + \dots \dots \dots
 \end{aligned}$$

1 . 1 + + r
 . 1 1 1 1
 . . . + . 1 + . + + . +
 . . 1 . 1 . + 1 1 . +
 2 . . 2 2 2 +
 3 . . 2 2 2 +
 . . 1 + +
 1 1 1 + +
 . . + . . . 1 1 +
 . . + . 1 . . . 1
 . . . r . . . + +
 . . . + . . . + +
 . . . + . . . +
 . . . + +
 r . . . 1 + r 1
 3 +
 + r 1
 2 . . . r + + 1
 + r r + 1
 1 + r r
 2 3 . . . r
 . r + 2 2
 r + +
 2
 . + + + 1 . r + 1 + 1 1 . 1 1 + + .
 . + + 1 + 1 1 + 1 1 1 r . 1 + . 1 . 1 . 1 1 1
 1 + 1 . 1 r +
 4 1 1 + . . 2 1 2 2 2 2 . 2 r 2 2 1 3 2 3 2 . . . 1
 . r + + + 2 +
 r 1 +
 . . . + r + + 1 . . . + . r
 . 4 3 2 2 1 1 . 2 . 1 1
 1 r . . . r r
 2 + 2
 r 2 2 2 1 r 2 2 3 4 2 . 2 1 1 2 2 2 r
 1 . r + 2 + 1 2 + 1 r r . 2 1

A grid of dotted lines with several vertical lines and scattered characters.
 The characters are:

- Row 1: 'r 3' on the far left, '2' on the far right.
- Row 2: '2' on the far right.
- Row 3: '1' on the far left.
- Row 4: '1 . . . 1 r + . . . r 2 3 2 2 2 2 + 1 2 1
- Row 5: '1 . . . 1 r + . . . r 2 3 2 2 2 2 + 1 2 1
- Row 6: '2 3 2 2 2 2 + 1 2 1
- Row 7: '2 3 2 2 2 2 + 1 2 1
- Row 8: 'r r r r
- Row 9: '1 1 1 1
- Row 10: '1 1 1 1
- Row 11: '1 1 1 1
- Row 12: '1 1 1 1
- Row 13: '1 1 1 1
- Row 14: '1 1 1 1
- Row 15: '1 1 1 1
- Row 16: '1 1 1 1
- Row 17: '1 1 1 1
- Row 18: '1 1 1 1
- Row 19: '1 1 1 1
- Row 20: '1 1 1 1
- Row 21: '1 1 1 1
- Row 22: '1 1 1 1
- Row 23: '1 1 1 1
- Row 24: '1 1 1 1
- Row 25: '1 1 1 1
- Row 26: '1 1 1 1
- Row 27: '1 1 1 1
- Row 28: '1 1 1 1
- Row 29: '1 1 1 1
- Row 30: '1 1 1 1
- Row 31: '1 1 1 1
- Row 32: '1 1 1 1
- Row 33: '1 1 1 1
- Row 34: '1 1 1 1
- Row 35: '1 1 1 1
- Row 36: '1 1 1 1
- Row 37: '1 1 1 1
- Row 38: '1 1 1 1
- Row 39: '1 1 1 1
- Row 40: '1 1 1 1
- Row 41: '1 1 1 1
- Row 42: '1 1 1 1
- Row 43: '1 1 1 1
- Row 44: '1 1 1 1
- Row 45: '1 1 1 1
- Row 46: '1 1 1 1
- Row 47: '1 1 1 1
- Row 48: '1 1 1 1
- Row 49: '1 1 1 1
- Row 50: '1 1 1 1
- Row 51: '1 1 1 1
- Row 52: '1 1 1 1
- Row 53: '1 1 1 1
- Row 54: '1 1 1 1
- Row 55: '1 1 1 1
- Row 56: '1 1 1 1
- Row 57: '1 1 1 1
- Row 58: '1 1 1 1
- Row 59: '1 1 1 1
- Row 60: '1 1 1 1
- Row 61: '1 1 1 1
- Row 62: '1 1 1 1
- Row 63: '1 1 1 1
- Row 64: '1 1 1 1
- Row 65: '1 1 1 1
- Row 66: '1 1 1 1
- Row 67: '1 1 1 1
- Row 68: '1 1 1 1
- Row 69: '1 1 1 1
- Row 70: '1 1 1 1
- Row 71: '1 1 1 1
- Row 72: '1 1 1 1
- Row 73: '1 1 1 1
- Row 74: '1 1 1 1
- Row 75: '1 1 1 1
- Row 76: '1 1 1 1
- Row 77: '1 1 1 1
- Row 78: '1 1 1 1
- Row 79: '1 1 1 1
- Row 80: '1 1 1 1
- Row 81: '1 1 1 1
- Row 82: '1 1 1 1
- Row 83: '1 1 1 1
- Row 84: '1 1 1 1
- Row 85: '1 1 1 1
- Row 86: '1 1 1 1
- Row 87: '1 1 1 1
- Row 88: '1 1 1 1
- Row 89: '1 1 1 1
- Row 90: '1 1 1 1
- Row 91: '1 1 1 1
- Row 92: '1 1 1 1
- Row 93: '1 1 1 1
- Row 94: '1 1 1 1
- Row 95: '1 1 1 1
- Row 96: '1 1 1 1
- Row 97: '1 1 1 1
- Row 98: '1 1 1 1
- Row 99: '1 1 1 1
- Row 100: '1 1 1 1

A page of dot grid paper with six vertical lines and scattered mathematical symbols and numbers. The symbols include r , $+$, 2 , 1 , and 3 .

Symbols and numbers visible on the page:

- Top row: r (multiple instances)
- Second row: 2 , r , $+$, 2 , $+$, r
- Third row: 1 , r , 2 , $+$, $+$, 2
- Fourth row: r , $+$, $+$, $+$
- Fifth row: 1 , $+$, r , r
- Sixth row: 1 , 2 , r , r
- Seventh row: r , 1 , 2
- Eighth row: 1 , 2 , 1 , r , 1 , r , $+$, $+$, 3
- Ninth row: $+$, r
- Tenth row: 1 , 2 , r , r , $+$
- Eleventh row: 2
- Twelfth row: r , r , $+$
- Thirteenth row: r , $+$, 1
- Fourteenth row: r , $+$
- Fifteenth row: 2 , 2 , 3 , 2 , 2 , 2 , r , 2 , r , 3 , r , 2 , 3
- Sixteenth row: $+$, r , $+$, $+$, $+$, $+$, 1
- Seventeenth row: $+$
- Eighteenth row: r
- Nineteenth row: r , $+$, 1
- Twentieth row: 1 , $+$, 1 , r , $+$
- Bottom row: 2 , $+$, 1 , $+$, $+$, 2 , $+$, 2 , $+$, r , 1 , 3 , $+$, 3 , r , 1 , 1 , 1 , 1 , 2 , 2 , 2 , r , 2 , 2 , r , 2 , 3 , 1 , 2

+. +	2 1 2 + 1 + + 3 2 1 1	. 2 1	r 1 . + .	1 2 2 1 + 1	2 r 1 . . 1 1 +
+ r 1	. 1 2 + . 1 1 1 1 1 1	. 2 1	+ 1 r r +	1 1 1 + . . .	. + . . + . + . . . 1 1
. + .	1 + 1 + 1 1 1 2 1 1 +	. 1 r	2 + + + +	r . . . . .	. 1 . . + + 1 r . 2 . +
1 r +	2 1 2 1 1 1 1 3 1 1 1	. 2 2	+ + 2 1 +	. 2 2 2 . . .	. r r +
r + 2	1 1 . 2 2 . 2 1	. r 1	. 2 r . .	2 + 2 . . . .	. 2 + 1
. + +	1 + 1 + 1 + 2 1 2 1 +	1 + +	1 2 3 + +	2 2 2 1 + .	3 3 3 3 2 1 1 2 2 3 2 3
2 2 1	2 1 + 1 2 . 1 1 2 1 1	. r +	. + 1 + +	1 1 1 + + .	2 + 1 + 1 2 2 2 3 3 2 +
r r .	2 + 2 + 1 . + 2 2 2 +	. r .	1 + 1 1 1	1 1 1 1 1 2	+ + 1 1 1 1 + 1 + 1 + 1
+ r .	. + + + 1 + +	. 1 +	+ + . r .	. . . . . 1 .	+ + 1 + + + 1 r . + 1 +
1 1 r	. . . . + + 1 1 1 +	1 2 2	2 . 1 r +	1 1 1 1 2 .	2 3 2 1 1 2 1 3 2 1 2 2
3 2 2	1 . + 2 3 2 . .	3 3 +	. r 3 3 .	. 2 2 . 2 2	. 3 . 3 3 3 3 2 3 2 4
+ r .	. + + + + + + 1 + + +	1 + 1	+ . + . 1	+ . . + . 1	+ r + . + 1 + r 1 1 . +
+ r .	. + . + 1 2 + 1	. 3 r	1 2 + r +	2 2 2 1 . .	1 2 + + 1 2 1 1 2 . 2 4
3 3 3	2 r 1 + 2 . 1 . 3 2 . .	. 2	1 2 . . 2	1 3 3 2 . 2	3 2 2 3 3 2 1 3 2 1 2 .
3 . 2	1 2 1 2 3 2 3 2 2 2 1	3 1 2	2 4 2 3 3	3 2 3 2 + 2	2 3 4 3 3 3 3 4 3 3 3 3
. 2 2	. . . . r 2 1 r 2 2 + +	2 r .	+ . r . .	3 3 3 3 . .	. 2 2 + 2 1 2 2 2 2 2 +
. . 1	2 1 2 2 3 3 3 3 3 2 1	. . .	+ 2 3 2 2	2 1 . 1 . .	. 1 2 + 2 r + . . + . .
. . 1	2 2 2 1 . . + 2 2 2 2	. . .	. . . . .	. . . . .	. . . . r + . 1
+ . .	. . . + . . . . . + . . .	. 2 +	. + . + .	. . . . . 1 .	. . . . . 1 1 +
. . .	. . . . . . . . . . 1 . .	. 2 r	. 1 . . . .	. . + + + 1 .	. . . . . . . . . 1 . .
. 1 2	. . . . . . . . . . . . .	. . .	r . . . . .	. . r + .	1 2 1 1 1 1 1 1 + + 2 . .
. . .	. . . . . . . . . . . . .	. . .	. . . . .	. . . . .	2 r + . . 2 . .
1 . r	. . + . 1 1 . 2 1 2 2 +	1 1 2	1 1 + r r	+ . 1 + . . .	. r + . 1 2 1 1 1 2 . 1
r 1 2	. . . . r 1 . . 2 2 2 . .	. 1 3	. . 2 . .	1 2 2 2 . .	. 3 2 . . r + + 1 2 . +
. + .	. . . . . . . . . . . . .	. 1 . .	. . . . .	. . . . .	. r . r r . . r + + 1 .
1 r r	. . . . . . . . . . + . .	. . .	r . . . . .	. . . . .	1 + + r r r 1 . 1 1 + 1
+ . .	. . . + r . . . . . . . .	. . .	+ . . . .	. . . . . 1	. . . . . . . . . 1 1
+ + 1	3 3 3 3 4 2 . 3 4 2 3	. r .	. + 1 + +	2 1 2 1 . 1	. + 1 + + + 1 . 1 . . r
+ . .	4 4 4 3 4 4 2 3 3 2 2	1 1 1	. 1 1 2 2	. 2 2 + 1 2 + . 1 3
+ 1 1 2 2	. . r + + + .
. r + 1 r 1	. 1 + +	1 1 + . 1 1 . .
. . .	1 r . + 1 + . 1 1 1 +	. r r 1 r + . . r r .
. 1 . r	1 . . . +
. + 1 . + 1 1 1 +	. . r	. + + + 1 1
+ + + 1 . + 1 1 + r	+ . 2 . 2 r . . . 1 1 . . 2 2 1
. . r r .	. r +	. r
+ + + + r	+ r 1 + + 2 + 1
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r . .	. + + + + . + + + +	+ . 1 + .
. + r r	. 1 + . .	+ + 1 .
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. . .	2 + 1 1 1 . . . + . 1 + 1	. . r 3 1	+ 1 + + 2 2 +
1 . .	. 1 1 . . . + 1 . . +	r . . . + . .	. 1 + . + . r
. . .	1 + . + + r 1

The image shows a grid of dots with scattered characters and symbols. The grid is divided into four vertical sections by thick vertical lines. The characters and symbols are scattered across the grid, including letters 'r', '1', '+', and numbers '2'. The symbols are arranged in a way that suggests a pattern or a sequence, but the exact meaning is unclear. The symbols are scattered across the grid, with some appearing in clusters and others in isolation. The symbols are arranged in a way that suggests a pattern or a sequence, but the exact meaning is unclear.

A grid of dotted lines with vertical lines. The grid is divided into four vertical sections by three vertical lines. The rightmost section is bounded by a blue vertical line. Scattered characters and symbols are present throughout the grid, including 'r', '+', '1', and '2'. The characters are arranged in a pattern that suggests a mathematical or logical sequence, though they are not clearly organized into a single structure.

A grid of dotted lines with several vertical lines. The vertical lines are: a thick black line on the far left, two thick grey lines, a thin black line, a thin grey line, a thick black line, and a thick blue line on the far right. Scattered symbols include: '+' signs at various positions; '2' at the top left, middle left, and bottom left; '1' at the middle left; 'r' at the top center, middle center, and bottom center; '3' at the middle right; and 'r r' at the bottom right.

A grid of dotted lines with several vertical lines and scattered text characters. The characters are as follows:

- Top right: 2 2, 2, 1, +
- Second column from left: 1, 1, +
- Third column from left: r
- Fourth column from left: r
- Fifth column from left: 1, r, r, 2, 1
- Bottom left: 1
- Bottom middle: r, +, 1
- Bottom right: r

Annexure 4

Plant species occurring in the study area (*alien weeds, species marked in green are known to be endemic to the study area only).

Plant taxa	Endemism	Local name	Specific attributes
PTERIDOPHYTES			
ANEMIACEAE			
<i>Mohria caffrorum</i> (L.) Desv.	Endemic to SA	Brandbossie, Scented Fern	
OPHIOGLOSSACEAE			
<i>Ophioglossum nudicaule</i> L.f.	Endemic to the CCR	Slender Adder's-Tongue	
PTERIDACEAE			
<i>Cheilanthes capensis</i> (Thunb.) Sw.	Not endemic to SA	Cape Lip Fern	
<i>Cheilanthes contracta</i> (Kunze) Mett. ex Kuhn	Endemic to SA		
<i>Cheilanthes hastata</i> (L.f.) Kunze	Not endemic to SA		
ANGIOSPERMS			
PALAEODICOTYLEDONS			
HYDNORACEAE			
<i>Hydnora africana</i> Thunb.	Not endemic to SA	Bobbejaankos / Jakkalskos	medicinal & edible
LAURACEAE			
<i>Cassytha ciliolata</i> Nees	Endemic to SA	False Dodder / Nooienshaar	medicinal
MONOCOTYLEDONS			
AGAVACEAE			
<i>Chlorophytum rangei</i> (Engl. & K.Krause) Nordal	Endemic to the GCE	Grass-lily	
<i>Chlorophytum undulatum</i> (Jacq.) Oberm.	Endemic to the GCE		
ALLIACEAE			
<i>Tulbaghia capensis</i> L.	Endemic to the GCE		aromatic
<i>Tulbaghia dregeana</i> Kunth	Endemic to the GCE	Ajuin, Wildeknoffel, Wildelook	
AMARYLLIDACEAE			
<i>Amaryllis belladonna</i> L.	Endemic to the CCR	Belladonna Lily / March-lily / Misblom	medicinal

<i>Boophone disticha</i> (L.f.) Herb.	Not endemic to SA	Gifbol / Kopseerblom	medicinal & poisonous
<i>Brunsvigia josephinae</i> (Redouté) Ker Gawl.	Endemic to the GCE	Lantanter	
<i>Brunsvigia orientalis</i> (L.) Aiton ex Eckl.	Endemic to the GCE	Koningskandelaar	
<i>Crossyne guttata</i> (L.) D. & U.Müll.-Doblies	Endemic to SA	April Fool Lily / Maartblom / Sambreelblom	
<i>Gethyllis afra</i> L.	Endemic to the GCE	Kukumakranka	medicinal & edible (fruit aromatic)
<i>Gethyllis ciliaris</i> (Thunb.)	Endemic to the GCE		edible (fruit aromatic)
<i>Gethyllis villosa</i> (Thunb.) Thunb.	Endemic to the GCE		edible (fruit aromatic)
<i>Haemanthus coccineus</i> L.	Not endemic to SA	Paintbrush / Powderpuff	medicinal
<i>Nerine humilis</i> (Jacq.) Herb.	Endemic to the GCE	Berglelie	
<i>Nerine sarniensis</i> (L.) Herb.	Endemic to the CCR	Guernsey Lily	
<i>Strumaria spiralis</i> L'Hér.	Endemic to the CCR	Cape Snowflake / Tolbol	
<i>Strumaria tenella</i> (L.f.) Snijman	Endemic to SA		
ASPARAGACEAE			
<i>Asparagus capensis</i> L.	Not endemic to SA	Katdoring / Krulkransie / Wilde-aspersie	medicinal, edible roots
<i>Asparagus declinatus</i> L.	Not endemic to SA		medicinal
<i>Asparagus retrofractus</i> L.	Not endemic to SA		medicinal
<i>Asparagus rubicundus</i> P.J.Bergius	Endemic to SA		
<i>Asparagus striatus</i> (L.f.) Thunb.	Endemic to SA	Bergappel / Bobbejaanappel	medicinal
<i>Asparagus undulatus</i> (L.f.) Thunb.	Not endemic to SA		
ASPHODELACEAE			
<i>Aloe microstigma</i> Salm-Dyck	Endemic to SA	Karoo Aalwyn	
<i>Aloe perfoliata</i> L.	Endemic to the CCR	Kransaalwyn	
<i>Bulbine favosa</i> (Thunb.) Schult. & Schult.f	Endemic to the CCR	Bulbine / Kopieva	
<i>Bulbine foleyi</i> E.Phillips	Endemic to SA		
<i>Bulbine frutescens</i> (L.) Willd.	Not endemic to SA	Rankkopieva	medicinal
<i>Bulbine lagopus</i> (Thunb.) N.E.Br.	Not endemic to SA		
<i>Bulbine longifolia</i> Schinz	Endemic to the GCE		
<i>Bulbine mesembryanthoides</i> Haw.	Endemic to SA	Waterkannetjies / waterglas	
<i>Bulbine praemorsa</i> (Jacq.) Spreng.	Endemic to the GCE	Blougif / Slymstok / Slymuintjie	
<i>Bulbinella caudafelis</i> (L.f.) T.Durand & Schinz	Endemic to the GCE	Bulbinella = Bulbinella / Katstert	
<i>Bulbinella nutans</i> (Thunb.) T.Durand & Schinz subsp. <i>nutans</i>	Endemic to the GCE	Katstert / Koeikwas	

<i>Bulbinella punctulata</i> Zahlbr.	Endemic to the CCR		
<i>Bulbinella trinervis</i> (Baker) P.L.Perry	Endemic to the CCR		
<i>Bulbinella triquetra</i> (L.f.) Kunth	Endemic to the GCE	Katstert	
<i>Gasteria disticha</i> (L.) Haw.	Endemic to SA	Oukossies / Beestongblaar	flowers edible
<i>Haworthia arachnoidea</i> (L.) Duval	Endemic to the GCE	Spinnekopbolletjie	
<i>Haworthia herbacea</i> (Mill.) Stearn	Endemic to the CCR		
<i>Haworthia mirabilis</i> (Haw.) Haw. var. <i>maraisii</i> (Poelln.) M.B.Bayer	Endemic to the CCR		
<i>Haworthia maculata</i> (Poelln.) M.B.Bayer	Endemic to the CCR		
<i>Haworthia reticulata</i> (Haw.) Haw. var. <i>subregularis</i> (Baker) Pilbeam	Endemic to the CCR		
<i>Tulista pumila</i> (L.) G.D.Rowley	Endemic to the GCE	Vratjiesaalwee	
<i>Trachyandra chlamydophylla</i> (Baker) Oberm.	Endemic to the CCR	Cape Spinach / Wildeblomkool	
<i>Trachyandra falcata</i> (L.f.) Kunth	Endemic to the GCE	Veldkool	young flowering stalks edible
<i>Trachyandra flexifolia</i> (L.f.) Kunth	Endemic to the GCE		
<i>Trachyandra hispida</i> (L.) Kunth	Endemic to the CCR	Hairy veldkool	young flowering stalks edible
<i>Trachyandra montana</i> J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Trachyandra muricata</i> (L.f.) Kunth	Endemic to the GCE		
<i>Trachyandra jacquiniana</i> (Roem. & Schult.) Oberm.	Endemic to the GCE	Anysblom	
<i>Trachyandra revoluta</i> (L.) Kunth	Endemic to SA	Watergras / Waterknolle / Watertoue	
COLCHICACEAE			
<i>Colchicum capense</i> (L.) J.C.Manning & Vinn. subsp. <i>capense</i>	Endemic to the GCE	Cup-and-saucer / Patrysblom	
<i>Colchicum coloratum</i> J.C.Manning & Vinn. subsp. <i>burchellii</i> (Baker) J.C.Manning & Vinn.	Endemic to the GCE		
<i>Colchicum eghimbocymbion</i> (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.	Endemic to the GCE		
<i>Colchicum hughocymbion</i> (U.Müll.-Doblies & D.Müll.-Doblies) J.C.Manning & Vinn.	Endemic to the CCR		
<i>Ornithoglossum viride</i> (L.f.) Aiton	Endemic to SA	Eendjies / Slangkop	poisonous
<i>Wurmbea marginata</i> (Desr.) B.Nord.	Endemic to the CCR	Swartkoppie	
<i>Wurmbea punctata</i> (L.) J.C.Manning & Vinn.	Endemic to the CCR	Hanekammetjie	
<i>Wurmbea spicata</i> (Burm.f.) T.Durand & Schinz	Endemic to the CCR		poisonous
<i>Wurmbea variabilis</i> B.Nord.	Endemic to the GCE		

CYPERACEAE			
<i>Ficinia bulbosa</i> (L.) Nees	Endemic to SA		
<i>Ficinia deusta</i> (P.J.Bergius) Levyns	Endemic to the GCE		
<i>Ficinia indica</i> (Lam.) Pfeiff.	Endemic to SA	Biesiekweek / Knoppiesbiesie / Ystervarkgras	
<i>Ficinia nigrescens</i> (Schrad.) J.Raynal	Not endemic to SA	Swartkopbiesie	
<i>Ficinia secunda</i> (Vahl) Kunth	Endemic to the GCE		
<i>Ficinia trichodes</i> (Schrad.) Benth. & Hook.f.	Endemic to SA		
<i>Ficinia tristachya</i> (Rottb.) Nees	Endemic to SA		
<i>Ficinia</i> sp. 1	Endemic to the CCR		
<i>Isolepis incomtula</i> Nees	Endemic to the GCE		
<i>Schoenoxiphium ecklonii</i> Nees var. <i>ecklonii</i>	Endemic to the CCR		
<i>Tetraria nigrovaginata</i> (Nees) C.B.Clarke	Endemic to the GCE		
HAEMODORACEAE			
<i>Wachendorfia multiflora</i> (Klatt) J.C.Manning & Goldblatt	Endemic to the GCE	Kleinrooikanol	rootstock yields a red dye
<i>Wachendorfia paniculata</i> Burm.	Endemic to the GCE	Koffiepit / Rooikanol	
HEMEROCALLIDACEAE			
<i>Caesia contorta</i> (L.f.) T.Durand & Schinz	Endemic to SA	Blue grass-lily / Bloutjienks	
HYACINTHACEAE			
<i>Albuca acuminata</i> Baker	Not endemic to SA	Slime-lily / Tamarak	
<i>Albuca aurea</i> Jacq.	Endemic to the CCR		
<i>Albuca canadensis</i> (L.) F.M.Leight.	Endemic to the GCE	Wittamarak	
<i>Albuca cooperi</i> Baker	Not endemic to SA	Blougif	medicinal
<i>Albuca flaccida</i> Jacq.	Endemic to the GCE		
<i>Albuca juncifolia</i> Baker	Endemic to the CCR		
<i>Albuca longipes</i> Baker	Not endemic to SA		
<i>Albuca namaquensis</i> Baker	Not endemic to SA	Growwe Tamarak	
<i>Albuca papyracea</i> J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Albuca spiralis</i> L.f.	Endemic to the GCE		
<i>Albuca suaveolens</i> (Jacq.) J.C.Manning & Goldblatt	Endemic to the GCE		
<i>Albuca viscosa</i> L.f.	Not endemic to SA	Taaitamarak	
<i>Dipcadi brevifolium</i> (Thunb.) Fourc.	Not endemic to SA	Slangui	
<i>Drimia anomala</i> (Baker) Baker	Endemic to SA	Brandui / jeukbol	

<i>Drimia calcarata</i> (Baker) Stedje	Not endemic to SA		
<i>Drimia capensis</i> (Burm.f.) Wijnands	Endemic to the GCE	Maerman	
<i>Drimia dregei</i> (Baker) J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Drimia elata</i> Jacq.	Not endemic to SA		poisonous (irritant)
<i>Drimia exuviata</i> (Jacq.) Jessop	Endemic to SA	Gifbol	
<i>Drimia filifolia</i> (Jacq.) J.C.Manning & Goldblatt	Endemic to the GCE	Gifbol	
<i>Drimia fragrans</i> (Jacq.) J.C.Manning & Goldblatt	Endemic to the GCE	Gifbol	
<i>Drimia haworthioides</i> Baker	Endemic to SA		
<i>Drimia hesperantha</i> J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Drimia physodes</i> (Jacq.) Jessop	Endemic to the GCE	Cape Bergslangkop	
<i>Drimia platyphylla</i> (B.Nord.) J.C.Manning & Goldblatt	Not endemic to SA	African-snowdrop	
<i>Drimia salteri</i> (Compton) J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Drimia sigmoidea</i> J.C.Manning & J.M.J.Deacon	Endemic to the CCR	Volstruiskos	
<i>Drimia vermiformis</i> J.C.Manning & Goldblatt	Endemic to SA		
<i>Lachenalia aurioliae</i> G.D.Duncan	Endemic to SA	Viooltjie / Cape Hyacinth	
<i>Lachenalia contaminata</i> Aiton	Endemic to the CCR		
<i>Lachenalia juncifolia</i> Baker var. <i>juncifolia</i>	Endemic to the GCE		
<i>Lachenalia lutea</i> G.D.Duncan	Endemic to the CCR		
<i>Lachenalia moniliformis</i> W.F.Barker	Endemic to the CCR		
<i>Lachenalia mutabilis</i> Sweet	Endemic to the GCE	Bontviooltjie	
<i>Lachenalia orchioides</i> (L.) Aiton var. <i>orchioides</i> <i>Lachenalia orchioides</i> (L.) Aiton var. <i>glaucina</i> (Jacq.) W.F.Barker	Endemic to the CCR	Groenviooltjie	
<i>Lachenalia pusilla</i> Jacq.	Endemic to the GCE		
<i>Lachenalia pustulata</i> Jacq.	Endemic to the CCR		
<i>Lachenalia stayneri</i> W.F.Barker	Endemic to the CCR		
<i>Lachenalia unicolor</i> Jacq.	Endemic to the GCE		
<i>Lachenalia unifolia</i> Jacq. var. <i>unifolia</i>	Endemic to the GCE		
<i>Ledebouria</i> sp. nov.	Endemic to the GCE	African Squill	
<i>Massonia depressa</i> Houtt.	Endemic to SA	Botterkannetjie / Ramblom / Suikerkannetjie	
<i>Ornithogalum dubium</i> Houtt.	Endemic to SA	Geeltjienk	
<i>Ornithogalum graminifolium</i> Thunb.	Endemic to SA		
<i>Ornithogalum hispidum</i> Hornem. subsp. <i>hispidum</i>	Endemic to the GCE		
<i>Ornithogalum juncifolium</i> Jacq. var. <i>juncifolium</i>	Not endemic to SA		
<i>Ornithogalum nannodes</i> F.M.Leight.	Endemic to SA		
<i>Ornithogalum pilosum</i> L.f.	Endemic to the CCR		

HYPOXIDACEAE			
<i>Empodium plicatum</i> (Thunb.) Garside	Endemic to the GCE	Ploegtydblommetjie	
<i>Pauridia aquatica</i> (L.f.) Snijman & Kocyan	Endemic to the GCE	Watersterretjie	
<i>Pauridia capensis</i> (L.) Snijman & Kocyan	Endemic to the GCE	Peacock Flower / Poublommetjie	
<i>Pauridia flaccida</i> (Nel) Snijman & Kocyan	Endemic to the CCR	Sterretjie	
<i>Pauridia minuta</i> (L.f.) T.Durand & Schinz	Endemic to the CCR	Klipsterretjie	
<i>Pauridia gracilipes</i> (Schltr.) Garside	Endemic to the GCE		
IRIDACEAE			
<i>Aristea africana</i> (L.) Hoffmanns.	Endemic to the CCR	Blousuurkanol	
<i>Aristea dichotoma</i> (Thunb.) Ker Gawl.	Endemic to the GCE	Vensterbrug	
<i>Babiana ambigua</i> (Roem. & Schult.) G.J.Lewis	Endemic to the CCR	Bobajaantjie	corm edible
<i>Babiana arenicola</i> Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Babiana patula</i> N.E.Br.	Endemic to the CCR		
<i>Babiana stricta</i> (Aiton) Ker Gawl.	Endemic to the CCR		
<i>Bobartia orientalis</i> J.B.Gillett subsp. <i>orientalis</i>	Endemic to SA	Rush-lily / Geelblombiesie	
<i>Ferraria variabilis</i> Goldblatt & J.C.Manning	Not endemic to SA	Spinnekopblom / Spider-lily	corm edible
<i>Freesia caryophyllacea</i> (Burm.f.) N.E.Br.	Endemic to the CCR	Kammetjie	
<i>Freesia fucata</i> J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Freesia marginata</i> J.C.Manning & Goldblatt	Endemic to the CCR		
<i>Freesia refracta</i> (Jacq.) Klatt	Endemic to the CCR	Flissie / Kammetjie	
<i>Geissorhiza aspera</i> Goldblatt	Endemic to the CCR	Blou Sysie	
<i>Geissorhiza confusa</i> Goldblatt	Endemic to the CCR	Syblom / Sysie	
<i>Geissorhiza delicatula</i> Goldblatt	Endemic to the CCR		
<i>Geissorhiza erosa</i> (Salisb.) R.C.Foster	Endemic to the CCR		
<i>Geissorhiza heterostyla</i> L.Bolus	Endemic to the GCE		
<i>Geissorhiza inflexa</i> (D.Delaroche) Ker Gawl.	Endemic to the CCR	Witsyblom	
<i>Geissorhiza juncea</i> (Link) A.Dietr.	Endemic to the CCR		
<i>Geissorhiza ornithogaloides</i> Klatt subsp. <i>ornithogaloides</i>	Endemic to the CCR		
<i>Geissorhiza scillaris</i> A.Dietr.	Endemic to the CCR		
<i>Geissorhiza ovata</i> (Burm.f.) Asch. & Graebn.	Endemic to the CCR		
<i>Gladiolus alatus</i> L.	Endemic to the CCR	Kalkoentjie / Kipkippie	
<i>Gladiolus carinatus</i> Aiton	Endemic to the GCE	Blou-Afrikaner	
<i>Gladiolus floribundus</i> Jacq.	Endemic to SA	Pypie / Afrikaner	
<i>Gladiolus guthriei</i> F.Bolus	Endemic to the CCR	Kaneelpypie	

<i>Gladiolus hyalinus</i> Jacq.	Endemic to SA	Small Brown Afrikaner / Klippyjie	
<i>Gladiolus inflexus</i> Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Gladiolus orchidiflorus</i> Andrews	Not endemic to SA	Groenkalkoentjie / Grey Kalkoentjie	
<i>Gladiolus patersoniae</i> F.Bolus	Endemic to the CCR		
<i>Gladiolus permeabilis</i> D.Delaroche subsp. <i>permeabilis</i>	Endemic to SA	Patrysuintjie	corm edible
<i>Gladiolus recurvus</i> L.	Endemic to the CCR	Voorloperjie	
<i>Gladiolus venustus</i> G.J.Lewis	Endemic to the CCR	Perskalkoentjie	
<i>Gladiolus virescens</i> Thunb. <i>Gladiolus virescens</i> Thunb. var. <i>roseovenosus</i> G.J.Lewis	Endemic to the CCR		
<i>Hesperantha acuta</i> (Licht. ex Roem. & Schult.) Ker Gawl. subsp. <i>acuta</i>	Endemic to the GCE	Heperantha = Aandblom	
<i>Hesperantha bachmannii</i> Baker	Endemic to SA	Witrokkie / Aandblom	
<i>Hesperantha falcata</i> (L.f.) Ker Gawl.	Endemic to the CCR	Bontrokkie / Aandblommetjie	
<i>Hesperantha radiata</i> (Jacq.) Ker Gawl.	Not endemic to SA		
<i>Ixia atrandra</i> Goldblatt & J.C.Manning	Endemic to the CCR	Kalossie	
<i>Ixia capillaris</i> L.f.	Endemic to the CCR		
<i>Ixia collina</i> Goldblatt & Snijman	Endemic to the CCR		
<i>Ixia divaricata</i> Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Ixia</i> sp. Aff. <i>I. dieramoides</i>	Endemic to the CCR		
<i>Ixia exiliflora</i> Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Ixia latifolia</i> D.Delaroche	Endemic to the GCE		
<i>Ixia simulans</i> Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Ixia vanzijliae</i> L.Bolus	Endemic to the CCR		
<i>Lapeirousia anceps</i> (L.f.) Ker Gawl.	Endemic to the GCE	Cabong	
<i>Lapeirousia jacquinii</i> N.E.Br.	Endemic to the GCE	Kabong / Paletblaar / Rukkeperdjie	
<i>Lapeirousia micrantha</i> (E.Mey. ex Klatt) Baker	Endemic to the CCR		
<i>Lapeirousia pyramidalis</i> (Lam.) Goldblatt subsp. <i>pyramidalis</i>	Endemic to the GCE	Naeltjie	
<i>Melaspheerula graminea</i> (L.f.) Ker Gawl.	Endemic to the GCE	Baardmannetjie / Fairy-bell / Feeklokkie	
<i>Micranthus junceus</i> (Baker) N.E.Br.	Endemic to the CCR	Comb-flower / Vleibloemmetjie	
<i>Micranthus tubulosus</i> (Burm.) N.E.Br.	Endemic to the CCR		
<i>Moraea barnardiella</i> Goldblatt	Endemic to the CCR	Galaxia group = Clock-flower / horlosieblom	
<i>Moraea bellendenii</i> (Sweet) N.E.Br.	Endemic to the CCR	Patrysuintjie	
<i>Moraea bituminosa</i> (L.f.) Ker Gawl.	Endemic to the CCR	Teeruintjie	
<i>Moraea ciliata</i> (L.f.) Ker Gawl.	Endemic to SA	Growweuintjie. White, as well as bright yellow colour forms occur in the study area	
<i>Moraea falcifolia</i> Klatt	Not endemic to SA		

<i>Moraea fugax</i> (D.Delaroche) Jacq.	Endemic to the GCE	Soetuintjie / Klipuintjie	corm edible
<i>Moraea galaxia</i> (L.f.) Goldblatt & J.C.Manning	Endemic to the CCR		
<i>Moraea gawleri</i> Spreng.	Endemic to the GCE	Yellow, as well as salmon colour forms occur in the study area.	
<i>Moraea helicoidea</i> Goldblatt & J.C.Manning, sp. nov. (subg. <i>Vieusseuxia</i>)	Endemic to the CCR		
<i>Moraea inconspicua</i> Goldblatt	Endemic to the GCE	Taaiuintjie	
<i>Moraea longistyla</i> (Goldblatt) Goldblatt	Endemic to the CCR	Yellow, bright salmon and soft lilac colour forms occur in the study area.	
<i>Moraea macrocarpa</i> Goldblatt	Endemic to the CCR		
<i>Moraea miniata</i> Andrews	Endemic to SA	Pronktulp	poisonous
<i>Moraea neglecta</i> G.J.Lewis	Endemic to the CCR		
<i>Moraea ochroleuca</i> (Salisb.) Drapiez	Endemic to the CCR	Apricot Tulp	poisonous
<i>Moraea polyanthos</i> L.f.	Endemic to SA	Bloutulp	poisonous
<i>Moraea thomasiae</i> Goldblatt	Endemic to the CCR		
<i>Moraea tripetala</i> (L.f.) Ker Gawl.	Endemic to the CCR	Blouuintjie	
<i>Moraea umbellata</i> Thunb.	Endemic to the CCR		
<i>Moraea unguiculata</i> Ker Gawl.	Endemic to SA	White, as well as red brown colour forms occur in the study area.	
<i>Moraea virgata</i> Jacq.	Endemic to the GCE	Pypie / volstruisuitjie	
<i>Moraea vuvuzela</i> Goldblatt & J.C.Manning sp. nov.	Endemic to the CCR		
<i>Romulea atrandra</i> G.J.Lewis var. <i>atrandra</i>	Endemic to SA	Knikkertjie / Froetang	
<i>Romulea cruciata</i> (Jacq.) Baker var. <i>intermedia</i> (Bég.) M.P.de Vos	Endemic to the CCR		
<i>Romulea luteoflora</i> (M.P.de Vos) M.P.de Vos var. <i>luteoflora</i>	Endemic to SA	Froetang / Knikker	
<i>Romulea flava</i> (Lam.) M.P.de Vos var. <i>flava</i>	Endemic to the GCE	Geelfroetang / Geel Knikkertjie	
<i>Romulea hirsuta</i> (Steud. ex Klatt) Baker var. <i>hirsuta</i> <i>Romulea hirsuta</i> (Steud. ex Klatt) Baker var. <i>cuprea</i> (Bég.) M.P.de Vos	Endemic to the CCR		
<i>Romulea minutiflora</i> Klatt	Endemic to SA	Kleinfroetang / Kleinknikker	
<i>Romulea setifolia</i> N.E.Br. var. <i>aggregata</i> M.P.de Vos	Endemic to the GCE		
<i>Romulea tortilis</i> Baker var. <i>dissecta</i> M.P.de Vos	Endemic to the CCR		
<i>Romulea triflora</i> (Burm.f.) N.E.Br.	Endemic to the CCR		
<i>Sparaxis maculosa</i> Goldblatt	Endemic to the CCR	Cape-Buttercup / Fluweeltjie	
<i>Syringodea longituba</i> (Klatt) Kuntze subsp. <i>violacea</i> (M.P.de Vos) Goldblatt & J.C.Manning	Endemic to the CCR	Cape Crocus	
<i>Tritonia undulata</i> (Burm.f.) Baker South African endemic	Endemic to the CCR	Basterkalkoentjie	
<i>Tritonia flabellifolia</i> (D.Delaroche) G.J.Lewis var. <i>flabellifolia</i>	Endemic to the CCR		

<i>Tritoniopsis antholyza</i> (Poir.) Goldblatt	Endemic to the CCR	Pypie / Karkarblom / Bergpypie	
<i>Tritoniopsis ramosa</i> (Eckl. ex Klatt) G.J.Lewis	Endemic to the CCR	Snake Flower	
<i>Watsonia aletroides</i> (Burm.f.) Ker Gawl.	Endemic to the CCR	Pypie / Rooipypie	
<i>Watsonia meriana</i> (L.) Mill. var. <i>meriana</i>	Endemic to the GCE	Kanolpypie / Lakpypie / Suurkanol / Suurkanolpypie	
<i>Watsonia spectabilis</i> Schinz	Endemic to the CCR	Kanolpypie	
<i>Watsonia</i> sp. nov. 1	Endemic to the CCR		
<i>Watsonia</i> sp. nov. 2	Endemic to the CCR		
<i>Xenoscapa fistulosa</i> (Spreng. ex Klatt) Goldblatt & J.C.Manning	Endemic to the GCE	Feepypie	
JUNCAGINACEAE			
<i>Triglochin bulbosa</i> L. subsp. <i>bulbosa</i>	Endemic to the GCE		
ORCHIDACEAE			
<i>Bartholina burmanniana</i> (L.) Ker Gawl.	Endemic to SA	Spider Orchid	
<i>Disa flexuosa</i> (L.) Sw.	Endemic to the CCR	Bacon-And-Eggs	
<i>Disa harveiana</i> Lindl. subsp. <i>harveiana</i>	Endemic to the CCR	Lilac Disa	
<i>Disa obliqua</i> (Lindl.) Bolus subsp. <i>obliqua</i>	Endemic to the CCR		
<i>Disa satyroides</i> (L.f.) Druce	Endemic to the GCE		
<i>Disa triloba</i> Lindl.	Endemic to the CCR		
<i>Disa tenuis</i> Lindl.	Endemic to the CCR		
<i>Disperis bolusiana</i> Schltr. ex Bolus subsp. <i>bolusiana</i>	Endemic to the CCR	Witch Orchid	
<i>Disperis capensis</i> (L.f.) Sw.	Endemic to SA		
<i>Disperis circumflexa</i> (L.) T.Durand & Schinz subsp. <i>circumflexa</i>	Endemic to the CCR		
<i>Disperis cucullata</i> Sw.	Endemic to the CCR	Witch Orchid	
<i>Disperis villosa</i> (L.f.) Sw.	Endemic to the CCR		
<i>Holothrix aspera</i> (Lindl.) Rchb.f.	Endemic to the GCE	Nonnatjie	
<i>Holothrix cernua</i> (Burm.f.) Schelpe	Endemic to SA		
<i>Holothrix secunda</i> (Thunb.) Rchb.f.	Endemic to the GCE		
<i>Holothrix villosa</i> Lindl. var. <i>villosa</i>	Not endemic to SA		
<i>Pterygodium alatum</i> (Thunb.) Sw.	Endemic to the CCR	Pterygodium = Bonnet Orchid / Monkshood Orchid / Moederkappie	
<i>Pterygodium catholicum</i> (L.) Sw.	Endemic to the CCR	Mammakappie / Mombakkiesblom	
<i>Pterygodium orobanchoides</i> (L.f.) Schltr.	Endemic to the CCR	Bastertrewwa	
<i>Pterygodium pentherianum</i> Schltr.	Endemic to the CCR	Moederkappie / Oumakappie	

<i>Pterygodium platypetalum</i> Lindl.	Endemic to the CCR		
<i>Pterygodium volucris</i> (L.f.) Sw.	Endemic to the CCR		
<i>Satyrium candidum</i> Lindl.	Endemic to the CCR	Wit trewwa	edible root
<i>Satyrium coriifolium</i> Sw.	Endemic to the CCR	Geel Trewwa	
<i>Satyrium erectum</i> Sw.	Endemic to the GCE	Ewwa-Trewwa / Pienktrewwa	edible root
<i>Satyrium erectum</i> Sw. x <i>S. coriifolium</i> Sw.	Endemic to the CCR		
POACEAE			
* <i>Aira cupaniana</i> Guss.	Not native to SA		
<i>Aristida diffusa</i> Trin. subsp. <i>diffusa</i>	Endemic to SA	Besemsteekgras	
* <i>Briza maxima</i> L.	Not native to SA	Grootbewertjie	
* <i>Briza minor</i> L.	Not native to SA	Kleinbewertjie	
* <i>Bromus diandrus</i> Roth	Not native to SA	Langnaaldbromus	
<i>Capeochloa arundinacea</i> (P.J.Bergius) N.P.Barker & H.P.Linder	Endemic to the CCR	Olifantgras	
<i>Chaetobromus involucratus</i> (Schrad.) Nees subsp. <i>dregeanus</i> (Nees) Verboom	Not endemic to SA	Ghagras	
<i>Cynodon dactylon</i> (L.) Pers.	Not endemic to SA	Kweekgras	
<i>Ehrharta calycina</i> Sm.	Not endemic to SA	Rooigras / Polgras	
<i>Ehrharta capensis</i> Thunb.	Endemic to the CCR	Knol-Ehrharta	
<i>Ehrharta delicatula</i> (Nees) Stapf	Endemic to the GCE		
<i>Ehrharta melicoides</i> Thunb.	Endemic to the GCE		
<i>Ehrharta ramosa</i> (Thunb.) Thunb. subsp. <i>ramosa</i>	Endemic to the CCR		
<i>Ehrharta villosa</i> J.H.Schult. var. <i>villosa</i>	Endemic to the CCR	Pypgras / Muggiegras	
<i>Eragrostis curvula</i> (Schrad.) Nees	Not endemic to SA	Berg-soetgras / Blousaadgras	bread / beer making
<i>Festuca scabra</i> Vahl	Not endemic to SA	Munniksgras	
<i>Koeleria capensis</i> (Steud.) Nees	Not endemic to SA	Polgras / Strandgras	
<i>Pentameris airoides</i> Nees subsp. <i>airoides</i>	Not endemic to SA		
<i>Pentameris curvifolia</i> (Schrad.) Nees	Endemic to SA		
<i>Pentameris eriostoma</i> (Nees) Steud.	Endemic to SA		
<i>Pentameris glandulosa</i> (Schrad.) Steud.	Endemic to SA		
<i>Pentameris malouinensis</i> (Steud.) Galley & H.P.Linder	Endemic to the CCR		
<i>Pentameris patula</i> (Nees) Steud.	Endemic to the GCE		
<i>Schismus barbatus</i> (Loefl. ex L.) Thell.	Not endemic to SA	Winterhaasgras	
<i>Stipagrostis zeyheri</i> (Nees) De Winter subsp. <i>zeyheri</i>	Endemic to SA	Cape Bushman Grass	
<i>Tenaxia stricta</i> (Schrad.) N.P.Barker & H.P.Linder	Endemic to SA		

<i>Themeda triandra</i> Forssk.	Not endemic to SA	Rooigras / Rooisaadgras	May cause poisoning under field conditions
<i>Tribolium echinatum</i> (Thunb.) Renvoize	Endemic to the CCR		
<i>Tribolium hispidum</i> (Thunb.) Desv.	Endemic to SA		
<i>Tribolium uniolae</i> (L.f.) Renvoize	Endemic to the CCR	Koringgras	
<i>Tribolium utriculosum</i> (Nees) Renvoize	Endemic to the GCE		
RESTIONACEAE			
<i>Cannomois scirpoides</i> (Kunth) Mast.	Endemic to the CCR		
<i>Cannomois spicata</i> Mast.	Endemic to the CCR		
<i>Elegia filacea</i> Mast.	Endemic to the CCR		
<i>Elegia vaginulata</i> Mast.	Endemic to SA		
<i>Hypodiscus striatus</i> (Kunth) Mast.	Endemic to the GCE		
<i>Restio capensis</i> (L.) H.P.Linder & C.R.Hardy	Endemic to the GCE		
<i>Restio distichus</i> Rottb.	Endemic to the CCR		
<i>Restio filiformis</i> Poir.	Endemic to the CCR		
<i>Restio gaudichaudianus</i> Kunth	Endemic to the GCE		
<i>Restio gossypinus</i> Mast.	Endemic to the GCE		
<i>Restio rigoratus</i> (Mast.) H.P.Linder & C.R.Hardy	Endemic to the CCR		
<i>Restio sieberi</i> Kunth	Endemic to SA	Besemriet	used to make brooms
<i>Restio triflora</i> Rottb.	Endemic to SA		
<i>Staberoha distachyos</i> (Rottb.) Kunth	Endemic to the CCR		
<i>Thamnochortus bachmannii</i> Mast.	Endemic to the GCE	Steenboksriet	
<i>Thamnochortus lucens</i> (Poir.) H.P.Linder	Endemic to the CCR	Jakkalssterriet	
<i>Willdenowia arescens</i> Kunth	Endemic to the GCE		
<i>Willdenowia incurvata</i> (Thunb.) H.P.Linder	Endemic to the GCE	Sonkwasriet	
RUSCACEAE			
<i>Eriospermum bowieanum</i> Baker	Endemic to the CCR	Eriospermum = Cottonseed	
<i>Eriospermum capense</i> (L.) Thunb. subsp. <i>capense</i> <i>Eriospermum capense</i> (L.) Thunb. subsp. <i>stoloniferum</i> (Marloth) P.L.Perry	Endemic to SA	Bobbejaanoor / Elephant's Ear / Olifantsoor	
<i>Eriospermum cernuum</i> Baker	Endemic to the CCR	Perdeklou	
<i>Eriospermum dielsianum</i> Poelln. subsp. <i>dielsianum</i>	Endemic to the GCE		
<i>Eriospermum graminifolium</i> A.V.Duthie	Endemic to the CCR		
<i>Eriospermum lanceifolium</i> Jacq.	Endemic to the CCR		

<i>Eriospermum nanum</i> Marloth	Endemic to the CCR		
<i>Eriospermum proliferum</i> Baker	Endemic to the GCE		
<i>Eriospermum pubescens</i> Jacq.	Endemic to the CCR		possibly poisonous
TECOPHILAEACEAE			
<i>Cyanella hyacinthoides</i> L.	Endemic to the GCE	Blouraaptol	edible
<i>Cyanella lutea</i> L.f. subsp. <i>lutea</i>	Endemic to SA	Geelraaptol	edible
EUDICOTYLEDONS			
AIZOACEAE			
<i>Acrodon bellidiflorus</i> (L.) N.E.Br.	Endemic to the CCR		
<i>Acrosanthes teretifolia</i> Eckl. & Zeyh.	Endemic to the CCR		
<i>Aizoon karooicum</i> Compton	Endemic to the CCR	Spekvygie	
<i>Aizoon sarmentosum</i> L.f.	Endemic to the GCE		
<i>Antimima microphylla</i> (Haw.) Dehn	Endemic to the CCR	Kussingvygie	
<i>Antimima peersii</i> (L.Bolus) H.E.K.Hartmann	Endemic to the CCR		
<i>Antimima stokoei</i> (L.Bolus) H.E.K.Hartmann	Endemic to the CCR		
<i>Apatesia helianthoides</i> (Aiton) N.E.Br.	Endemic to the CCR		
<i>Brianhantleya intrusa</i> (Kensit) Chess., S.A.Hammer & I.Oliv.	Endemic to the CCR		
<i>Carpobrotus edulis</i> (L.) L.Bolus subsp. <i>edulis</i>	Endemic to SA	Hottentot Fig / Suurvy	medicinal, leaves & fruit edible
<i>Carpobrotus mellei</i> (L.Bolus) L.Bolus	Endemic to the CCR		
<i>Cephalophyllum curtrophyllum</i> (L.Bolus) Schwantes	Endemic to the GCE		
<i>Cephalophyllum purpureo-album</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Cleretum bellidiforme</i> (Burm.f.) G.D.Rowley	Endemic to the GCE	Bokbaaivygie	
<i>Cleretum papulosum</i> (L.f.) L.Bolus subsp. <i>papulosum</i>	Endemic to SA		
<i>Conicosia elongata</i> (Haw.) N.E.Br.	Endemic to SA	Gansies / Varkiesknol / Varkslaai	
<i>Conophytum ficiforme</i> (Haw.) N.E.Br.	Endemic to the CCR	Toontjies	
<i>Delosperma inconspicuum</i> L.Bolus	Endemic to the CCR	Skaapvygie	
<i>Delosperma pageanum</i> (L.Bolus) L.Bolus	Endemic to the CCR		
<i>Drosanthemum ambiguum</i> L.Bolus	Endemic to the CCR	Douvygie	
<i>Drosanthemum asperulum</i> (Salm-Dyck) Schwantes	Endemic to the CCR		
<i>Drosanthemum bellum</i> L.Bolus	Endemic to the CCR		
<i>Drosanthemum calycinum</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Drosanthemum globosum</i> L.Bolus	Endemic to the GCE		

<i>Drosanthemum hallii</i> L.Bolus	Endemic to the CCR		
<i>Drosanthemum hispidum</i> (L.) Schwantes	Not endemic to SA	Fyn T'nouroebos	toxic to rabbit
<i>Drosanthemum karrooense</i> L.Bolus	Endemic to SA		
<i>Drosanthemum micans</i> (L.) Schwantes	Endemic to the CCR		
<i>Drosanthemum papillatum</i> L.Bolus	Endemic to the CCR		
<i>Drosanthemum parvifolium</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Drosanthemum pulchrum</i> L.Bolus	Endemic to the CCR		
<i>Drosanthemum speciosum</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Drosanthemum striatum</i> (Haw.) Schwantes S	Endemic to the CCR		
<i>Drosanthemum vandermerwei</i> L.Bolus	Endemic to the CCR		
<i>Drosanthemum sp. 1</i>	Endemic to the CCR		
<i>Erepsia anceps</i> (Haw.) Schwantes	Endemic to the CCR	Altydvygie	
<i>Erepsia bracteata</i> (Aiton) Schwantes	Endemic to the CCR		
<i>Erepsia gracilis</i> (Haw.) L.Bolus	Endemic to the CCR		
<i>Galenia africana</i> L.	Not endemic to SA	Kraalbos / Geelbrakbos	medicinal
<i>Galenia sarcophylla</i> Fenzl	Not endemic to SA	Joubertsbrakbossie / Vanwyksbrakbossie	
<i>Glottiphyllum depressum</i> (Haw.) N.E.Br.	Endemic to the GCE	Skilpadkos	
<i>Hymenogyne glabra</i> (Aiton) Haw. South	Endemic to the CCR		
<i>Lampranthus aureus</i> (L.) N.E.Br.	Endemic to the CCR	Golden Brightfig	
<i>Lampranthus debilis</i> (Haw.) N.E.Br.	Endemic to the CCR	Rankvygie	
<i>Lampranthus elegans</i> (Jacq.) Schwantes	Endemic to the CCR		
<i>Lampranthus haworthii</i> (Haw.) N.E.Br.	Endemic to the CCR		
<i>Lampranthus leipoldtii</i> (L.Bolus) L.Bolus	Endemic to the CCR		
<i>Lampranthus scaber</i> (L.) N.E.Br.	Endemic to the CCR		
<i>Lampranthus spiniformis</i> (Haw.) N.E.Br.	Endemic to the CCR		
<i>Leipoldtia schultzei</i> (Schltr. & Diels) Friedrich	Endemic to the GCE	Langbeen T'nouroebos	
<i>Malephora latipetala</i> (L.Bolus) H.Jacobsen & Schwantes	Endemic to the GCE	Vingerkanna	
<i>Mesembryanthemum caudatum</i> L.Bolus	Endemic to the CCR		
<i>Mesembryanthemum grossum</i> Aiton	Endemic to the GCE		
<i>Mesembryanthemum guerichianum</i> Pax	Not endemic to SA	Soutslaai	
<i>Mesembryanthemum junceum</i> Haw.	Endemic to SA	Asbos / Loogbos / Lidjiesbos/ Seepbos	soap-making
<i>Mesembryanthemum longistylum</i> DC.	Endemic to the CCR		
<i>Mesembryanthemum nodiflorum</i> L.	Not endemic to SA		
<i>Mesembryanthemum pallens</i> Aiton subsp. <i>pallens</i>	Endemic to the GCE		
<i>Mesembryanthemum splendens</i> L.	Endemic to SA	Donkievygie	

<i>Mesembryanthemum varians</i> Haw.	Endemic to the CCR		
<i>Oscularia deltoides</i> (L.) Schwantes	Endemic to the CCR	Sandsteenwygie / Dassievygie	
<i>Ruschia caroli</i> (L.Bolus) Schwantes	Endemic to the CCR		
<i>Ruschia costata</i> L.Bolus	Endemic to the CCR		
<i>Ruschia diversifolia</i> L.Bolus	Endemic to the CCR		
<i>Ruschia lineolata</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Ruschia multiflora</i> (Haw.) Schwantes	Endemic to the GCE		
<i>Ruschia tumidula</i> (Haw.) Schwantes	Endemic to the CCR		
<i>Ruschiella argentea</i> (L.Bolus) Klak	Endemic to the GCE		
<i>Ruschiella lunulata</i> (A.Berger) Klak	Endemic to the GCE		
<i>Scopelogenia verruculata</i> (L.) L.Bolus	Endemic to the CCR		
<i>Stayneria neilii</i> (L.Bolus) L.Bolus	Endemic to the CCR		
<i>Tetragonia decumbens</i> Mill.	Not endemic to SA	Duinespinasie	edible
<i>Tetragonia fruticosa</i> L.	Endemic to the GCE	Klimopkinkelbossie	
<i>Tetragonia microptera</i> Fenzl	Not endemic to SA	Kinkelbos / Klapperbrak	
<i>Tetragonia nigrescens (portulacoides)</i> Fenzl	Endemic to the GCE		
<i>Tetragonia sarcophylla</i> Fenzl	Endemic to SA		
<i>Tetragonia spicata</i> L.f.	Not endemic to SA		
<i>Tetragonia verrucosa</i> Fenzl	Endemic to the GCE		
<i>Trichodiadema calvatum</i> L.Bolus	Endemic to the CCR	Diadem Vygie	
AMARANTHACEAE			
* <i>Atriplex cinerea</i> Poir. subsp. <i>bolusii</i> (C.H.Wright) Aellen var. <i>adamsonii</i> Aellen	Not endemic to SA	Saltbush	
* <i>Atriplex semibaccata</i> R.Br. var. <i>appendiculata</i> Aellen	Not endemic to SA	Creeping Saltbush	
<i>Chenolea convallis</i> Snijman & J.C.Manning	Endemic to the CCR		
<i>Chenopodium mucronatum</i> Thunb.	Not endemic to SA		
<i>Manochlamys albicans</i> (Aiton) Aellen	Not endemic to SA	Spanspekbos / Hondebossie / Boesmanseep	soap making
<i>Salsola aphylla</i> L.f.	Not endemic to SA	Grootganna / Soutganna / Seepganna / Loogganna	soap making & fodder plant
* <i>Salsola kali</i>	Not endemic to SA	Rolbossie / Russian Thistle	
ANACAMPSEROTACEAE			
<i>Anacampseros lanceolata</i> (Haw.) Sweet subsp. <i>lanceolata</i>	Endemic to the GCE	Boesmansuring / Haaskos	
<i>Anacampseros retusa</i> Poelln.	Not endemic to SA		
<i>Anacampseros telephiastrum</i> DC.	Endemic to SA	Gemsboksurings / Haassuring	fermentation

ANACARDIACEAE			
<i>Heeria argentea</i> (Thunb.) Meisn.	Endemic to the CCR	Kliphout	medicinal & tannins
<i>Searsia angustifolia</i> (L.) F.A.Barkley	Endemic to the CCR	Wilgerkorentebos	
<i>Searsia dissecta</i> (Thunb.) Moffett	Endemic to the CCR	Langsteel Korentebossie	
<i>Searsia incisa</i> (L.f.) F.A.Barkley var. <i>incisa</i>	Endemic to SA	Rub-rub berry / Baardbessie	
<i>Searsia longispina</i> (Eckl. & Zeyh.) Moffett	Endemic to SA	Besemkraaibessie / Doringtaaibos	
<i>Searsia lucida</i> (L.) F.A.Barkley	Not endemic to SA	Blinktaaibos	
<i>Searsia pallens</i> (Eckl. & Zeyh.) Moffett	Not endemic to SA	Bleekkoeniebos	
<i>Searsia rosmarinifolia</i> (Vahl) F.A.Barkley	Endemic to the CCR	Roosmaryntaaibos	
<i>Searsia tomentosa</i> (L.) F.A.Barkley	Not endemic to SA	Korentebos	tannins
<i>Searsia undulata</i> (Jacq.) T.S.Yi, A.J.Mill. & J.Wen	Not endemic to SA	Kuni-bush / Koeniebos / Rosyntjebos / Taaibos / Njarabessie / T'kunie Bush	medicinal & fruit edible, firewood
APIACEAE			
<i>Anginon swellendamensis</i> (Eckl. & Zeyh.) B.L.Burt	Endemic to the CCR	Wildeseldery / Wildevinkel	
<i>Annesorhiza grandiflora</i> (Thunb.) M.Hiroe	Endemic to the CCR	Harige-anyswortel	
<i>Annesorhiza laticostata</i> Magee	Endemic to the CCR		
<i>Annesorhiza nuda</i> (Aiton) B.L.Burt	Endemic to the CCR	Soetanyswortel	edible root
<i>Annesorhiza triternata</i> (Eckl. & Zeyh.) Vessio, Tilney & B-E.van Wyk	Endemic to the CCR		
<i>Annesorhiza radiata</i> Magee	Endemic to the CCR		
<i>Arctopus echinatus</i> L.	Endemic to the GCE	Platdoring / Sieketroos	medicinal
<i>Centella asiatica</i> (L.) Urb.	Not endemic to SA	Waternael / Pennywort / Varkoortjies	medicinal & edible
<i>Centella capensis</i> (L.) Domin	Endemic to the CCR		
<i>Centella macrocarpa</i> (Rich.) Adamson	Endemic to the CCR		
<i>Centella villosa</i> L.	Endemic to the CCR		
<i>Chamarea capensis</i> (Thunb.) Eckl. & Zeyh.	Endemic to the GCE	Cape Caraway / Vinkelwortel	edible
<i>Chamarea gracillima</i> (H.Wolff) B.L.Burt	Endemic to the CCR		
<i>Conium sphaerocarpum</i> Hilliard & B.L.Burt	Endemic to the GCE	Hemlock	
<i>Dasispermum tenue</i> (Sond.) Magee & B.-E.van Wyk	Endemic to the CCR		
<i>Itasina filifolia</i> (Thunb.) Raf.	Endemic to the CCR	Grass Parsley	
<i>Lichtensteinia interrupta</i> (Thunb.) Sond.	Endemic to SA	Kalmoes	medicinal
<i>Lichtensteinia obscura</i> (Spreng.) Koso-Pol.	Endemic to the CCR		
<i>Torilis arvensis</i> (Huds.) Link	Not endemic to SA	Hedge Parsley	

APOCYNACEAE			
<i>Astephanus triflorus</i> (L.f.) Schult.	Endemic to the GCE		
<i>Carissa bispinosa</i> (L.) Desf. ex Brenan	Not endemic to SA	Num-Num / Lemoenbessie	edible fruit & medicinal
<i>Cynanchum africanum</i> (L.) Hoffmanns.	Endemic to SA	Bokhoring	medicinal & poisonous
<i>Duvalia caespitosa</i> (Masson) Haw. subsp. <i>caespitosa</i>	Endemic to SA	Gortjie	
<i>Eustegia minuta</i> (L.f.) Schult.	Endemic to the GCE	Dwarf Milkroof	
<i>Fockea comaru</i> (E.Mey.) N.E.Br.	Not endemic to SA	Kambro	fleshy tuber edible
<i>Gomphocarpus cancellatus</i> (Burm.f.) Bruyns	Not endemic to SA	Katoenbos / Bergtonteldoosbos	
<i>Gomphocarpus fruticosus</i> (L.) Aiton f. subsp. <i>fruticosus</i>	Not endemic to SA	Cotton Milkweed / Firesticks / Gansies / Gansiesbos	medicinal & poisonous
<i>Microlooma sagittatum</i> (L.) R.Br.	Endemic to SA	Melktou / Wax-creeper	medicinal & fruits edible
<i>Microlooma tenuifolium</i> (L.) K.Schum.	Endemic to SA	Kannetjies / Bokhoringkies	fruits edible
<i>Quaqua mammillaris</i> (L.) Bruyns	Endemic to the GCE	Aroena / Ouram	medicinal & edible
<i>Sarcostemma viminale</i> (L.) R.Br. subsp. <i>viminale</i>	Not endemic to SA	Spantou / Melktou	medicinal
<i>Secamone alpini</i> Schult.	Not endemic to SA	Bobbejaantou	
<i>Stapelia hirsuta</i> L. var. <i>hirsuta</i>	Endemic to SA	Aasblom	
ASTERACEAE			
<i>Amellus strigosus</i> (Thunb.) Less. subsp. <i>strigosus</i>	Endemic to SA	Astertjie / Bloublommetjie	
<i>Amphiglossa perotrichoides</i> DC.	Endemic to the CCR	Kopseerbossie	
<i>Amphiglossa rudolphii</i> Koekemoer	Endemic to the GCE		
<i>Amphiglossa tomentosa</i> (Thunb.) Harv.	Not endemic to SA		
<i>Anaxeton asperum</i> (Thunb.) DC. subsp. <i>asperum</i>	Endemic to the CCR		
<i>Arctotheca calendula</i> (L.) Levyns	Not endemic to SA	Cape Weed / Botterblom / Cape Dandelion / Kaapse Madeliefie	poisonous
<i>Arctotis acaulis</i> L.	Endemic to the GCE	Renostergousblom	
<i>Arctotis dregei</i> Turcz.	Endemic to SA		
<i>Arctotis</i> cf. <i>incisa</i> Thunb. (sp 11 Manning & Goldblatt 2012)	Endemic to the CCR	Botterblom	
<i>Arctotis</i> cf. <i>undulata</i> Jacq. (sp 1 Manning & Goldblatt 2012)	Endemic to the CCR		
<i>Athanasia filiformis</i> L.f.	Endemic to SA	Klaaslouwbos	
<i>Athanasia humilis</i> Källersjö	Endemic to the CCR		
<i>Athanasia</i> cf. <i>scabra</i> Thunb.	Endemic to the CCR		
<i>Athanasia trifurcata</i> (L.) L.	Endemic to the GCE	Klaaslouwbos / Kouterbos	

<i>Berkheya armata</i> (Vahl) Druce	Endemic to the CCR	Grootdissel / Vlakte-dissel / Vlakte-doring	
<i>Berkheya heterophylla</i> (Thunb.) O.Hoffm.	Endemic to SA	Graweelwortel	
<i>Berkheya</i> sp. aff. <i>rigida</i> (Thunb.) Erwart, Jean White & B.Rees	Endemic to the CCR	Disseldoring	
<i>Bolandia pedunculosa</i> (DC.) Cron	Endemic to SA		
<i>Chrysocoma ciliata</i> L.	Not endemic to SA	Beesbos / Bitterbos / Bitterkaroo	
<i>Chrysocoma tridentata</i> DC.	Endemic to the CCR	Beesbos	
<i>Cineraria lobata</i> L'Hér.	Endemic to SA		
<i>Cineraria platycarpa</i> DC.	Endemic to the GCE		
<i>Corymbium africanum</i> L. subsp. <i>scabridum</i> (P.J.Bergius) Weitz f	Endemic to SA	Plampers	
<i>Corymbium glabrum</i> L. var. <i>glabrum</i>	Endemic to SA	Heuningbos	
<i>Corymbium villosum</i> L.f.	Endemic to the CCR	Heuningbossie	
<i>Corymbium</i> sp.			
<i>Cotula bipinnata</i> Thunb.	Endemic to the GCE	Kleinknoppies	
<i>Cotula coronopifolia</i> L.	Not endemic to SA	Gansgras / Eendkos	medicinal & possibly poisonous
<i>Cotula macroglossa</i> Bolus ex Schltr.	Endemic to the CCR	Knopies	
<i>Cotula sororia</i> DC.	Endemic to SA		
<i>Cotula tenella</i> E.Mey. ex DC.	Endemic to the GCE		
<i>Cotula turbinata</i> L.	Endemic to the CCR	Ganskos	
<i>Crassothonna cacalioides</i> (L.f.) B.Nord.	Not endemic to SA		
<i>Cullumia reticulata</i> (L.) Greuter, M.V.Agab. & Wagenitz subsp. <i>angustifolia</i> (Hutch.) (L.) Greuter, M.V.Agab. & Wagenitz	Endemic to the CCR	Steekhaarbos	
<i>Cullumia sulcata</i> (Thunb.) Less.	Endemic to the CCR	Cullumia = Steekhaarbos	
<i>Curio crassulifolius</i> (DC.) P.V.Heath	Endemic to the CCR		
<i>Curio radicans</i> (L.) P.V.Heath	Not endemic to SA	Bobbejaantootjies / Vingertjies	
<i>Cymbopappus adenosolen</i> (Harv.) B.Nord.	Endemic to the CCR		
<i>Dimorphotheca nudicaulis</i> (L.) DC. var. <i>nudicaulis</i>	Endemic to the CCR	Witmagriet	poisonous
<i>Dimorphotheca pluvialis</i> (L.) Moench	Not endemic to SA	Reënblommetjie	poisonous
<i>Dimorphotheca sinuata</i> DC.	Not endemic to SA	Namaqualand Daisy	poisonous
<i>Dimorphotheca</i> sp. nov. A le Roux 1045 & 1239			
<i>Dolichotheix ericoides</i> (Lam.) Hilliard & B.L.Burt	Endemic to the CCR	Kliprenosterbos	
<i>Edmondia fasciculata</i> (Andrews) Hilliard	Endemic to the GCE	Sewejaartjie	
<i>Elytropappus glandulosus</i> Less.	Endemic to the CCR		medicinal & possibly poisonous

<i>Elytropappus gnaphaloides</i> (L.) Levyns	Endemic to the CCR		
<i>Elytropappus intricata</i> (Levyns) Koekemoer	Endemic to the CCR		
<i>Elytropappus rhinocerotis</i> (L.f.) Less.	Not endemic to SA	Renosterbos	medicinal
<i>Eriocephalus africanus</i> L. var. <i>paniculatus</i> (Cass.) M.A.N.Müll.,P.P.J.Herman & Kolberg	Endemic to SA	Wild Rosemary / Kapokbossie	medicinal & aromatic
<i>Eriocephalus ericoides</i> (L.f.) Druce subsp. <i>ericoides</i>	Not endemic to SA	Gewone Kapokbossie	medicinal & aromatic
<i>Eriocephalus grandiflorus</i> M.A.N.Müll.	Endemic to the GCE		aromatic
<i>Euryops multifidus</i> (Thunb.) DC.	Endemic to the GCE	Hanepootharpuisbos	medicinal
<i>Euryops rehmannii</i> Compton	Endemic to the GCE	Harpuisbos	
<i>Felicia bergeriana</i> (Spreng.) O.Hoffm.	Endemic to the CCR	Astertjie	
<i>Felicia denticulata</i> Grau	Endemic to the CCR		
<i>Felicia filifolia</i> (Vent.) Burt Davy subsp. <i>schaeferi</i> (Dinter) Grau	Endemic to SA	Draaibossie / Persbergdraaibos	
<i>Felicia hyssopifolia</i> (P.J.Bergius) Nees	Not endemic to SA		
<i>Felicia minima</i> (Hutch.) Grau	Endemic to the GCE		
<i>Gazania ciliaris</i> DC.	Endemic to the CCR		
<i>Gazania krebsiana</i> Less. subsp. <i>krebsiana</i> <i>Gazania krebsiana</i> Less. subsp. <i>arctotooides</i> (Less.) Roessler	Not endemic to SA	Rooigazania / Oranjegousblom / Rooibotterblom	
<i>Gnaphalium capense</i> Hilliard	Endemic to the GCE		
<i>Gnaphalium pauciflorum</i> DC.	Endemic to the CCR		
<i>Gorteria personata</i> L. subsp. <i>gracilis</i> Roessler	Endemic to the CCR	Beetle daisy / Klitskruid	
<i>Gymnodiscus capillaris</i> (L.f.) DC.	Endemic to the GCE	Geelkruid / Hongerblom	
<i>Helichrysum asperum</i> (Thunb.) Hilliard & B.L.Burt var. <i>asperum</i>	Not endemic to SA	Strooiblom	
<i>Helichrysum cylindriflorum</i> (L.) Hilliard & B.L.Burt	Endemic to the GCE		
<i>Helichrysum excisum</i> (Thunb.) Less.	Endemic to the CCR		
<i>Helichrysum hamulosum</i> E.Mey. ex DC.	Endemic to SA		
<i>Helichrysum hebelepis</i> DC.	Endemic to the GCE	Heuningbos	medicinal
<i>Helichrysum incarnatum</i> DC.	Endemic to the CCR		
<i>Helichrysum indicum</i> (L.) Grierson	Endemic to the CCR		
<i>Helichrysum lancifolium</i> (Thunb.) Thunb.	Endemic to the CCR		
<i>Helichrysum litorale</i> Bolus	Endemic to SA		
<i>Helichrysum moesianum</i> Thell.	Endemic to SA	Kooigoed	
<i>Helichrysum patulum</i> (L.) D.Don	Endemic to the CCR		
<i>Helichrysum revolutum</i> (Thunb.) Less.	Endemic to the GCE		
<i>Helichrysum rosum</i> (P.J.Bergius) Less. var. <i>rosum</i>	Endemic to SA	Sewejaartjie / Strawflower	
<i>Helichrysum rutilans</i> (L.) D.Don	Endemic to SA		

<i>Helichrysum saxicola</i> Hilliard	Endemic to the CCR		
<i>Helichrysum teretifolium</i> (L.) D.Don	Endemic to SA		
<i>Heterolepis peduncularis</i> DC.	Endemic to the CCR	Rotsgousblom	
<i>Hirpicium integrifolium</i> (Thunb.) Less.	Endemic to the CCR	Haarbossie	
<i>Hymenolepis speciosa</i> (Hutch.) Källersjö	Endemic to the CCR	Basterkaroo	
* <i>Hypochaeris radicata</i> L.	Not endemic to SA	Skaapslaai / Cat's ear / Flatweed	
<i>Ifloga repens</i> (L.) Hilliard & B.L.Burt	Endemic to the CCR	Witnaaldebossie	
<i>Ifloga ambigua</i> (L.) Druce	Endemic to the CCR	Naaldebos	
<i>Ifloga woodii</i> (N.E.Br) B.L.Burt	Not endemic to SA		
<i>Ifloga paronychioides</i> (DC.) Fenzl	Endemic to the GCE		
<i>Lachnospermum fasciculatum</i> (Thunb.) Baill.	Endemic to SA		
<i>Lachnospermum neglectum</i> Schltr. ex J.C.Manning & Goldblatt	Endemic to the CCR		
* <i>Lactuca serriola</i> L.	Not endemic to SA	Wild lettuce / Milk thistle	
<i>Leysera gnaphalodes</i> (L.) L.	Not endemic to SA	Skilpadteebossie / Teringteebossie / Hongertee / Duinetee	medicinal & aromatic, tea
<i>Macledium spinosum</i> (L.) S.Ortiz	Endemic to SA	Steekblom	
<i>Marasmodes</i> sp. nov.	Endemic to the CCR		
<i>Metalasia acuta</i> P.O.Karis	Endemic to the CCR	Blombos	
<i>Metalasia adunca</i> Less.	Endemic to the GCE		
<i>Metalasia agathosmoides</i> Pillans	Endemic to the CCR		
<i>Metalasia brevifolia</i> (Lam.) Levyns	Endemic to the CCR	Blombos / Blombossie	
<i>Metalasia densa</i> (Lam.) P.O.Karis	Not endemic to SA	Blombos	
<i>Metalasia dregeana</i> DC.	Endemic to the CCR		
<i>Metalasia erubescens</i> DC.	Endemic to the CCR		
<i>Metalasia plicata</i> P.O.Karis	Endemic to the CCR		
<i>Nidorella ivifolia</i> (L.) J.C.Manning & Goldblatt	Not endemic to SA	Bakbesembossie / Oondbos	
<i>Oedera capensis</i> (L.) Druce	Endemic to the CCR	Perdekaroo	
<i>Oedera genistifolia</i> (L.) Anderb. & K.Bremer	Endemic to SA	Kleinperdekaroo	aromatic
<i>Oedera squarrosa</i> (L.) Anderb. & K.Bremer	Endemic to the CCR	Vierkantperdekaroo	
<i>Oncosiphon grandiflorum</i> (Thunb.) Källersjö	Endemic to the GCE	Grootstinkkruid	
<i>Oncosiphon suffruticosum</i> (L.) Källersjö	Endemic to the GCE	Stinkkruid / Wurmbossie	medicinal
<i>Osteospermum bidens</i> Thunb.	Endemic to the GCE	Boneseed	
<i>Osteospermum moniliferum</i> L. subsp. <i>moniliferum</i>	Not endemic to SA	Bietou / Bosluisbessie	medicinal & fruit edible
<i>Osteospermum monstrosum</i> (Burm.f.) J.C.Manning & Goldblatt	Endemic to the GCE	Trekkertjie	

<i>Osteospermum polygaloides</i> L.	Endemic to SA		
<i>Osteospermum scariosum</i> DC.	Not endemic to SA	Skaapbos	
<i>Osteospermum spinosum</i> L. var. <i>spinosum</i>	Endemic to the CCR		
<i>Osteospermum tomentosum</i> (L.f.) Norl.	Endemic to the CCR		
<i>Othonna arbuscula</i> (Thunb.) Sch.Bip.	Endemic to the GCE	Traap / Knolharpuis / Knolrepuis	
<i>Othonna auriculifolia</i> Licht. ex Less.	Endemic to the GCE	Bobbejaankool	poisonous
<i>Othonna bulbosa</i> L.	Endemic to the CCR		
<i>Othonna ciliata</i> L.f.	Endemic to the CCR		
<i>Othonna digitata</i> L.	Endemic to the CCR		
<i>Othonna gymnodiscus</i> (DC.) Sch.Bip.	Endemic to the CCR		
<i>Othonna parviflora</i> P.J.Bergius	Endemic to the CCR	Bobbejaankool / Bokveldharpuis	
<i>Othonna perfoliata</i> (L.f.) Jacq.	Endemic to the CCR		
<i>Othonna pinnata</i> L.f.	Endemic to the CCR		
<i>Othonna retrofracta</i> Jacq.	Endemic to the GCE		
<i>Pentzia incana</i> (Thunb.) Kuntze	Not endemic to SA	Skaapkaroo / Ankerkaroo	medicinal aromatic
<i>Perdicium capense</i> L.	Endemic to the CCR		
<i>Phaenocoma prolifera</i> (L.) D.Don	Endemic to the CCR	Rooisewejaartjie / Red Everlasting	aromatic
<i>Printzia polifolia</i> (L.) Hutch.	Endemic to the CCR		
<i>Pseudognaphalium undulatum</i> (L.) Hilliard & B.L.Burt	Not endemic to SA	Cudweed / Groenbossie	
<i>Pteronia camphorata</i> (L.) L. var. <i>camphorata</i>	Endemic to the GCE	Sandgombos	
<i>Pteronia divaricata</i> (P.J.Bergius) Less.	Endemic to the GCE	Geelgombos	
<i>Pteronia elongata</i> Thunb.	Endemic to the GCE	Gombos	
<i>Pteronia fasciculata</i> L.f.	Endemic to the CCR		
<i>Pteronia fastigiata</i> Thunb.	Endemic to the GCE		
<i>Pteronia flexicaulis</i> L.f.	Endemic to the CCR	Gombossie	
<i>Pteronia hirsuta</i> L.f.	Endemic to SA		
<i>Pteronia hutchinsoniana</i> Compton	Endemic to SA		
<i>Pteronia incana</i> (Burm.) DC.	Endemic to SA	Asbossie / Bitterbos / Bloubos / Laventelbossie / Ribbokbos	aromatic
<i>Pteronia ovalifolia</i> DC.	Endemic to the GCE	Grysgombos	
<i>Pteronia paniculata</i> Thunb.	Not endemic to SA	Gombossie	
<i>Pulicaria scabra</i> (Thunb.) Druce	Not endemic to SA	Aambeibos	medicinal
<i>Relhania relhanioides</i> (Schltr.) K.Bremer	Endemic to the CCR	Perdekaroo	
<i>Rhynchosidium pumilum</i> (L.f.) DC.	Endemic to the GCE	Geelsneeu	
<i>Rhynchosidium sessiliflorum</i> (L.f.) DC.	Endemic to the GCE		
<i>Senecio abbreviatus</i> S.Moore	Endemic to SA	Groundsel / Hogerblom / Ragwort	

<i>Senecio anthemifolius</i> Harv.	Endemic to the CCR		
<i>Senecio arenarius</i> Thunb.	Not endemic to SA	Hongerblom	
<i>Senecio burchellii</i> DC.	Not endemic to SA	Geelgifbos	poisonous
<i>Senecio erosus</i> L.f.	Endemic to the GCE	Smooth Groundsel / Sticky-Leaved Groundsel	
<i>Senecio glutinarius</i> DC.	Endemic to the CCR	Dunsiekte-senecio / Hongerbossie	
<i>Senecio incertus</i> DC.	Endemic to the CCR		
<i>Senecio junceus</i> (DC.) Harv.	Endemic to SA	Sjambokbos	
<i>Senecio laxus</i> DC.	Endemic to SA		
<i>Senecio paarlensis</i> DC.	Endemic to the CCR		
<i>Senecio pinifolius</i> (L.) Lam.	Endemic to SA		
<i>Senecio pubigerus</i> L.	Endemic to the CCR	Skraalbossie	poisonous
<i>Senecio repandus</i> Thunb.	Endemic to the CCR		
<i>Senecio rosmarinifolius</i> L.f.	Endemic to SA	Gryshongerblom	poisonous
<i>Senecio sarcoides</i> C.Jeffrey	Endemic to the GCE		
<i>Senecio sophioides</i> DC.	Endemic to the CCR		
<i>Senecio vestitus</i> (Thunb.) P.J.Bergius	Endemic to the GCE	Paperleaf Ragwort	
* <i>Sonchus oleraceus</i>	Not endemic to SA European weed	Sydissel / Tuindissel / Sowthistle / Milkthistle	medicinal & vegetable
<i>Stoebe cinerea</i> (L.) Thunb.	Endemic to the CCR	Vaal Hartebeeskaroo	medicinal
<i>Stoebe fusca</i> (L.) Thunb.	Endemic to the CCR		
<i>Stoebe nervigera</i> (DC.) Sch.Bip.	Endemic to the GCE		
<i>Stoebe rugulosa</i> Harv.	Endemic to the CCR		
<i>Stoebe spiralis</i> Less.	Endemic to the CCR	Slangbos	
<i>Syncarpha canescens</i> (L.) B.Nord. subsp. <i>canescens</i>	Endemic to the GCE	Everlasting	
<i>Syncarpha gnaphaloides</i> (L.) DC.	Endemic to the CCR	Vlaktetee	
<i>Syncarpha mucronata</i> (P.J.Bergius) B.Nord.	Endemic to the CCR		
<i>Syncarpha staehelina</i> (L.) B.Nord.	Endemic to the CCR		
* <i>Taraxacum officinale</i> (L.) Weber ex F.H. Wigg	Not endemic to SA European weed	Perdeblom / Common dandelion	medicinal & vegetable
<i>Troglophyton parvulum</i> (Harv.) Hilliard & B.L.Burt	Endemic to the GCE		
<i>Ursinia anthemoides</i> (L.) Poir. subsp. <i>anthemoides</i>	Not endemic to SA	Magriet	
<i>Ursinia chrysanthemoides</i> (Less.) Harv.	Endemic to SA	Bergmagriet	
<i>Ursinia nana</i> DC. subsp. <i>nana</i>	Not endemic to SA	Kleinbergmagriet	medicinal
<i>Ursinia nudicaulis</i> (Thunb.) N.E.Br.	Endemic to the CCR		
<i>Ursinia oreogena</i> Schltr. ex Prassler	Endemic to the CCR		
<i>Ursinia pilifera</i> (P.J.Bergius) Poir.	Endemic to the GCE	Grootbergmagriet	

<i>Ursinia punctata</i> (Thunb.) N.E.Br.	Endemic to the CCR		
<i>Ursinia</i> sp. nov. <i>AleRoux 1173</i>	Endemic to the CCR		
<i>Zyrphelis monticola</i> (Compton) Zinnecker-Wiegand	Endemic to the CCR	Pluimastertjie	
BORAGINACEAE			
<i>Echiostachys incanus</i> (Thunb.) Levyns	Endemic to the CCR	Bottelborsel	
* <i>Echium plantagineum</i> P.Browne	Not endemic to SA	Bloudissel / Paterson's curse	
<i>Lobostemon argenteus</i> (P.J.Bergius) H.Buek	Endemic to SA	Agtdaegeneesbos	
<i>Lobostemon fruticosus</i> (L.) H.Buek	Endemic to the GCE	Douwurbos / luibos	medicinal
<i>Lobostemon laevigatus</i> (L.) H.Buek	Endemic to the CCR		
<i>Lobostemon gracilis</i> Levyns	Endemic to the CCR		
BRASSICACEAE			
<i>Erucastrum strigosum</i> (Thunb.) O.E.Schulz	Not endemic to SA		
<i>Heliophila arenaria</i> Sond.	Endemic to the CCR	Sporrie	
<i>Heliophila coronopifolia</i> L.	Endemic to the GCE	Blousporrie / Blue Flax	
<i>Heliophila crithmifolia</i> Willd.	Endemic to the GCE		
<i>Heliophila descurva</i> Schltr.	Endemic to the CCR		
<i>Heliophila elata</i> Sond.	Endemic to the CCR		
<i>Heliophila linoides</i> Schltr.	Endemic to the CCR		
<i>Heliophila meyeri</i> Sond. var. <i>minor</i> Marais	Endemic to the CCR		
<i>Heliophila pendula</i> Willd.	Endemic to SA		
<i>Heliophila pinnata</i> L.f.	Endemic to the GCE		
<i>Heliophila pusilla</i> L.f. var. <i>pusilla</i>	Endemic to the CCR		
<i>Heliophila scoparia</i> Burch. ex DC. var. <i>scoparia</i>	Endemic to the CCR		
<i>Heliophila subulata</i> Burch. ex DC.	Endemic to the GCE		
<i>Heliophila</i> cf. <i>thunbergii</i> (Eckl. & Zeyh.) Steud.	Endemic to the GCE		
<i>Lepidium africanum</i> (Burm.f.) DC.	Endemic to SA	Birdseed / Kanariesaadgras / Peperbossie	medicinal & possibly poisonous
BRUNIACEAE			
<i>Staavia trichotoma</i> (Thunb.) Pillans	Endemic to the CCR		
CAMPANULACEAE			
<i>Microcodon glomeratum</i> A.DC.	Endemic to the CCR		
<i>Prismatocarpus crispus</i> L'Hér.	Endemic to SA	Klokkiesblom	

<i>Prismatocarpus fruticosus</i> L'Hér.	Endemic to the CCR		
<i>Prismatocarpus lycioides</i> Adamson	Endemic to the CCR		
<i>Prismatocarpus pedunculatus</i> (P.J.Bergius) A.DC.	Endemic to the CCR		
<i>Wahlenbergia androsacea</i> A.DC.	Not endemic to SA	Blouklokkie / African Blue-bell	medicinal & edible
<i>Wahlenbergia capensis</i> (L.) A.DC.	Endemic to the CCR		
<i>Wahlenbergia cinerea</i> (L.f.) Lammers	Endemic to SA		
<i>Wahlenbergia debilis</i> H.Buek	Endemic to the CCR		
<i>Wahlenbergia macrostachys</i> (A.DC.) Lammers	Endemic to the CCR		
<i>Wahlenbergia neorigida</i> Lammers	Endemic to the CCR		
<i>Wahlenbergia nodosa</i> (H.Buek) Lammers	Endemic to SA	Muistepelkaroo	
<i>Wahlenbergia prostrata</i> A.DC.	Not endemic to SA		
<i>Wahlenbergia rubioides</i> (Banks ex A.DC.) Lammers	Endemic to the CCR		
<i>Wahlenbergia subulata</i> (L'Hér.) Lammers var. <i>tenuifolia</i> (Adamson) W.G.Welman	Endemic to the CCR		
<i>Wahlenbergia tenerrima</i> (H.Buek) Lammers	Endemic to SA		
CARYOPHYLLACEAE			
<i>Cerastium capense</i> Sond.	Not endemic to SA	Mouse-ear / Horingblom	
<i>Dianthus albens</i> Aiton	Endemic to SA	Wild Pink / Wilde-angelier	
<i>Dianthus bolusii</i> Burt Davy	Endemic to the CCR		
<i>Dianthus caespitosus</i> Thunb.	Endemic to the CCR		
<i>Dianthus thunbergii</i> S.S.Hooper	Endemic to SA		
* <i>Petrorhagia prolifera</i> (L.) Ball & Heywood	Not endemic to SA		
<i>Pollichia campestris</i> Aiton	Not endemic to SA	Waxberry / Aarbossie / Teesuikerkaroo	medicinal & fruit edible
* <i>Polycarpon tetraphyllum</i> (L.) L.	Not endemic to SA	Four-leaved allseed	
* <i>Silene cretica</i> L.	Not endemic to SA		
* <i>Silene gallica</i> L.	Not endemic to SA European weed	Small Catchfly	possibly poisonous
<i>Silene undulata</i> Aiton	Not endemic to SA	Wild Tobacco / Catchfly	cultural
* <i>Spergularia bocconii</i> (Scheele) Asch. & Graebn.	Not endemic to SA	Sand Spurry	Southern Africa
* <i>Spergularia media</i> (L.) C.Presl ex Griseb.	Not endemic to SA	Perennial Sea Spurry	
* <i>Stellaria media</i> (L.) Vill.	Not endemic to SA Cosmopolitan weed	Starwort	medicinal & suspected to be poisonous to sheep
CELASTRACEAE			

<i>Gloveria integrifolia</i> (L.f.) M.Jordaan	Endemic to the GCE	Spalkpendoring	
<i>Maytenus oleoides</i> (Lam.) Loes.	Endemic to the GCE	Klipkershout	
CONVOLVULACEAE			
<i>Convolvulus capensis</i> Burm.f.	Endemic to SA	Cape Bindweed / Skaapklimop	
CRASSULACEAE			
<i>Adromischus caryophyllaceus</i> (Burm.f.) Lem.	Endemic to the CCR	Nentabos	possibly poisonous
<i>Adromischus filicaulis</i> (Eckl. & Zeyh.) C.A.Sm. subsp. <i>marlothii</i> (Schönland) Toelken	Endemic to SA		
<i>Adromischus maculatus</i> (Salm-Dyck) Lem.	Endemic to the CCR		
<i>Cotyledon orbiculata</i> L. var. <i>orbiculata</i> <i>Cotyledon orbiculata</i> L. var. <i>spuria</i> (L.) Toelken	Not endemic to SA	Kouterie / Varkoor / Beesbulk / Honde-oorplakkie	medicinal & poisonous
<i>Crassula atropurpurea</i> (Haw.) D.Dietr. var. <i>atropurpurea</i>	Endemic to SA		
<i>Crassula bergioides</i> Harv.	Endemic to the CCR		
<i>Crassula biplanata</i> Haw.	Endemic to the CCR		
<i>Crassula capensis</i> (L.) Baill.	Endemic to the CCR	Cape Snowdrop / Skaamblom	
<i>Crassula capitella</i> Thunb. subsp. <i>thyrsiflora</i> (Thunb.) Toelken	Endemic to SA		
<i>Crassula ciliata</i> L.	Endemic to the CCR		
<i>Crassula cotyledonis</i> Thunb.	Not endemic to SA	Bergplakkie	
<i>Crassula cymosa</i> P.J.Bergius	Endemic to SA		
<i>Crassula dichotoma</i> L.	Endemic to SA		
<i>Crassula muricata</i> Thunb.	Endemic to SA		
<i>Crassula expansa</i> Dryand. subsp. <i>expansa</i>	Not endemic to SA		
<i>Crassula fascicularis</i> Lam.	Endemic to the CCR	Karnaatjieblom / Keiserskroon / Klipblom	
<i>Crassula hemisphaerica</i> Thunb.	Endemic to SA		
<i>Crassula muscosa</i> L.	Not endemic to SA	Lizard's Tail / Skoenveterbossie	
<i>Crassula nemorosa</i> (Eckl. & Zeyh.) Endl. ex Walp.	Not endemic to SA		
<i>Crassula nudicaulis</i> L. cf. var. <i>platyphylla</i> (Harv.) Toelken	Endemic to SA		
<i>Crassula orbicularis</i> L.	Endemic to SA	Klipblom	
<i>Crassula perforata</i> Thunb. subsp. <i>perforata</i>	Endemic to SA	Concertina Plant / Konsertinabossie / Sosaties / Sosatiesbossie	
<i>Crassula pubescens</i> Thunb. subsp. <i>pubescens</i>	Endemic to SA		
<i>Crassula rogersii</i> Schönland	Endemic to SA		
<i>Crassula rupestris</i> Thunb. subsp. <i>rupestris</i>	Not endemic to SA	Concertina plant / Sosaties	
<i>Crassula saxifraga</i> Harv.	Endemic to SA		

<i>Crassula strigosa</i> L.	Endemic to SA		
<i>Crassula subaphylla</i> (Eckl. & Zeyh.) Harv.	Not endemic to SA		
<i>Crassula subulata</i> L. var. <i>subulata</i>	Endemic to SA		
<i>Crassula tetragona</i> L. subsp. <i>tetragona</i> <i>Crassula tetragona</i> L. subsp. <i>acutifolia</i> (Lam.) Toelken	Endemic to SA	Karkai	
<i>Crassula thunbergiana</i> Schult.	Not endemic to SA		
<i>Crassula tomentosa</i> Thunb.	Not endemic to SA		
<i>Crassula umbella</i> Jacq.	Endemic to SA		
<i>Crassula</i> sp. nov	Endemic to the CCR		
<i>Tylecodon paniculatus</i> (L.f.) Toelken	Not endemic to SA	Botterboom	
<i>Tylecodon ventricosus</i> (Burm.f.) Toelken	Endemic to SA	Klipnenta	poisonous
CUCURBITACEAE			
<i>Kedrostis capensis</i> (Sond.) A.Meeuse	Not endemic to SA	Bobbejaankomkommer	
DIPSACACEAE			
<i>Scabiosa columbaria</i> L.	Not endemic to SA	Jongmansknoop	medicinal
DROSERACEAE			
<i>Drosera cistiflora</i> L.	Endemic to the GCE	Snotrosie / Sonnedou / Vliegvangertjie	
EBENACEAE			
<i>Diospyros austro-africana</i> De Winter	Endemic to SA	Fire-sticks / Kritikom / Kraibessie	
<i>Diospyros glabra</i> (L.) De Winter	Endemic to the CCR	Bloubesiebos / Kraibossie / Star-apple / Vliebessiebos	
<i>Euclea tomentosa</i> E.Mey. ex A.DC.	Endemic to the GCE	Klipkers / Heuninggwarrie	
<i>Euclea undulata</i> Thunb.	Endemic to SA	Gewone Ghwarrie	medicinal
ERICACEAE			
<i>Erica anguliger</i> (N.E.Br.) E.G.H.Oliv.	Endemic to the CCR		
<i>Erica boucheri</i> E.G.H.Oliv.	Endemic to the CCR		
<i>Erica calycina</i> L.	Endemic to the CCR	Heide	
<i>Erica coarctata</i> J.C.Wendl.	Endemic to the CCR		
<i>Erica coccinea</i> L. subsp. <i>coccinea</i>	Endemic to the CCR		
<i>Erica eriocephala</i> Lam.	Endemic to the CCR		
<i>Erica inaequalis</i> (N.E.Br.) E.G.H.Oliv.	Endemic to the CCR	Heide	

<i>Erica mammosa</i> L.	Endemic to the CCR	Ninepin Heath / Rooiklossieheide	
<i>Erica pilosiflora</i> E.G.H.Oliv. subsp. <i>purpurea</i> E.G.H.Oliv.	Endemic to the CCR		
<i>Erica pinea</i> Thunb.	Endemic to the CCR		
<i>Erica plukenetii</i> L.	Endemic to the GCE	Hangertjies	
<i>Erica plumosa</i> Thunb.	Endemic to the CCR	Wolheide	
<i>Erica quadrangularis</i> Salisb.	Endemic to the CCR	Baby-heath	
<i>Erica rigidula</i> (N.E.Br.) E.G.H.Oliv.	Endemic to the GCE		
<i>Erica serrata</i> Thunb.	Endemic to the CCR		
<i>Erica setacea</i> Andrews	Endemic to the CCR		
<i>Erica totta</i> Thunb.	Endemic to the CCR	Heide	
EUPHORBIACEAE			
<i>Adenocline</i> sp. A le Roux & E van Jaarsveld No. 1411	Endemic to SA		
<i>Clutia alaternoides</i> L. var. <i>alaternoides</i>	Endemic to SA	Bliksembos	
<i>Clutia polifolia</i> Jacq.	Endemic to SA		
<i>Clutia pubescens</i> Thunb.	Endemic to the CCR		
<i>Euphorbia burmannii</i> (Klotzsch & Garcke) E.Mey. ex Boiss	Not endemic to SA	Steenbokmelkbos / Soetmelkbos	useful as fodder
<i>Euphorbia hamata</i> (Haw.) Sweet	Endemic to the GCE	Olifantsmelkbos	useful as fodder
<i>Euphorbia mauritanica</i> L.	Not endemic to SA	Beesmelkbos / Geelmelkbos	useful as fodder & possibly poisonous
<i>Euphorbia nesemannii</i> R.A.Dyer	Endemic to the CCR		
<i>Euphorbia rhombifolia</i> Boiss.	Not endemic to SA	Steenbokmelkbos / Soetmelkbos / Springbok melkbos	possibly poisonous
<i>Euphorbia silenifolia</i> (Haw.) Sweet	Endemic to SA		
<i>Euphorbia tuberosa</i> L.	Endemic to the GCE	Melkbol / Wilderamnas	possibly poisonous
FABACEAE			
* <i>Acacia cyclops</i> A.Cunn. ex G.Don	Not endemic to SA	Rooigras	
* <i>Acacia mearnsii</i> De Wild.	Not endemic to SA	Black Wattle	
* <i>Acacia saligna</i> (Labill.) H.L.Wendl.	Not endemic to SA	Port Jackson	
<i>Amphithalea ornata</i> Boatwr. & J.C.Manning	Endemic to the CCR		
<i>Argyrolobium argenteum</i> Eckl. & Zeyh.	Endemic to SA		
<i>Aspalathus acanthoclada</i> R.Dahlgren	Endemic to the CCR	Cape Gorse	
<i>Aspalathus acuminata</i> Lam. subsp. <i>acuminata</i>	Endemic to the GCE		
<i>Aspalathus alpestris</i> (Benth.) R.Dahlgren	Endemic to the CCR		
<i>Aspalathus aurantiaca</i> R.Dahlgren	Endemic to the CCR		

<i>Aspalathus cephalotes</i> Thunb. subsp. <i>cephalotes</i> <i>Aspalathus cephalotes</i> Thunb. subsp. <i>violaceae</i> R.Dahlgren	Endemic to the CCR		
<i>Aspalathus ciliaris</i> L.	Endemic to the CCR		
<i>Aspalathus flexuosa</i> Thunb.	Endemic to the CCR		medicinal
<i>Aspalathus heterophylla</i> L.f.	Endemic to the CCR		
<i>Aspalathus hirta</i> E.Mey. subsp. <i>hirta</i>	Endemic to the CCR		
<i>Aspalathus hispida</i> Thunb. subsp. <i>hispida</i>	Endemic to SA		
<i>Aspalathus lactea</i> Thunb. subsp. <i>breviloba</i> R.Dahlgren	Endemic to the CCR		
<i>Aspalathus linearis</i> (Burm.f.) R.Dahlgren	Endemic to the CCR	Rooibostee / Bush tea	medicinal, tea
<i>Aspalathus muraltioides</i> Eckl. & Zeyh.	Endemic to the CCR		
<i>Aspalathus nigra</i> L.	Endemic to the CCR		
<i>Aspalathus pachyloba</i> Benth.	Endemic to the CCR		
<i>Aspalathus petersonii</i> R.Dahlgren	Endemic to the CCR		
<i>Aspalathus pinguis</i> Thunb. subsp. <i>pinguis</i>	Endemic to the CCR		
<i>Aspalathus quinquefolia</i> L. subsp. <i>virgata</i> (Thunb.) R.Dahlgren	Endemic to the CCR		
<i>Aspalathus recurva</i> Benth.	Endemic to the CCR		
<i>Aspalathus rubiginosa</i> R.Dahlgren	Endemic to the CCR		
<i>Aspalathus rugosa</i> Thunb.	Endemic to the CCR		
<i>Aspalathus spicata</i> Thunb.	Endemic to the CCR		
<i>Aspalathus spinescence</i> Thunb. subsp. <i>lepida</i> (E.Mey.) R.Dahlgren	Endemic to the GCE		
<i>Aspalathus spinosa</i> L. subsp. <i>flavispinga</i> (C.Presl ex Benth.) R.Dahlgren	Endemic to the CCR		
<i>Aspalathus submissa</i> R.Dahlgren	Endemic to the CCR		
<i>Aspalathus tridentata</i> L. subsp. <i>tridentata</i>	Endemic to the CCR		
<i>Aspalathus tuberculata</i> Walp.	Endemic to the CCR		
<i>Aspalathus wurmbeana</i> E.Mey.	Endemic to the CCR		
<i>Aspalathus</i> sp. nov 1 AleRoux & Hconradie 1297	Endemic to the CCR		
<i>Aspalathus</i> sp. nov 2 AleRoux 1346	Endemic to the CCR		
<i>Calobota cytisoides</i> (Berg.) Eckl. & Zeyh.	Endemic to the CCR		
<i>Crotalaria excisa</i> (Thunb.) Baker f.	Endemic to the GCE	Geelkeurtjie	
<i>Euchlora hirsuta</i> (Thunb.) Druce	Endemic to the GCE		
<i>Indigofera</i> sp. nov. cf. <i>angustifolia</i> (Prof. C. Stirton)	Endemic to the CCR	Indigo	
<i>Indigofera heterophylla</i> Thunb.	Endemic to SA		medicinal
<i>Indigofera incana</i> Thunb.	Endemic to the CCR		

<i>Indigofera meyeriana</i> Eckl. & Zeyh.	Endemic to SA		
<i>Indigofera procumbens</i> L.	Endemic to the CCR		
<i>Lebeckia contaminata</i> (L.) Thunb.	Endemic to the CCR		
<i>Lebeckia sepiaria</i> (L.) Thunb.	Endemic to the CCR		
<i>Lessertia frutescens</i> (L.) Goldblatt & J.C.Manning subsp. <i>frutescens</i>	Endemic to SA	Kankerbos / Belletjie / Gansies / Eendjies	medicinal
<i>Lessertia herbacea</i> (L.) Druce	Endemic to SA	Baloon Pea / Blaasertjie	
<i>Lotononis densa</i> (Thunb.) Harv. subsp. <i>gracilis</i> (E.Mey.) B.-E.van Wyk	Endemic to the GCE		
<i>Lotononis involucrata</i> (P.J.Bergius) Benth. subsp. <i>involucrata</i>	Endemic to the CCR		poisonous
<i>Lotononis leptoloba</i> Bolus	Endemic to the GCE		
<i>Lotononis rigida</i> (E.Mey.) Benth.	Endemic to the CCR		
<i>Melolobium exudans</i> Harv.	Endemic to the CCR		
<i>Otholobium candicans</i> (Eckl. & Zeyh.) C.H.Stirt.	Endemic to SA		poisonous
<i>Otholobium striatum</i> (Thunb.) C.H.Stirt.	Endemic to the CCR		
<i>Rafnia acuminata</i> (E.Mey.) G.J.Campbell & B.-E.van Wyk	Endemic to the CCR	Widow Pea	edible roots (substitute for liquorice)
<i>Rafnia angulata</i> Thunb. subsp. <i>montana</i> G.J.Campbell & B.-E.van Wyk	Endemic to the CCR		edible (tannin-rich tea)
* <i>Trifolium angustifolium</i> L.	Not endemic to SA	Narrow-leaved clover	
<i>Vachellia karroo</i> (Hayne) Banfi & Gallaso	Not endemic to SA	Soetdoring / Karoodoring	medicinal & various other household uses, seeds roasted as coffee substitute, firewood
<i>Wiborgia mucronata</i> (L.f.) Druce	Endemic to the GCE	Silver Wing-pea / Silwer Vlerk-ertjie	
<i>Wiborgia obcordata</i> (P.J.Bergius) Thunb.	Endemic to the GCE		
<i>Wiborgia sericea</i> Thunb.	Endemic to the GCE	Silky Wing-pea / Sy Vlerk-ertjie	
<i>Wiborgia tenuifolia</i> E.Mey.	Endemic to the CCR		
FRANKENIACEAE			
<i>Frankenia pulverulenta</i> L.	Endemic to SA		
FUMARIACEAE			
<i>Cysticapnos cracca</i> (Cham. & Schldl.) Lidén	Endemic to the GCE		
<i>Cysticapnos vesicaria</i> (L.) Fedde subsp. <i>vesicaria</i>	Endemic to the GCE	Klappertjies	

<i>*Fumaria muralis</i> Sond. Ex W.D.J.Koch	Not endemic to SA	Duiwelskerwel	
GENTIANACEAE			
<i>Chironia baccifera</i> L.	Endemic to SA	Christmas Berry / Aambeibossie	medicinal
<i>Chironia linoides</i> L. subsp. <i>linoides</i>	Endemic to the GCE	Bitterwortel / Centaury	
<i>Sebaea aurea</i> (L.f.) Roem. & Schult.	Endemic to the CCR	Yellowwort / Naeltjieblom	
<i>Sebaea exacoides</i> (L.) Schinz	Endemic to the CCR	Naeltjiesblom / Naeltjiesbossie	
GERANIACEAE			
<i>*Erodium moschatum</i> (L.) L'Hér.	Not native to Southern Africa	Musk stork's-bill	medicinal & suspected to be poisonous to stock
<i>Pelargonium abrotanifolium</i> (L.f.) Jacq.	Endemic to SA		
<i>Pelargonium alchemilloides</i> (L.) L'Hér.	Endemic to SA	Wildemalva	medicinal
<i>Pelargonium alternans</i> J.C.Wendl.	Endemic to the CCR	Blomkoolmalva	
<i>Pelargonium articulatum</i> (Cav.) Willd.	Endemic to the GCE		
<i>Pelargonium carneum</i> Jacq.	Endemic to the CCR		
<i>Pelargonium carnosum</i> (L.) L'Hér.	Endemic to the GCE		fleshy twigs edible
<i>Pelargonium chamaedryfolium</i> Jacq.	Endemic to the CCR		aromatic
<i>Pelargonium conradiae</i> J.C. Manning & A.le Roux	Endemic to the CCR		
<i>Pelargonium crispum</i> (P.J.Bergius) L'Hér.	Endemic to the CCR	Lemon-scented pelargonium	aromatic
<i>Pelargonium fergusoniae</i> L.Bolus	Endemic to the CCR		
<i>Pelargonium flabelliforme</i> E.M.Marais	Endemic to the CCR		
<i>Pelargonium karooicum</i> Compton & P.E.Barnes	Endemic to the GCE		
<i>Pelargonium lobatum</i> (Burm.f.) L'Hér.	Endemic to the CCR	Kaneelbol	
<i>Pelargonium longifolium</i> (Burm.f.) Jacq.	Endemic to the CCR		
<i>Pelargonium luteolum</i> N.E.Br.	Endemic to the GCE		
<i>Pelargonium magenteum</i> J.J.A.van der Walt	Endemic to the GCE	Rabas	
<i>Pelargonium multicaule</i> Jacq. subsp. <i>multicaule</i>	Endemic to SA		
<i>Pelargonium myrrhifolium</i> (L.) L'Hér. var. <i>myrrhifolium</i>	Endemic to the GCE	Wildemalva	
<i>Pelargonium ovale</i> (Burm.f.) L'Hér.	Endemic to the CCR		
<i>Pelargonium pillansii</i> Salter	Endemic to the CCR		
<i>Pelargonium plurisectum</i> Salter	Endemic to the CCR		
<i>Pelargonium proliferum</i> (Burm.f.) Steud.	Endemic to the CCR		
<i>Pelargonium radiatum</i> (Andrews) Pers.	Endemic to the CCR		
<i>Pelargonium radulifolium</i> (Eckl. & Zeyh.) Steud.	Endemic to the GCE		

<i>Pelargonium rapaceum</i> (L.) L'Hér.	Endemic to SA	Norra / Oertjie / Bergpatat	tuberous roots edible
<i>Pelargonium senecioides</i> L'Hér.	Endemic to the GCE		
<i>Pelargonium setulosum</i> Turcz.	Endemic to the CCR		
<i>Pelargonium ternatum</i> (L.f.) Jacq.	Endemic to the CCR		
<i>Pelargonium tetragonum</i> (L.f.) L'Hér.	Endemic to SA		
<i>Pelargonium trifidum</i> Jacq.	Endemic to SA		aromatic
<i>Pelargonium trifoliolatum</i> (Eckl. & Zeyh.) E.M.Marais	Endemic to the CCR		
<i>Pelargonium triste</i> (L.) L'Hér.	Endemic to the GCE	Kaneeltjie	medicinal & tuberous roots edible, tannins
<i>Pelargonium undulatum</i> (Andrews) Pers.	Endemic to the CCR		
<i>Pelargonium xanthopetalum</i> E.M.Marais	Endemic to the CCR		
<i>Pelargonium sp. nov. E M Marais & A le Roux 1408</i>			
LAMIACEAE			
<i>Ballota africana</i> (L.) Benth.	Not endemic to SA	Kattekruide / Catmint	medicinal
<i>Salvia africana-caerulea</i> L.	Endemic to the GCE	Bloublommetjie Salie	medicinal
<i>Salvia chamelaeagnea</i> P.J.Bergius	Endemic to the CCR	Bloublommetjie Salie	medicinal
LIMEACEAE			
<i>Limeum aethiopicum</i> Burm.f.	Not endemic to SA	Aarbossie	possibly poisonous
<i>Limeum africanum</i> L.	Endemic to the GCE	Koggelmandervoet	
LINACEAE			
<i>Linum africanum</i> L.	Endemic to the CCR	African Flax	medicinal
LOBELIACEAE			
<i>Cyphia bulbosa</i> (L.) P.J.Bergius	Endemic to the CCR	Bergbaroe	
<i>Cyphia campestris</i> C.Presl var. <i>campestris</i>	Endemic to the CCR		
<i>Cyphia digitata</i> (Thunb.) Willd. subsp. <i>digitata</i>	Endemic to the GCE	Baroe / Barup / Vlaktebaroe	
<i>Cyphia incisa</i> (Thunb.) Willd. var. <i>incisa</i> C. <i>incisa</i> (Thunb.) Willd. var. <i>cardamines</i> (Thunb.) E.Phillips	Endemic to the CCR	Baroe	
<i>Cyphia linarioides</i> C.Presl ex Eckl. & Zeyh.	Endemic to SA	Kameka / Veldbaroe	
<i>Cyphia phyteuma</i> (L.) Willd.	Endemic to the CCR		
<i>Cyphia volubilis</i> (Burm.f.) Willd. var. <i>volubilis</i>	Endemic to the CCR	Aardboontjie / Bergbaroe	medicinal & edible tuber
<i>Grammatotheca bergiana</i> (Cham.) C.Presl	Endemic to SA		

<i>Lobelia capillifolia</i> (C.Presl) A.DC.	Endemic to the CCR		
MALVACEAE			
<i>Anisodonteia elegans</i> (Cav.) Bates	Endemic to the CCR	African Mallow / Berggroos	
<i>Anisodonteia fruticosa</i> (P.J.Bergius) Bates	Endemic to the CCR		
<i>Hermannia alnifolia</i> L.	Endemic to the CCR	Doll's Rose / Poprosie	
<i>Hermannia althaeifolia</i> L.	Endemic to the GCE	Bokkiesblom / Klokkiesbos / Lanternbos	
<i>Hermannia confusa</i> T.M.Salter	Endemic to the CCR		
<i>Hermannia cuneifolia</i> Jacq. var. <i>cuneifolia</i>	Endemic to SA	Broodbos / Pleisterbos	
<i>Hermannia lavandulifolia</i> L.	Endemic to the CCR		
<i>Hermannia pinnata</i> L.	Endemic to the CCR		
<i>Hermannia pulchella</i> L.f.	Not endemic to SA	Bergpleisterbos	
<i>Hermannia trifurca</i> L.	Endemic to the GCE	Broodbos	
MENISPERMACEAE			
<i>Cissampelos capensis</i> L.f.	Endemic to the GCE	Cissampelos / Davidjieswortel	medicinal
MOLLUGINACEAE			
<i>Adenogramma glomerata</i> (L.f.) Druce	Endemic to the GCE	Muggiegras	
<i>Pharnaceum aurantium</i> (DC.) Druce	Not endemic to SA	Sneeuvygie	
<i>Polpoda capensis</i> C.Presl	Endemic to the GCE		
<i>Psammotropha quadrangularis</i> (L.f.) Fenzl	Endemic to the GCE		
<i>Psammotropha</i> sp. nov. A le Roux No. 444	Endemic to the CCR		
MONTINIACEAE			
<i>Montinia caryophyllacea</i> Thunb.	Not endemic to SA	Peperbos / Bergklapper	root possibly poisonous
MYRICACEAE			
<i>Morella quercifolia</i> (L.) Killick	Endemic to SA	Maagpynbossie	
<i>Morella serrata</i> (Lam.) Killick	Not endemic to SA	Waterolier / Berg-wasbessie / Lance-leaved Waxberry	
NEURADACEAE			
<i>Grielum humifusum</i> Thunb. var. <i>humifusum</i>	Not endemic to SA	Pietsnot / Duikerwortel	root edible

OLEACEAE			
<i>Olea europaea</i> L. subsp. <i>africana</i> (Mill.) P.S.Green	Not endemic to SA	Wild Olive / Olienhout / Ysterhout	medicinal & edible oil, timber (small)
OROBANCHACEAE			
<i>Hyobanche sanguinea</i> L.	Not endemic to SA	Inkblom / Katnaels	
OXALIDACEAE			
<i>Oxalis</i> sp 1 cf. <i>annae</i> F.Bolus	Endemic to the GCE		
<i>Oxalis ciliaris</i> Jacq. var. <i>ciliaris</i>	Endemic to SA		edible root/corm
<i>Oxalis</i> sp 2 cf. <i>commutata</i> Sond.	Endemic to the CCR	Suring	
<i>Oxalis convexula</i> Jacq.	Endemic to the CCR		
<i>Oxalis depressa</i> Eckl. & Zeyh.	Not endemic to SA		
<i>Oxalis engleriana</i> Schltr.	Endemic to the CCR		edible root/corm
<i>Oxalis fergusonae</i> T.M.Salter	Endemic to the GCE	Tapytsuring	
<i>Oxalis flava</i> L.	Endemic to the GCE	Bobbejaansuring / Vingersuring	
<i>Oxalis glabra</i> Thunb.	Endemic to the CCR	Tapytsuring	
<i>Oxalis hirta</i> L.	Endemic to the GCE		
<i>Oxalis imbricata</i> Eckl. & Zeyh.	Endemic to SA		
<i>Oxalis livida</i> Jacq.	Endemic to the CCR	Steentjiesuring	
<i>Oxalis luteola</i> Jacq.	Endemic to the GCE	Geeloogsuring	
<i>Oxalis microdonta</i> T.M.Salter	Endemic to the CCR		
<i>Oxalis obtusa</i> Jacq.	Endemic to the GCE	Kalwersuring / Klawersuring / Langbeensuring	medicinal & edible
<i>Oxalis pardalis</i> Sond. <i>O. cf. camelopardalis</i> T.M.Salter <i>O. cf. confertifolia</i> (Kuntze) R.Knuth <i>O. cf. leptogramma</i> T.M.Salter	Endemic to the GCE		
<i>Oxalis pes-caprae</i> L.	Endemic to SA		
<i>Oxalis pocockiae</i> L.Bolus	Endemic to the GCE		
<i>Oxalis polyphylla</i> Jacq.	Endemic to the CCR	Vingersuring	
<i>Oxalis</i> sp 3 cf. <i>pseudo-hirta</i> T.M.Salter	Endemic to the CCR		
<i>Oxalis pulchella</i> Jacq. var. <i>tomentosa</i> Sond.	Endemic to the GCE		
<i>Oxalis punctata</i> L.f.	Endemic to SA		
<i>Oxalis purpurea</i> L.	Endemic to the GCE		
<i>Oxalis</i> sp 4 cf. <i>truncatula</i> Jacq.	Endemic to the CCR		
PLANTAGINACEAE			

<i>*Plantago coronopus</i> L.	Not endemic to SA European weed	Buck's-horn Plantain	
<i>*Plantago lanceolata</i> L.	Not endemic to SA European weed	Ribwort Plantain	medicinal & fodder
PLUMBAGINACEAE			
<i>Limonium amoenum</i> (C.H.Wright) R.A.Dyer	Endemic to the GCE	Sea-pink / Papierblom	
<i>Limonium equisetinum</i> (Boiss.) R.A.Dyer	Endemic to the GCE		
POLYGALACEAE			
<i>Muraltia alopecuroides</i> (L.) DC.	Endemic to SA	Kleinboeldok	
<i>Muraltia divaricata</i> Eckl. & Zeyh.	Endemic to the CCR		
<i>Muraltia</i> cf. <i>ferox</i> Levyns	Endemic to the CCR		
<i>Muraltia heisteria</i> (L.) DC.	Endemic to the CCR	Boeldokdoring / Kastybos / Voëltjie-kan-nie-sit-nie	medicinal
<i>Muraltia macrocarpa</i> Eckl. & Zeyh.	Endemic to SA		
<i>Muraltia ononidifolia</i> Eckl. & Zeyh.	Endemic to the CCR		
<i>Muraltia rhamnoides</i> Chodat	Endemic to the CCR		
<i>Muraltia scoparia</i> (Eckl. & Zeyh.) Levyns	Endemic to the CCR	Duinebessie	
<i>Muraltia spinosa</i> (L.) F.Forest & J.C.Manning	Endemic to SA	Skilpadbessie	medicinal & fruit edible
<i>Muraltia trinervia</i> (L.f.) DC.	Endemic to the CCR		
<i>Polygala fruticosa</i> P.J.Bergius	Endemic to SA	Featherdusters / Heart-leaved Polygala	
<i>Polygala microlopha</i> DC. var. <i>microlopha</i>	Endemic to SA		
<i>Polygala scabra</i> L.	Endemic to SA		
<i>Polygala umbellata</i> L.	Endemic to the CCR		
POLYGONACEAE			
<i>Rumex cordatus</i> Poir.	Endemic to SA	Tongblaar / Maksuring / Rooisuring	tanning
<i>Rumex lativalvis</i> Meisn.	Endemic to the CCR	Veldsuring	
<i>Rumex sagittatus</i> Thunb.	Endemic to SA	Ranksuring / Climbing Sorrel	
PRIMULACEAE			
<i>*Anagallis arvensis</i> L.	Not endemic to SA Cosmopolitan weed	Scarlet Pimpernel / Blouselblommetjie	poisonous
<i>Anagallis</i> cf. <i>huttonii</i> Harv.	Endemic to SA	White pimpernel	

PROTEACEAE			
<i>Leucadendron brunioides</i> Meisn. var. <i>brunioides</i>	Endemic to the GCE	Foetid Conebush	
<i>Leucadendron chamelaea</i> (Lam.) I.Williams	Endemic to the CCR	Witsenberg Conebush (
<i>Leucadendron eucalyptifolium</i> H.Buek ex Meisn.	Endemic to SA	Geelbos / Groot-geelbos	
<i>Leucadendron rubrum</i> Burm.f.	Endemic to the CCR	Dikkopeierbos / Spinning Top / Tolletjiesbos	
<i>Leucadendron salignum</i> P.J.Bergius	Endemic to SA	Stompieknopbos	
<i>Leucadendron teretifolium</i> (Andrews) I.Williams	Endemic to the CCR	Needle-leaf Conebush	
<i>Leucadendron tinctum</i> I.Williams	Endemic to the CCR	Spicy Conebush	
<i>Leucospermum calligerum</i> (Salisb. ex Knight) Rourke	Endemic to the CCR	Arid Pincushion / Luisies / Rooiluisie / Speldekussing	
<i>Leucospermum hypophyllocarpodendron</i> (L.) Druce subsp. <i>canaliculatum</i> (H.Buek ex Meisn.) Rourke	Endemic to the CCR	Grey-snakeskin Pincushion	
<i>Leucospermum rodolentum</i> (Salisb. ex Knight) Rourke	Endemic to the GCE	Beesbos / Klipboom / Sandveld Pincushion / Sandveldluisiesbos	
<i>Leucospermum utriculosum</i> Rourke	Endemic to the CCR	Brede River Pincushion	
<i>Paranomus dispersus</i> Levyns	Endemic to the CCR	Long-head Sceptre	
<i>Protea humiflora</i> Andrews	Endemic to the CCR	Patent-leaf Sugarbush	
<i>Protea laurifolia</i> Thunb.	Endemic to the CCR	Grey-leaf Sugarbush / Laurel Sugarbush / Louriersuikerbos	
<i>Protea lorifolia</i> (Salisb. ex Knight) Fourc.	Endemic to SA	Riemblaar-suikerbos / Strap-leaved Sugarbush	
<i>Protea nitida</i> Mill.	Endemic to the CCR	Waboom	tannins, timber
<i>Protea repens</i> (L.) L.	Endemic to SA	Sugarbush / Suikerbos	medicinal & nectar (<i>bossiestroop</i>)
<i>Protea restionifolia</i> (Salisb. ex Knight) Rycroft	Endemic to the CCR		
<i>Protea restionifolia</i> x <i>Protea laurifolia</i>	Endemic to the CCR		
<i>Serruria acrocarpa</i> R.Br.	Endemic to the CCR	Common Rootstock Spiderhead / Spinnepkopbossie	
<i>Serruria fasciflora</i> Salisb. ex Knight	Endemic to the CCR	Common Pin Spiderhead	
RHAMNACEAE			
<i>Phylica constricta</i> Pillans var. <i>constricta</i> <i>P. constricta</i> Pillans var. <i>staavioides</i> Pillans	Endemic to the CCR		
<i>Phylica excelsa</i> J.C.Wendl. var. <i>excelsa</i>	Endemic to the CCR		
<i>Phylica parviflora</i> P.J.Bergius	Endemic to the CCR		
<i>Phylica rogersii</i> Pillans	Endemic to the CCR		
<i>Trichocephalus stipularis</i> (L.) Brongn.	Endemic to the GCE	Hondegesig / Dogface	
ROSACEAE			

<i>Cliffortia amplexistipula</i> Schltr.	Endemic to the CCR		
<i>Cliffortia crenata</i> L.f.	Endemic to the CCR		
<i>Cliffortia polygonifolia</i> L.	Endemic to the CCR	Paddabos	
<i>Cliffortia ruscifolia</i> L.	Endemic to SA	Steekbos	
<i>Cliffortia sericea</i> Eckl. & Zeyh.	Endemic to the CCR		
<i>Cliffortia varians</i> Weim.	Endemic to the CCR		
RUBIACEAE			
<i>Anthospermum galioides</i> Rchb.f.	Endemic to SA		
<i>Anthospermum spathulatum</i> Spreng.	Endemic to SA	Jakkalsstert	
<i>Galium capense</i> Thunb. subsp. <i>capense</i>	Endemic to SA	Tiny tots	
<i>Galium tomentosum</i> Thunb.	Not endemic to SA	Kleefgras	
<i>Nenax acerosa</i> Gaertn.	Endemic to the CCR		
<i>Nenax hirta</i> (Cruse) T.M.Salter subsp. <i>hirta</i>	Endemic to the CCR		
RUTACEAE			
<i>Agathosma</i> cf. <i>acocksii</i> Pillans	Endemic to the CCR		aromatic
<i>Agathosma capensis</i> (L.) Dummer	Endemic to the GCE	Boegoe / Anysboegoe	aromatic
<i>Agathosma cerefolium</i> (Vent.) Bartl. & H.L.Wendl.	Endemic to the CCR	Anysboegoe / Strandboegoe / Steenbokboegoe	medicinal & aromatic
<i>Agathosma leptospermoides</i> Sond.	Endemic to the CCR		aromatic
<i>Agathosma ovata</i> (Thunb.) Pillans	Not endemic to SA	Basterboegoe / Rivierboegoe	aromatic
<i>Agathosma parva</i> (manuscript name for sp. 20 in Goldblatt & Manning) A le Roux No 1165	Endemic to the CCR	Klipspringerboegoe	aromatic
<i>Agathosma virgata</i> (Lam.) Bartl. & H.L.Wendl.	Endemic to the CCR	Skaapboegoe	aromatic
<i>Agathosma</i> sp. nov. 1 A le Roux 1153 & 1397	Endemic to the CCR		aromatic
<i>Agathosma</i> sp. nov. 2 A le Roux 1268	Endemic to the CCR		aromatic
<i>Coleonema</i> sp. nov. cf. <i>album</i> (Thunb.) Bartl. & H.L.Wendl.	Endemic to the CCR	Cape May / Wit-confettibos	medicinal & aromatic
<i>Coleonema juniperinum</i> Sond.	Endemic to the CCR		aromatic
<i>Diosma acmaeophylla</i> Eckl. & Zeyh.	Endemic to the GCE	Ribbokboegoe	aromatic
<i>Diosma ramosissima</i> Bartl. & H.L.Wendl.	Endemic to the GCE		aromatic
<i>Euchaetis pungens</i> (Bartl. & H.L.Wendl.) I. Williams	Endemic to the GCE		aromatic
<i>Macrostylis tenuis</i> E.Mey. ex Sond.	Endemic to the CCR		aromatic
SANTALACEAE			
<i>Colpoon compressum</i> P.J.Bergius	Not endemic to SA	Bloupruimbos / Cape Sumach / Cape Tannin Bush	medicinal, tannins

<i>Thesium dissitiflorum</i> Schltr.	Endemic to the CCR		
<i>Thesium imbricatum</i> Thunb.	Not endemic to SA		
<i>Thesium strictum</i> P.J.Bergius	Endemic to SA	Teringbos	medicinal
<i>Thesium subnudum</i> Sond.	Endemic to the CCR		
<i>Viscum capense</i> L.f.	Endemic to the GCE	Cape mistletoe / lidjiestee / voëlent	medicinal
<i>Viscum rotundifolium</i> L.f.	Endemic to SA	Rooi Voëlent	medicinal
SAPINDACEAE			
<i>Dodonaea viscosa</i> Jacq. var. <i>angustifolia</i> (L.f.) Benth.	Not endemic to SA	Ysterhout / Sandolien	medicinal
SCROPHULARIACEAE			
<i>Buddleja saligna</i> Willd.	Not endemic to SA	Witoliën hout / Basteroliën hout	medicinal
<i>Chaenostoma caeruleum</i> (L.f.) Kornhall	Endemic to the GCE	Skunk bush / Stinkbossie	
<i>Chaenostoma decipiens</i> (Hilliard) Kornhall	Endemic to the CCR		
<i>Chaenostoma glabratum</i> Benth.	Endemic to the CCR		
<i>Chaenostoma uncinatum</i> (Desr.) Kornhall	Endemic to the CCR		
<i>Chenopodiopsis hirta</i> (L.f.) Hilliard	Endemic to the CCR		
<i>Diascia capensis</i> (L.) Britten	Endemic to the CCR	Twinspurs / Horinkies	
<i>Diascia parviflora</i> Benth.	Endemic to the GCE		
<i>Dischisma capitatum</i> (Thunb.) Choisy	Endemic to the CCR	False Slugwort / Basterslakblom	
<i>Hebenstretia dentata</i> L.	Endemic to the GCE	Slugwort / Slakblom / Vlagblom	
<i>Hebenstretia ramosissima</i> Jaroszcz	Endemic to the CCR		
<i>Hemimeris racemosa</i> (Houtt.) Merr.	Endemic to the GCE	Yellow-Faces / Geelgesiggies / Bobbejaangesiggies	
<i>Lyperia antirrhinoides</i> (L.f.) Hilliard	Endemic to the GCE	Widow's-Phlox / Traanblommetjie	
<i>Lyperia tristis</i> (L.f.) Benth.	Not endemic to SA	Aandblom	
<i>Manulea cheiranthus</i> (L.) L.	Endemic to the CCR	Finger-Phlox / Vingertjies	
<i>Manulea leiostachys</i> Benth.	Endemic to the CCR		
<i>Microdon dubius</i> (L.) Hilliard	Endemic to the GCE	Cat's Tail Bush / Katstertbos	
<i>Nemesia affinis</i> Benth	Not endemic to SA	Cape Snapdragon / Leeubekkies	
<i>Nemesia barbata</i> (Thunb.) Benth.	Endemic to the GCE	Bloubekkie / Bloukappertjie / Ferweeltjie / Fluweeltjie	
<i>Nemesia gracilis</i> Benth.	Endemic to the CCR		
<i>Nemesia pageae</i> L.Bolus	Endemic to the CCR		
<i>Oftia africana</i> (L.) Bocq.	Endemic to the CCR	Lazy Bush / Sukkelbossie / Koekblommetjiesbos	
<i>Phyllopodium capillare</i> (L.f.) Hilliard	Endemic to the CCR	Capewort / Opslag	

<i>Phyllopodium cordatum</i> (Thunb.) Hilliard	Endemic to the CCR		
<i>Phyllopodium heterophyllum</i> (L.f.) Benth.	Endemic to the GCE		
<i>Polycarena aurea</i> Benth.	Endemic to the GCE	Cape=Phlox	
<i>Polycarena pubescens</i> Benth.	Endemic to the GCE		
<i>Polycarena rariflora</i> Benth.	Endemic to the GCE		
<i>Pseudoselago densifolia</i> (Hochst.) Hilliard	Endemic to the CCR	Powderpuff	
<i>Selago aspera</i> Choisy	Endemic to the CCR	Bitter Bush / Aarbossie	
<i>Selago eckloniana</i> Choisy	Endemic to the GCE		
<i>Selago glabrata</i> Choisy	Endemic to the GCE		
<i>Selago levynsiae</i> Hilliard	Endemic to the CCR		
<i>Selago micradenia</i> Hilliard	Endemic to the CCR		
<i>Selago scabrata</i> Thunb.	Endemic to the CCR		
<i>Selago thomii</i> Rolfe	Endemic to the CCR		
<i>Selago triquetra</i> L.f.	Endemic to the CCR		
<i>Selago venosa</i> Hilliard	Endemic to the CCR		
<i>Sutera foetida</i> Roth	Endemic to the GCE	Skunk Bush / Stinkbossie	
<i>Zaluzianskya divaricata</i> (Thunb.) Walp.	Endemic to the CCR	Drumsticks / Verfbloemmetjie	
SOLANACEAE			
<i>Lycium oxycarpum</i> Dunal	Endemic to SA	Karoo Honey-thorn / Wolwedoring	
<i>Lycium ferocissimum</i> Miers	Endemic to SA	Slangbessie / Cape Box Thorn	poisonous, edible fruit
<i>Solanum tomentosum</i> L.	Endemic to SA	Slangappelbos	medicinal
THEOPHRASTACEAE			
<i>Samolus porosus</i> (L.f.) Thunb.	Endemic to SA	Water-pimpernel	
* <i>Samolus valerandi</i> L.	Not endemic to SA	Brook weed	medicinal
THYMELAEACEAE			
<i>Gnidia laxa</i> (L.f.) Gilg	Endemic to the CCR	Saffron Bush / Saffraan	
<i>Gnidia scabra</i> Thunb.	Endemic to the GCE		
<i>Lachnaea capitata</i> (L.)	Endemic to the CCR	Mountain-Carnation / Bergangelier / Letjiesbos / Stringbark	
<i>Lachnaea grandiflora</i> (L.f.) Baill.	Endemic to the CCR		
<i>Passerina corymbosa</i> Eckl. ex C.H.Wright	Endemic to SA	Bakkersbos / windmakerbos	used to heat up ovens

<i>Passerina truncata</i> (Meisn.) C.L.Bredenkamp & A.E.van Wyk subsp. <i>truncata</i>	Endemic to the GCE	Gonna Bush	
<i>Struthiola ciliata</i> (L.) Lam.	Endemic to the GCE	Featherhead / Katstertjie / Roemenaggie / Veertjie / Stroopbossie	
<i>Struthiola confusa</i> C.H.Wright	Endemic to the CCR		
VAHLIACEAE			
<i>Vahlia capensis</i> (L.f.) Thunb. subsp. <i>capensis</i>	Not endemic to SA	Toiingbossie	
ZYGOPHYLLACEAE			
<i>Zygophyllum foetidum</i> Schrad. & J.C.Wendl. (<i>Roepera foetida</i> Schrad. & J.C.Wendl. Beier & Thulin)	Not endemic to SA	Slymbos / Jakkalspisbos	poisonous under certain conditions
<i>Zygophyllum fulvum</i> L. (<i>Roepera fulva</i> (L.) Beier & Thulin)	Endemic to the CCR	Twinleaf / Spekbos	
<i>Zygophyllum lichtensteinianum</i> Cham. & Schltld. (<i>Roepera lichtensteiniana</i> (Cham. & Schltld.) Beier & Thulin)	Endemic to SA	Vaalspekbos	
<i>Zygophyllum pygmaeum</i> Eckl. & Zeyh. (<i>Roepera pygmaea</i> (Cham. & Schltld.) Beier & Thulin)	Endemic to SA		
<i>Zygophyllum sessilifolium</i> L. (<i>Roepera sessilifolia</i> (Cham. & Schltld.) Beier & Thulin)	Endemic to the CCR	Witspekbos	poisonous
<i>Tribulus terrestris</i> L.	Not endemic to SA	Volstruisdubbeltjie	may cause dikkop disease in sheep in suitable conditions



Mopkop Vygies

The thin end of the wedge

by Anso le Roux, Ernst van Jaarsveld and Matt Buys

The Succulent Karoo, a semi-arid, winter rainfall region of South Africa, is renowned for its rich succulent flora. A number of vygie species are known from here, many of which are confined to a single locality. What is more, some have not been seen again since their original discovery. Until recently, *Phyllobolus caudatus*, commonly branded as the Mopkop Vygie, was only known from its type locality near De Doorns, and is currently listed as a threatened plant on the Red Data List. It was collected by Neville Pillans, a botanist from the University of Cape Town, at the beginning of the previous century and was described by Louisa Bolus (from the same university) in 1916 as a *Mesembryanthemum*. It has now been placed by M. Gerbaulet in the genus *Phyllobolus*.

In 2002, the Custodians for Rare and Endangered Wildflowers (CREW) collected a plant near Nieuwoudtville in the Northern Cape, which was identified as a Mopkop Vygie.

TOP LEFT: The leaves of the Mopkop Vygie, *Phyllobolus caudatus*, give the plant the appearance of a mop.

TOP RIGHT: The small beetles on the flowers of the Mopkop Vygies probably play a role in its pollination.

BELOW: Mopkop Vygies, *Phyllobolus caudatus*, with their characteristic red stems. Photos: A. le Roux.



We reserve an opinion on this matter, because for one, Nieuwoudtville is about 200 km away from the previous known distribution for *Phyllobolus caudatus*, in a completely different ecozone. Secondly, Gerbaulet also speculated that *Phyllobolus caudatus* could be a giant form of *Phyllobolus grossus*, a species known to occur in the Nieuwoudtville area. A lack of fresh material prevented Gerbaulet from making an informed decision on the matter.

While no living material of a Mopkop Vygie from the type locality has yet been found, a small population was recently discovered in the hills between Brandvlei Dam and the Breede River near Rawsonville. The leaves were noticed first during June 2006 and a follow-up visit in September greeted visitors with a splendid display of conspicuous bright yellow flowers. Photos of the plants in flower were sent to Ernst van Jaarsveld at Kirstenbosch, who identified the plants as *Phyllobolus caudatus*. This was later confirmed by Cornelia Klak, a vygie specialist at the Bolus Herbarium, University of Cape Town.

The vegetation where these plants were found consists of Breede Shale Renosterveld, which differs from Nieuwoudtville Shale Renosterveld near Nieuwoudtville and Breede Alluvium Fynbos that occurs in the general vicinity of the type locality near De Doorns. The plants grow on the seasonally moist, southern slopes of hills in shallow, stony, red clay soil derived from the shale, sandstone and quartzite bands of the Witteberg series, the youngest deposits of the much folded mountains of the Cape Supergroup.

Mopkop Vygies have been described as geophytic – preferring rock. They are deciduous, losing their leaves during the long dry summers. The slightly glaucous

(pale grey-green) leaves which appear during autumn, are soft, cylindrical, linear and opposite. Flowers appear in spring and are up to 60 mm in diameter, possibly the largest to be found in the genus *Phyllobolus*. The flowers are always full of leaf beetles, which probably play a role in its pollination. The fruiting capsules develop during late spring and eventually detach themselves from the plant. It is only with the start of the rains that the seeds are released. Like most vygies their capsules are ‘hygrochastic’, meaning they take up moisture which causes the tissues within to swell, thereby opening the lids that cover the fruit to allow the seeds to be washed out by the falling rain.

Damming evidence

A characteristic of the Breede River Valley is its vast floodplains with thick layers of alluvium deposits. Seasonal flooding of rivers during the winter rainy season is a common occurrence, but the area also experiences occasional heavy rainstorms in summer, which can result in heavy flooding, as was experienced in November 2008. Seasonal floods and the presence of a perennial thermal spring to the west of the Brandvlei Dam on the farm Brandvlei* played a significant role in shaping and sustaining the area around the newly found locality of the Mopkop Vygie plants. This spring is thought to be the strongest and hottest in southern Africa and it is said that the name ‘Brandvlei’ originates from the steam rising from it and the surrounding streamlets. (The spring yields 126 l/sec at a consistent temperature of 64 °C.) The existence of a hot spring also attracted the attention of botanists and other naturalists, no doubt in search of a spot in

which to take a dip and freshen up after a hard day's work. As a result, at least four new species were described from 'Brandvlei'.

William Burchell, the well known explorer, describing his visit to the spring on 14 April 1810, wrote: 'At five o'clock we reached Brand (or Brandt) Valley, and took up our lodging at the farm-house of De Wet. I immediately went to examine the Hot Spring, which is at a very short distance from the house, and found it much larger, and more remarkable, than the spring at Zwartberg. It formed a shallow pond of about fifty feet across, of the most transparent water; in the middle of which several strong springs bubble up through a bottom of loose white sand, and afterwards, flowing in a very copious stream, become a rivulet, which for at least a mile and a half continues so hot along the valley may, at any time of day, but more particularly in the morning, be traced by the steam which perpetually rises from it. The pond is sheltered by a small clump of white poplars, which thrive perfectly well, although growing at the very edge of the water, and bedewed with the hot steam, which ascends to their highest branches. No plant, it seems, can grow in the water itself, but the margins of the bank are thickly covered with sedge. *Royena glabra*, a *Rhus* and a variety of other plants stood within the influence of its heat'.

According to Mr D.V. De Wet, a direct descendent of the first de Wet who received the deed of transfer of the farm Brandvlei in 1756, family folklore described the area of the spring as a marsh from where three rivulets flowed forming a braided wetland. To facilitate irrigation, a deep trench was dug through the marsh. Later the water was channelled in furrows to adjacent farms to be used for irrigation and drinking for livestock. This shrank the original size of the marsh to almost half a hectare, the dimensions it still has today.

Irrigation with normal river run-off was practiced in the Breede River Valley as early as the Eighteenth Century, but the quantity of run-off water alone became inadequate in the Twentieth Century as the demand for irrigation in the dry summer months increased. This led to the construction of a dam in 1922 known as Lake Marais (or Meer Marais), 5 km to the south of Worcester and, just as Brandvlei Dam is today, it was fed by two tributaries of the Breede River: the Smalblaar and Holsloot Rivers. It was enlarged in 1950 to just more than double the original amount of water stored, a capacity of 95.3 million m³. A further enlargement of the dam in 1972 resulted in the construction of the Greater Brandvlei Dam, a government water scheme. When completed in 1985 its capacity was increased to 289 million m³, covering an area of 2553.5 ha.



Missing, presumed drowned

But what has this got to do with Mopkop Vygies? The construction of Lake Marais and its subsequent enlargement as the Brandvlei Dam inundated more than the existing marsh and large tracts of Breede Sand Fynbos were lost. In addition, the rising waters inundated the renosterveld which now barely lines the dam to the east and probably destroyed the larger part of the local habitat of *Phyllobolus caudatus* there. *Lampranthus vanzyliae*, believed to have grown in the same area, was collected from there in 1921 before construction of the dam, and never seen again. It is now presumed extinct. (Or drowned?)

The demand for water and subsequent need for bigger water storage facilities is forever increasing. Plans by the Department of Water Affairs are afoot to increase the Brandvlei Dam a third time. The only undoubtedly-known populations of Mopkop Vygies grow on a thin wedge of the remaining renosterveld vegetation at the water's edge of the Brandvlei Dam. Any rise in water levels will exterminate them. Respecting and conserving biodiversity, however small or insignificant an organism may seem, should be high up on everyone's agenda in today's times.

As custodians of this planet we need to teach this generation, and the next, to respect nature and to make decisions and take actions that contribute to the continued functioning of natural systems. Diverse systems are more resilient and can better survive and adapt to a changing environment. Any further loss of diversity could mean the end of living and the beginning of mere survival.

*Part of the premises of the Brandvlei Correctional Services.

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ABOVE: Mopkop Vygies like to grow in red, stony clay soil amongst Breede Shale Renosterveld.

BELOW: The large, fleshy fruits of the Mopkop Vygie.

BOTTOM: After a hot, dry summer spent underground, the leaves of the Mopkop Vygie emerge in autumn.

Photos: A. le Roux.



What's in a name?

The name *Phyllobolus* has nothing to do with Louisa Bolus or her uncle Harry Bolus (1834–1911), the well known botanical artist, businessman and philanthropist, but is derived from the Greek word *phyllon*, which means 'leaf' and from the Latin word *bolus*, to throw or cast, referring to the deciduous leaves found in some of the species. *Caudata* is from the Greek word *cauda* meaning tail, and probably refers to the tail-like leaves of the species, which also give it the appearance of a mop head lying on the ground – hence the colloquial name, Mopkop Vygie.

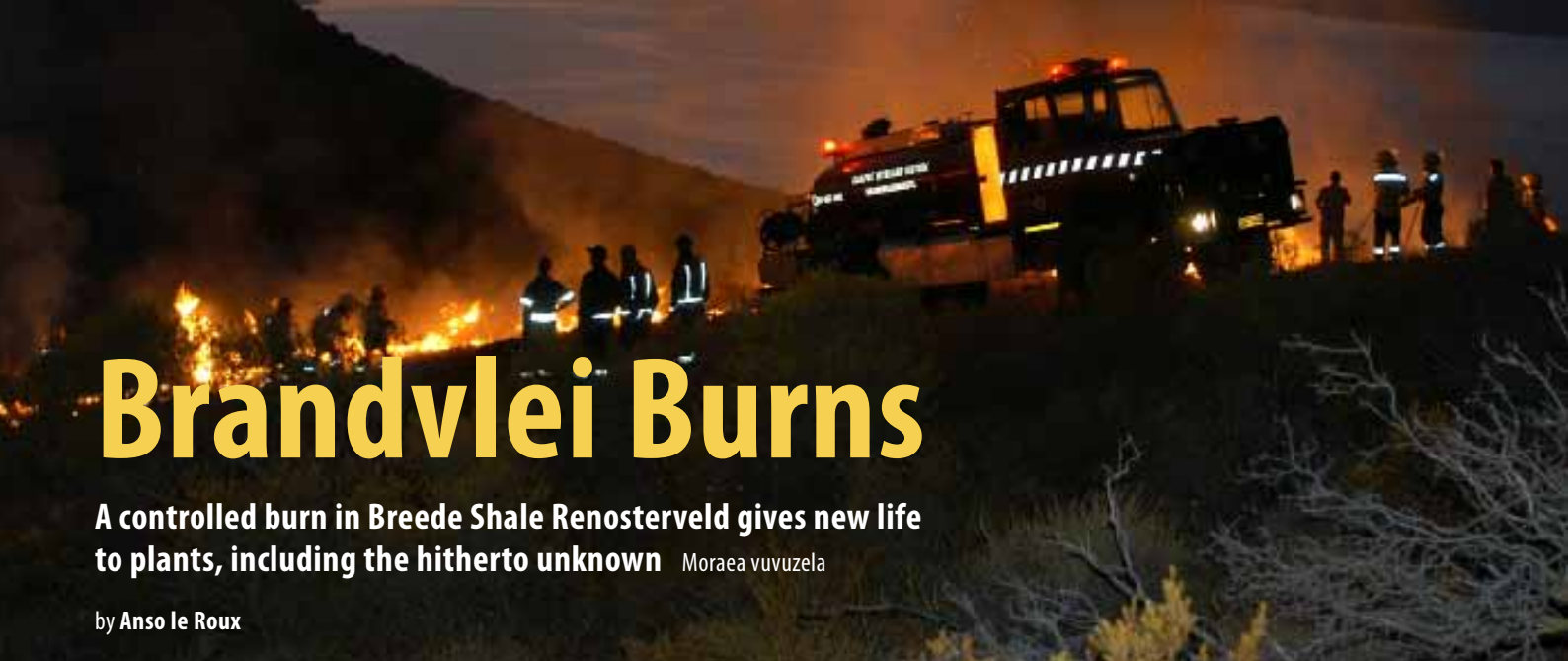
What does that mean?

Alluvium: Deposits derived from soils washed down by floods.

Deciduous: Shedding leaves at the end of a growth season.

Glaucous: Having a grey, blue-grey, blue-green or white bloom.

Perennial: Flowering throughout the year.



Brandvlei Burns

A controlled burn in Breede Shale Renosterveld gives new life to plants, including the hitherto unknown *Moraëa vuvuzela*

by Anso le Roux

The Brandvlei Dam lies between the towns of Worcester and Rawsonville in the Western Cape. It is surrounded by a vegetation type identified as Breede Shale Renosterveld which, typical of all fynbos vegetation types, evolved with fire. This means that it needs periodic burning to restore the veld and ensure the survival of several plant species that are sensitive to competition. The remaining natural areas around the Brandvlei Dam are surrounded by farming communities with associated power lines, roads, buildings and croplands. Because natural fires (started by lightning) and fires caused by humans are extinguished as soon as possible due to their threat to the various farming activities, the renosterveld vegetation on the northern edge of the dam had not burned for over 70 years.

The Applied Behaviour Ecology and Ecosystem Research Unit (ABEERU) of the University of South Africa has been conducting a long-term vegetation study and monitoring project on the hills and footslope areas surrounding the Brandvlei Dam. Preliminary results raised concerns that renosterbos domination, as a result of the absence of fire, especially on the moist southern slopes was impairing the reproduction and survival success of some plant species, especially

geophytes (plants with underground storage parts, like bulbs) and other species sensitive to dense canopy cover and competition.

Some areas around the dam are used for fishing and recreational purposes, and people making fires there posed a threat to the surrounding area as no proper firebreaks had been maintained to cope in the event of a runaway fire.

The process

As part of the larger ecological research project it was decided to initiate a controlled burn in a section of the area to investigate the effect of fire as a management tool for the ecosystem, and simultaneously to assist in protecting the area. As the study area lies on the border of the Fynbos and Succulent Karoo Biomes, concerns about the re-establishment of the vegetation after fire were raised, and Tony Rebelo was approached for advice. His expertise was an invaluable contribution to the project.

Already at the end of the summer of 2009, time was running out for a fire. We were trying to simulate natural conditions, which meant that we needed a fire to happen before the start of the rains and the subsequent growing season in autumn.

In collaboration with Erwin Weidemann of the Department of Water Affairs (DWA), Hannes Botha and Charl du Plessis, both from the Department of Agriculture, the area to be burned was investigated. Valuable advice was also given by Odette Curtis, from the Renosterveld Project, who has much experience in burning renosterveld. It was decided to burn an area of approximately 15 ha and, after approval of the fire plan by the Breede River District Municipality's Fire Department, a fire permit was issued. The deputy head of the Fire Protection Unit, Hermie Visser, offered to assist on the day of the burn.

Because several rare and endangered plants grow in the study area, the report was also sent to Deon Rossouw, Conservation Manager of the Limietberg Nature Reserve, who offered valuable advice and support and used the burn as a training exercise involving some of the Limietberg Nature Reserve's personnel on the day of the burn.

As three power lines run through the area, the proposed site for the burn had to be inspected by area managers of ESKOM (Transmission and Distribution divisions). Thick smoke caused by fire under power lines can act as a conductor which



ABOVE: Fire-fighters positioned along the firebreak, guarding the back-burn. Photo: Anso le Roux.

LEFT: The head-fire was successfully lit from the 10 m firebreak on the south-eastern slope, checked here by the Strike Force team of the Fire Brigade. Photo: Anso le Roux.

BELOW: Employees of DWA cutting a firebreak in old renosterveld with bush cutters. Photo: Anso le Roux.



could cause the lines to earth, thereby endangering the lives of everyone in the immediate area. Both reactors at the Koeberg nuclear plant were down at the time, so ESKOM allowed no fires within 5 km of their transmission lines as these were some of the few lines supplying the Cape Metropolis with electricity.

In preparation, workers from DWAF, as well as private neighbouring landowners, cut three firebreaks to ensure protection of the restoration site and various human structures. When DWAF were satisfied with the firebreaks, the fire was formally permitted after a site inspection.

After taking the weather forecast into account, the provisional date for the controlled burn was set for Wednesday 8 April 2009 – if the reactor at Koeberg was operating. Fire protection trailers were organized from DWAF, the Goudini Landbouvereniging and also from the Goudini Spa. The day before the burn a line of irrigation pipes was assembled at the foot of the steep slope in the firebreak in order to water the firebreak as much as possible to improve safety conditions as the area was very steep and difficult to reach by vehicle. Workers spent the night at the site,

keeping the pumps running and the sprayers moving along the 20 m firebreak from which the back-fire would be started. It was crucial that the fire could not jump this break, as a fire in the dense, overgrown renosterveld on the other side would be impossible to control. Thankfully, we got the go-ahead from ESKOM after a final inspection.

The day of the burn was wind free. A briefing was given by Hermie Visser and Deon Rossouw who co-ordinated proceedings. In total, 96 people were present. The vehicles carrying water and fire-fighters were positioned along the 20 m break. When everything was in place, the fire was started by Erwin Weidemann and carried further by two employees from the Limietberg Nature Reserve lighting a line of fire with drip torches, firstly in an easterly direction from the main firebreak, and later in a northerly direction along the road firebreak. The intention was to light a head-fire in the slight south-easterly wind when the back-burns were appropriately secured to the west.

Some mist set in around daybreak, and it was difficult to get any fire going, let alone an even line. An early start had been recommended because of the inflammable oils and contents of the vegetation and everybody was surprised

at the difficulty getting the fire going. With the Breede River directly to the north and the Brandvlei Dam to the south, early morning conditions were just too moist to sustain a fire. But conditions improved later and by midday, though still patchy, the fire was burning well. Controlled burning regulations state that burning must be done in temperatures lower than 28 °C, a relative humidity of more than 25% and wind speed of maximum 10 km/h. To do this, and to simulate natural conditions, a hot fire is needed. It was clear that weather conditions within the regulations could definitely not sustain a hot fire on an early autumn morning here!

In order to safeguard the site prior to expected windy conditions later in the afternoon and evening, the lighting of fires was stopped at 14h00. A south-westerly breeze, which completely changed direction to north-east, resulted in burning most of the unburnt patches in the planned area before the fire was put out by the fire-fighters at round about 18h00. It was a long day.

The team of Working on Fire (WOF) spent the night and the next day 'mopping up' – smothering remaining smouldering embers and securing flare-ups.



FROM LEFT TO RIGHT (anti-clockwise):
The dedicated fire-fighters of the Working on Fire team continuously checked the site. Photo: Anso le Roux.
Only a week after the fire, a Powder-puff Lily (*Haemanthus coccineus*) came up between the charred branches of a Botterboom (*Tylecodon paniculatus*). Photo: Anso le Roux.
Carpets of seeds from re-seeders such as *Protea laurifolia* covered the ground. Photo: Anso le Roux.
The first flowers of *Gladiolus guthriei* appeared two months after the fire. Photo: Anso le Roux.



TOP LEFT: *Oxalis pardalis* flowered prolifically two months later. Photo: Anso le Roux.

BOTTOM LEFT: *Moraea vuvuzela* flowered abundantly after the fire. Photo: Anso le Roux.

TOP RIGHT: *Pteronia hirsuta* grew and flowered extraordinarily prolifically after the fire. Photo: Anso le Roux.



The outcome

Thanks to thorough planning and the dedicated contribution of everybody involved, the project was completed successfully. Admiration, appreciation and much gratitude is owed to everyone.

In a natural scenario, fires started by lightning, mostly during late summer, in the surrounding mountains could be carried further by south-easterly and north-westerly winds. This could result in fires on the floodplains and in the renosterveld on the foothills of the mountains. In this project, care was taken not to burn when the geophytes were emerging after the dry season. The decision to burn when we did turned out to be perfect timing indeed as lightning did start a fire three days before the controlled burn was done.

Monitoring

The long-term research project involves continuous monitoring of the burnt renosterveld, which assesses the re-seeding, re-sprouting and overall response of the vegetation to the fire.

In the first growing season after the burn, the area was monitored every second week.

We walked through the veld, noting the occurrence of sprouting bulbs, re-growth, seedlings and any other relevant data. Fixed point photographs of the different slopes were taken as well.

After the first growing season following the burn, the area will be monitored monthly.

What we have learned

Burning the old veld proved beneficial for most species. Members of the Proteaceae (protea family) shed their seeds and geophytes flowered prolifically in the spring of 2009 especially *Gladiolus guthriei*, *G. recurvus*, *G. hyalinus*, *Watsonia spectabilis*, *Disa satyrioides* and other orchids. Species of Asteraceae (daisy family) such as *Arctotis*, *Berkheya*, *Othonna* and especially *Pteronia hirsuta* grew vigorously and flowered prolifically. All genera of the Iridaceae (iris family) benefited from the burn, especially *Tritoniopsis ramosa* and the recently discovered *Moraea vuvuzela** which were not seen in such vast numbers before the fire. Before the burn the latter, a small moraea, was only occasionally seen and had not been formally collected. Only after the burn were large stands of them seen on the south facing

slopes of the study area permitting formal collection and consequent description. (See the cover photo of this issue.)

Evidence of post-fire succession was the healthy grass layer that covered the moister southern slopes in December 2009.

The fire has benefited various smaller plant species and numerous geophytes, thought not to be present, appeared and flowered within a few weeks of the fire. Even though the research project is continuing with various monitoring plots placed in the burnt and un-burnt areas, the preliminary results indicate that although the vegetation structure has changed, with numerous other species appearing, the dominant species still persist. ♻️

* A new species, discovered by the author, Anso le Roux, and described by Peter Goldblatt and John Manning, was named in honour of South Africa's successful hosting of the 2010 Soccer World Cup which, for most of the world, will be memorable because of the vuvuzela. Anso le Roux first saw the 'new' moraea five years ago during fieldwork for his UNISA ecological studies, but only encountered a few solitary plants with not many of them flowering. After the burn, the moraea plants flowered so prolifically they were called a common weed by visitors to the site. He then collected specimens for the herbarium, and alerted plant taxonomist John Manning to them. John Manning then came out to see them in habitat, and the rest of the vuvuzela story is history (see further reading list below).

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***Drosanthemum* subgenus *Speciosa* (Aizoaceae): towards a revision of the plants with black staminodes**

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Summary: Nine species with black filamentous staminodes can be distinguished at present, the differences lying mainly in character states of leaf and calyx base surfaces, and in flower morphology. While flower colours cannot be used to identify a species, the morphology and size of the black filamentous elements appear distinctive for three different groups, which, however, do not agree with groupings suggested by similarities of leaves or calyx surfaces. A key is presented; *D. uniondalense* is described as a new species, *D. boerhavii* is re-established as a new name replacing *D. insolitum*, an illegitimate name. *D. bellum*, *D. edwardsiae*, *D. hallii*, *D. lavisii*, *D. pulchrum*, and *D. speciosum* are described as presently known, and for *D. micans* Hartmann (2011) is referred to.

Zusammenfassung (Hartmann): Neun Arten mit schwarzen filamentären Staminodien können derzeit sicher abgegrenzt werden; die Unterschiede liegen vor allem in Merkmalsausprägungen der Blatt- und Kelchoberflächen und in der Blütenmorphologie. Während Blütenfarben nicht hinreichen, um Arten zu bestimmen, erlauben Unterschiede im Bereich von Morphologie und Größe der schwarzen filamentären Staminodien die Identifikation. Es lassen sich aufgrund von Ähnlichkeiten in den schwarzen filamentären Staminodien drei Gruppen abgrenzen, die jedoch nicht mit den Gruppierungen aufgrund von Ähnlichkeiten in den Blatt- und Kelchoberflächen übereinstimmen. Ein Schlüssel wird erstellt; *D. uniondalense* wird als neue Art beschrieben, *D. boerhavii* wird als neuer Name als Ersatz für den illegitimen Namen *D. insolitum* etabliert. *D. bellum*, *D. edwardsiae*, *D. hallii*, *D. lavisii*, *D. pulchrum*, sowie *D. speciosum* werden nach dem derzeitigen Kenntnisstand beschrieben; für *D. micans* wird auf Hartmann (2011) verwiesen.

Introduction

The description of an unexpected carnival of flowers in *Drosanthemum speciosum* (Hartmann, 2008) laid the ground for a fresh approach to distinguish species in the genus based on characters unrelated to the only temporarily available flowers. At the same time, the question of species limits became demanding for ecological studies comprising a floristic analysis and a plant community classification in order to allow the description of the Breede Shale Renosterveld near the Brandvlei Dam, south of the town of Worcester in the Breede River Valley, South Africa.

In order to promote knowledge in both fields, an extensive study was undertaken: as many characters from growth form, branching patterns, internode lengths, diameters, and surface sculptures, leaf shapes, sizes, and numbers of bladder cells, fruit sizes and calyx surfaces as were available were measured or counted; finally, flowers were also included in the study. These data were compared with information from type material, as far as it was accessible, including JSTOR. All features were also documented as images taken in habitat mainly. It was also fortunate that data could be collected in an area that had been burnt under controlled conditions in April 2009, permitting the observation of regrowth including branch development at different times.

Never before has such a wide range of information been compared and checked one by one in order to try and find criteria that would permit the limitation of species independent from flower colours and their patterns, characters that have been used in the past almost exclusively (compare Hartmann, 2008). In order to make the decisions traceable, discussions of the various characters are presented, even though not all their states have been found to reflect taxonomic positions and taxon boundaries. In some cases, we have to go

down to single plants, in others we come to the conclusion that variation is such that only means derived from at least five counts or measurements in a population permit reliable and reproducible results.

A caveat must be pronounced with regard to the species included in this study: only those plants and species have been studied that possess black filamentous staminodes. Whether this is indeed a character expression reliably distinguishing the subgenus *Speciosa* from all other subgenera in the genus *Drosanthemum* is the topic of a parallel investigation undertaken mainly at the University of Bayreuth, Germany.

Taking such a restriction into consideration, the recognition of nine species is proposed here, one of them new (*D. uniondalense*) and another one a replacement of a younger name with an older name (*D. boerhavi*). For two species, *D. pulchrum* and *D. speciosum*, the treatment in Hartmann (2008) is available, all others are described here again, according to new information available. In this way, a base for further studies is presented, especially with molecular methods, in order to trace the possible evolution of *Drosanthemum* subg. *Speciosa* and its species.

Material and methods

Of the 1043 collections of *Drosanthemum* available for the study, 113 have been placed in the subgenus *Speciosa*, based on the fact that they possess black filamentous staminodes and prominent ridges alongside the bases of the capsules. Of these, 90 can be assessed down to species level, for 23 the available information is insufficient to permit a placement in any of the now recognized species.

All populations were visited in habitat, data being collected as far as the actual state of season permitted, photographs were taken, herbarium specimens were prepared, and living material was transplanted, either to a garden at Kuilsriver and/or to the greenhouse in Hamburg.

Some data of fruits and seeds of selected species were collected by students of the M.Sc. courses "Taxonomy" at the University of Bayreuth in 2008, 2009 and 2010 on dried material.

Selected fresh material was studied in the SEM (Philips SEM XL 30 ESEM) at Bayreuth, or in the SEM (Philips SEM XL 20) at Hamburg, both using Balzer CPD 030 machines for critical point drying. Further, fresh sections were studied in the light microscope (Leica DM 1000) at Bayreuth as well.

Type material has been seen in the course of earlier studies in the genus (e.g. Hartmann & Bruckmann, 2000; Rust *et al.*, 2002), and images

made available by JSTOR have been studied again in January 2011. The type of *D. boerhavi* has been sent on loan from S recently, permitting an assessment and resulting in a new name for the species later named *D. insolitum*.

Results

Growth form and branching: general features

Like most shrubs of Mesembryanthema, young plants of *Drosanthemum* grow erect with some internodes (mostly 4–6), the main branch ending in a terminal flower below which side branches develop (Figure 1) which can end in flowers as well in the same season (Figure 2).

All plants of the subgenus *Speciosa* form more or less erect squarrose shrubs, side branches never creep nor do they root easily in cultivation.

Shapes and sizes

Overall shapes can be arranged in three types:

(1) The formation of decumbent lateral branches result in low shrubs broader than tall

D. edwardsiae and *D. pulchrum* form this expansive growth form exclusively. Their lateral branches tend to lie on the ground at first (Hartmann, 2008: Figure 7b, *D. edwardsiae*) but can rise to 60 cm height supported by neighbouring shrubs (Hartmann, 2008: Figure 7f, *D. pulchrum*). In this way, diameters of up to 60 cm can be reached. This combination seems to be restricted to the two species mentioned as all other species form more or less erect stiff branches.

(2) Stiff branches can occur on low growing plants or on taller plants

(2a) Shrubs predominantly broader than tall

In open habitats, the plants form big cushion shapes of up to 25 cm tall and 60–80 cm in diameter in which all stiff branches end in a flower, all opening within a short period resulting in a splendid colourful display (Figure 3). In *D. speciosum*, the branches are irregularly placed and appear interwoven at first sight (Hartmann, 2008: Figure 7d, *D. speciosum*), while in *D. hallii* and *D. bellum* a pattern with basifugal growth predominates (see under branching). In both cases, the shrubs appear dense and full, the flowering branches usually point into all directions (Figure 3).

In denser vegetation, however, the branches can elongate and grow more vertically orientated, resulting in more narrow shapes with a smaller diameter, yet rarely much taller than wide.

(2b) Shrubs predominantly taller than wide

The remaining four species form rather slender shrubs in open habitats, looking like trees in many cases, with side branches formed equally all along the main stem and ending in erect bundles of flowers looking fastigiata. The basal branches



Figure 1. Seedling of *D. hallii* photographed on 29.3.2010 after the area had been burnt in April 2009, the main stem has already developed a fruit, four side branches from the base can be recognized. *Le Roux Brandbaan 2.* **Figure 2.** Seedling of the same age as in Figure 1, yet with five fruits: the middle one on the main stem and four on the basal four side branches. *Le Roux Brandbaan 3.* **Figure 3.** Flowering in a good season shows the single plants like prominent bouquets on 12.10.2007, the wealth of flowers being caused by rich branching in the previous season, not by formation of inflorescences. *Le Roux 4*, plant 2 in the foreground.

tend to possess wide angles between the side branches of one node, but soon these angles are reduced to below 45° between main and side branch (see below under branching). The slender tall growth is particularly well visible in *D. uniondalense* with heights up to 40 cm since the plants grow more or less solitary (Figure 4); *D. lavisii* (Figure 6) and *D. boerhavia* (Figure 5) usually reach 25 cm as maximum height, and for *D. micans* (Figure 7), 30 to 60 cm height have been recorded.

It must be noted that taller plants are also found in denser vegetation, e.g. those of *D. speciosum* and *D. edwardsiae*, which can be subtended by the neighbouring plants, but these species never form bundled flowering branches when standing in the open.

Branching patterns

(1) Basifugal development of side branches
Observations of plants of *D. hallii* after a controlled fire reveal a strict basifugal development of side branches (Figures 1, 2), i.e. the earliest formation of lateral shoots occurs at the two lowest nodes, resulting in a fast development of four side stems, leading to flower formation at about the same time as the primary flower starts anthesis. This predominance of side branch formation from the base leads to roundish shapes (Figure 3) in open habitats.

Each single side branch repeats the pattern (Figure 8), contributing to the bushy appearance of a plant. Furthermore, plants re-growing after a fire, follow that same pattern as well, yet they develop side branches only and do not replace the main stem (Figure 9).

Furthermore, branches of this type usually form a 90° angle between the side branches of one node, a feature that has also been found in *D. bellum*.

In both species, a reduction to a single side branch in the subapical region of a relative main branch can be observed, but the basal branching follows the described pattern always.

(2) Side branches all along the main stem

In all other species, the formation of side branches can be found at each node all along the stem, the ones from the lower nodes often longer than the ones from upper nodes (*D. boerhavia* Figure 5; *D. uniondalense*, Figure 10; *D. micans*, Figure 11; *D. lavisii*, Figure 12). In result, the flowers and the capsules are more or less held at one level above the plant, at first offering a sight of attraction to pollinators and later permitting the dispersal of seeds by raindrops falling onto the open capsule surface at a right angle.

Correlated with this effect of elongated branches is the fact that the basal angle of

branching usually is 45° or even less (Figures 5, 6, 7, 10, 11, 12), resulting in a fastigiate or broom-shaped arrangement, in contrast to the more widely spread side branches in *D. hallii* and *D. bellum*, as visible in Figures 8 and 9.

Leaves: leaf shapes

All species possess trigonous leaves in section, more rarely triquetrous with sharp margins and keel (Hartmann, 2008: Figures 6, 7), and all taper towards the tip and the bottom to different degrees, those of a pair never basally connate to any degree worth mentioning (Hartmann, 2008: Figures 7 a,c,e).

Leaf tips

Two groups can be distinguished in leaf tip formation:

(1) Uncinate leaves develop hook-shaped leaf tips, especially distinct in young leaves, but always persistent and differing in their cell composition from the remaining leaf, the hook resembling a recurved mucro. This leaf shape is found in *D. edwardsiae*, *D. lavisii*, and *D. uniondalense*, all three with smooth leaf surfaces (Figures 13-15).

(2) Rounded leaf tips can also bend backwards, but the tissue at the leaf tip does not differ from the remaining surface of the leaf, and in young leaves, the tips appear more roundish than older ones. Easy to place in this group are *D. speciosum* and *D. pulchrum* (Figures 16, 18), both never with recurved tips. More difficult to assess are *D. bellum* (Figure 19), *D. hallii* (Figure 20), *D. micans* (Figure 21), and *D. boerhavia* since they all start off with erect leaves (e.g. Figure 20), but inevitably they bend backwards with age (Figures 19, 21). Not rare are leaves with a recurved apical upper leaf surface, suggesting a recurved condition at first sight, but the lower leaf surface ends straight in such cases (Figure 19).

Most important in distinguishing these leaves from uncinata ones is an examination of the tissue at the leaf tip.

Keel and margins

(1) Rounded margins and keel occur in combination with rounded leaf tips, resulting in a trigonous shape in section as long as the leaves are fully turgescens (e.g. Figures 17, 18). Once these leaves shrivel when drying, the margins become sharper, see also below.

(2) Sharp margins and keel are always found in those leaves that develop a distinct hook at the leaf tip, clearly visible during the turgescens state from the beginning and retained until shrivelled (Figures 13-15).

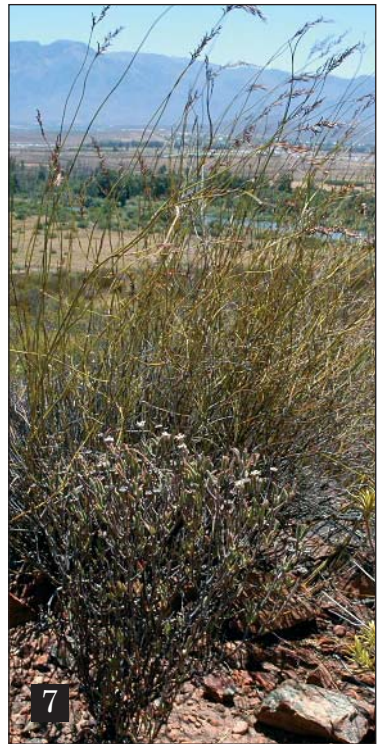


Figure 4. An almost tree-shaped growth form predominates in *D. unionalense* at the type locality reaching about 40 cm height. *Hartmann* 34813. **Figure 5.** A side view shows the basifugal development of side branches in *D. boerhavii*, up to 25 cm tall. *Hartmann & Bayer* 34478. **Figure 6.** Plants of *D. lavisii* appear more slender and bundled with a height up to 25 cm; they often settle among *Restios* and on quartzitic soils. *Hartmann & Bayer* 34703. **Figure 7.** Slender growth also characterizes *D. micans*, usually growing close to other shrubs and reaching 30–60 cm in height. *Le Roux* 86/6.

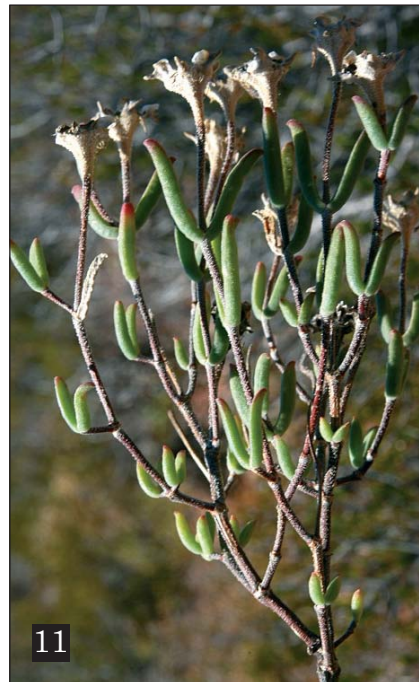


Figure 8. Basifugal branching with about 45° angles to each side, main branch equal to side branches, *D. hallii*. Le Roux Brandbaan 5. **Figure 9.** Regrowth after fire: only side branches are visible above the thickened hypocotyl. *D. hallii*. Le Roux Brandbaan 5. **Figures 10–12.** Side branches all along the main stem, apically bundled and resulting in the appearance of brooms. **Figure 10.** Raised fruits in *D. uniondalense*. Hartmann 34813. **Figure 11.** Usually only one side branch develops in *D. micans*. Le Roux 83/2. **Figure 12.** Sparsely branched plant of *D. lavisii* with hooked leaf tips. Hartmann & Bayer 34480.

Leaf shape in side view

In side view, three shapes can be distinguished:

(1) S-shaped leaves bend outwards at their bases, the pair forming a u, then turn into a vertical position with parallel margins and keel, and end in an outward curve, i.e. the upper leaf surface longer than the lower leaf surface (Figures 19, 21). *D. bellum*, *D. hallii*, *D. micans*, and *D. lavisii* possess such leaves, also *D. boerhavia* with age.

(2) Erect subterete leaves possess parallel sides and end in rounded tips at their straight ends. They have been found in *D. hallii* (Figure 20), *D. micans*, and *D. boerhavia*, in which species they can turn into s-shape with age and withering. In *D. pulchrum* (Figure 16), however, the leaves stay straight in shape during the entire lifetime.

(3) The elongate-oval shape widest in the middle is most clearly visible in *D. speciosum* with a flat upper leaf surface (Figure 18). In hooked leaves, the oval shape is altered somewhat, caused by the formation of a recurved upper leaf surface ending in a distinct hook. In *D. edwardsiae*, the hooked tip sits on top of the semi-oval shape in side view (Figure 15) which has a straight upper leaf surface. In contrast, the upper leaf surface is slightly curved in *D. uniondalense* (Figure 13) while the lower part is elongate and not semi-oval.

Surface of leaves

When Hartmann (2008) distinguished smooth and rough leaf surfaces, she referred to the number of bladder cells over a whole leaf section. This method cannot be applied to herbarium material because leaves shrink differently, as described under sizes and measurements. It was, therefore, decided to count the number of bladder cells per one side of the lower leaf surface. In the new classification, leaves with more than 18 bladder cells per side are called smooth, and leaves with fewer than 18 bladder cells per side are called rough.

Further, it was found that the variation of numbers, although constant during the entire lifetime of a leaf, can vary depending on the actual conditions the plants grow in. As a consequence, mean values per collection are used, a restriction that is coped for by the fact that in addition to fresh material it was possible to count bladder cells on leaves of herbarium material of the same plant. Further, single plants from the ecological plots were marked as well.

All samples fall into either of two groups: smooth leaved species are members of the species *D. speciosum*, *D. pulchrum*, *D. edwardsiae*, *D. uniondalense*, and *D. lavisii* (Figures 13–18, Diagram 1), all leaves appearing more greyish-green than the other species during the resting period. Rough-leaved species include *D. bellum*,

D. boerhavia, *D. hallii*, and *D. micans* (Diagram 1), all finely sparkling-shiny green (Figures 19–21). Closer inspection shows that leaves of *D. micans* (Figure 21) differ in most cases from leaves of *D. hallii* (Figure 20) and *D. bellum* (Figure 19) in appearing smoother to the eye. *D. boerhavia*, however, shows loosely dispersed values. The dense arrangement and overlapping values prevent a distinction of members of the four species involved, and other characters will have to be applied to separate the members reliably.

With respect to colour, it must be kept in mind that turgescent leaves appear sparkling and greener in all plants, whereas dry and shrivelled leaves appear grey.

Leaf sizes

Although regularly measurements of leaves are given in descriptions, they very rarely can be used on their own to identify and delimitate species. Leaf length increases in darker and wetter conditions and also along the branch, and values from, e.g., 7 mm length to 25 mm have been found in all leaf shapes. In contrast to this high variation in leaf length, leaf thickness does not vary much, and relative measurements, i.e. length to thickness, are not more informative than simple values of leaf length in a given type of leaf.

Leaf width depends on the degree of turgescence because when drying, the leaf folds lengthwise, deepening the channel on the upper leaf surface and reducing in this way the width of the leaf. In contrast, leaf thickness remains more or less the same during the lifespan of a leaf.

On fresh leaves, width and thickness can be compared, as was shown for *D. pulchrum* (3 mm both) with an almost terete leaf and *D. speciosum* (4 mm wide and 5–6 mm thick) with a triquetrous elongate-oval leaf (Hartmann, 2008), the latter appearing thicker than wide in most leaves seen. It has been observed, however, that with the increase in length in cultivation neither thickness nor width is enlarged at the same relation.

A sequence in correlated values in three steps can be observed from *D. lavisii* (with almost flat-tish leaves of up to 3 mm width and 1.5–2.5 mm thickness) over *D. uniondalense* (with 3 mm width and thickness) to *D. edwardsiae* (with leaves thicker than wide, 4.5–5 mm width, 5–6 mm thickness), all species with distinct uncinat leaves.

In the species with a rough leaf surface, leaves are always about as wide as thick, but they are usually trigonous in section, rarely terete. No significant differences in sizes can be found between these species, although the variation in leaf lengths can be considerable, even on one plant, as described above.



Inflorescence

Flowers sit solitary at the end of the first main stem (Figure 1) and on all subsequently formed branches (e.g. Figures 2, 10, 11); the apparent wealth of flowers is, therefore, a result of rich branching of the plant and not of the formation of dichasial inflorescences, as is the case in other genera, e.g. *Ruschia* subg. *Sarmentosae* (Dehn, 1993), in which construction flowers of an inflorescence open subsequently within a short period.

In the case of *Drosanthemum*, the single flowers at the ends of branches open also in a short time, individuals developing in this way into conspicuous huge bunches (Figure 3). At this state, plants can stand out dominantly in the otherwise still dry vegetation, making them a much wanted subject for flower beds in appropriate climates.

Pedicels

The length of pedicels ranges from 10 to 45 mm in members of *D.* subg. *Speciosa*, depending on the situation the plants grow in. As discussed above under growth form, individuals amongst other shrubs tend to develop longer internodes than plants in the open, and this tendency is kept during the growth of the pedicels, which at the same time can be thinner and not as stout as those on plants in the open. Independent from the position of the plant in the surrounding vegetation, it seems that the first formed flowers sit most often on shorter pedicels than later developed flowers on side branches. Such short stalks are usually noticeably thicker than those from plants amongst other bushes. The actual difference in diameter, however, lies in the range of 0.2 mm and values have never been found to be constant even in one plant.

In principle, pedicels of flowers grow during the ripening process of the fruit, hence the developmental state of flower and fruit influence the measured length as well. If data are wanted, it is advisable to measure ripe fruits that have reached their final extension.

In its surface anatomy, the pedicel resembles the vegetative internodes. Especially the bladder cells are very similar in shapes and distribution on the internodes and on the pedicels. In *D. bellum*, *D. boerhavii*, *D. edwardsiae*, *D. hallii* (Figure 20),

D. lavisii, and *D. uniondalense* (Figure 13), two size classes of bladder cells can be distinguished with a lens. The big bladder cells reach sizes of 0.1–0.2 mm, the length depending on the shape in which they have dried, the small ones reach 0.05 to 0.08 mm in the species with two size classes. In the species with only one bladder cell size class, the sizes range between 0.01 and 0.05 mm.

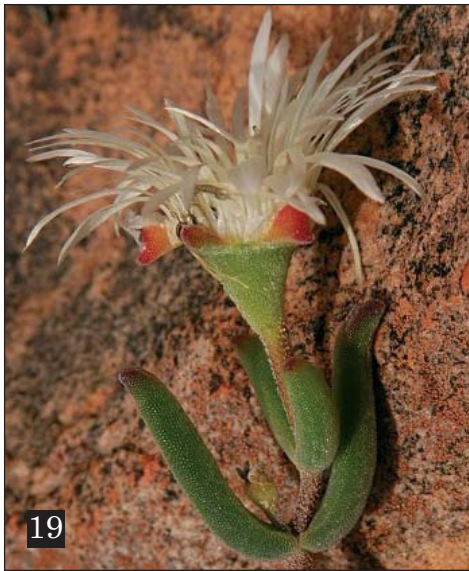
The big bladder cells are often prominent and globose, often raised above the epidermal surface and also often elongate-oval in shape, turning into narrow white bodies like short hairs, the internodes then appearing hirsute, as described for *D. boerhavii* (Figures 57, 58). In *D. micans*, big bladder cells are only formed in dry habitats beside small ones (Figure 21); in cultivation and in shady places, only small bladder cells in loose arrangement prevail, big ones are lacking. In *D. pulchrum* and *D. speciosum*, all bladder cells are of the same size and densely placed (Hartmann 2008: Figure 8c).

The density of the bladder cells appears at first sight to differ between species, but some caveats must be mentioned when assessing material. The number of bladder cells on an organ remains constant over the entire life time of the organ, and as a consequence, the bladder cells appear denser on younger internodes and also around the nodes. If the axis grows only a little, the bladder cells will remain in nearly their original places, but if the stem grows longer, the cells will be separated by intermediate normal epidermal cells and give an impression of a sparse distribution, e.g. commonly so along those branches and pedicels that grow amongst other shrubs.

Furthermore, during aging, the bladder cells turn into white grain-shaped bodies that are rubbed off by wind, rain, or passing animals, depleting the surface of bladder cells. This effect is less common in pedicels than in vegetative internodes which develop a solid secondary growth over many seasons underneath the epidermis, pushing the latter aside like a peel and replacing it by a new smooth secondary surface.

Overall, character states of the pedicel are strongly influenced by environmental factors and can hence be used only in some cases to determine differences between species.

Figures 13–18 (opposite). Smooth leaf surfaces in different leaf shapes. **Figures 13–15**. Hooked leaf tips. **Figure 13**. Note the two different size classes in bladder cells on the internodes. *D. uniondalense*. Hartmann 34813. **Figure 14**. *D. lavisii*. Bayer 7493. **Figure 15**. *D. edwardsiae*. Hartmann & Court 34648. **Figures 16–18**. Rounded leaf tips in different shapes. **Figures 16–17**. Almost terete leaves tapering towards base and tip. *D. pulchrum*. Bayer 7560. **Figure 16**. The leaf pair basally free. **Figure 17**. The small and densely placed bladder cells shiny as in Figure 14. **Figure 18**. The calyx base is equipped with protruding longish bladder cells, these papillae occur also down the stalk producing with age a hirsute stalk surface. *D. boerhavii*. Hartmann & Bayer 34697 (HBG).



Figures 19–21. Leaf surfaces in comparison. **Figure 19.** A rough leaf surface in *D. bellum*, the leaf tips spreading with age but not uncinatae. *Le Roux* Window 4 (near 70). **Figure 20.** Rough leaves on *D. hal-
lii*, note the regular rows of bladder cells along the leaves and the prominent bladder cells on the pedicel and internodes. *Le Roux* 17/1. **Figure 21.** A smooth leaf surface in *D. micans* on a recurved leaf without a mucro, i.e. not uncinatae. *Le Roux* 83/4. **Figure 22.** Longitudinal section through a flower demonstrating the elongate bladder cells along the sides of the calyx base. *Hartmann & Bayer* 34697. Photo: Bruce Bayer.

Calyx base

The conspicuous differences in bladder cells on calyx bases was already demonstrated by Hartmann (2008; Figures 8 a-f), albeit the application of names in that paper was only partially correct. Counts of bladder cells as lined up along the prominent crests alongside the calyx base of about 360 plants in c. 90 populations permit a better founded assessment now, especially when placed in correlation to leaf surfaces (Diagram 1).

Three groups can be distinguished in combining the relevant character expressions.

(1) Smooth leaves and smooth calyces.

Three species can be separated from all others since their calyces show 16 or more bladder cells per side: *D. pulchrum* and *D. speciosum*, as described in Hartmann (2008), and the new species *D. uniondalense*. With 19 to 26 bladder cells along the side of the calyx, *D. speciosum* shows the smoothest calyx surface of all species in the subgenus. *D. pulchrum* and *D. uniondalense* possess 16 to 18 lateral bladder cells but look smooth, too.

(2) Smooth leaves and rough calyces.

D. lavisii and *D. edwardsiae* share the possession of more than twenty bladder cells per leaf side and about ten along the calyx base, and they both possess uncinately leaves (see above, leaf tips). In addition, one population (Hartmann & Bayer 34688, HBG) appears in this group (black triangle in Diagram 1) that lacks such apically recurved teeth, possibly representing another new species.

(3) Rough leaves and rough calyces.

D. bellum, *D. boerhavia*, *D. hallii*, and *D. micans* form a rather compact group with 10-18 bladder cells per side of leaf and 10-15 per side of calyx. Although *D. micans* tends to have more bladder cells per side of leaf than the others, the overlap of values is considerable.

D. boerhavia, however, differs from all other species in the group by forming elongate bladder cells on the calyx that point outwards like rodlets in the flower (Figures 22, 58) and can hang down in the fruit. Samples are figured as *D. strictifolium* in Hartmann (2008: Figure 2 e and f), a name placed into synonymy with *D. boerhavia* here (see under taxonomy). Type material of *D. aureorubrum* (seen in JSTOR 7.1.2011) agrees with this form of calyx ornamentation as well, requiring a placement in synonymy of *D. boerhavia*, too.

Petal colours

In contrast to results from *D. speciosum* (Hartmann, 2008), colours and colour patterns of all other species appear less variable. Noteworthy is especially that in most cases populations share one flower colour type only, but some variation be-

tween plants of one population can be found in the actual colouring.

For example, *D. edwardsiae* has been published with a drawing and description indicating that the petals are deep reddish-purple with a yellow base (Figure 23). Photographs taken from near the type locality, however, possess bright scarlet petals in one plant and deep reddish-purple petals in another one (Schuette-Vlok s.n. 2006, Figures 24, 25).

The same scarlet petal colour pattern, i.e. a change from scarlet to light yellow and then to pink at the base, is found in most populations of *D. lavisii* (Figures 26-28), but the main colour in that species can also be closer to bright orange (Figure 28). The agreement in scarlet flower colour has led to the naming of material of *D. edwardsiae* as *D. lavisii*.

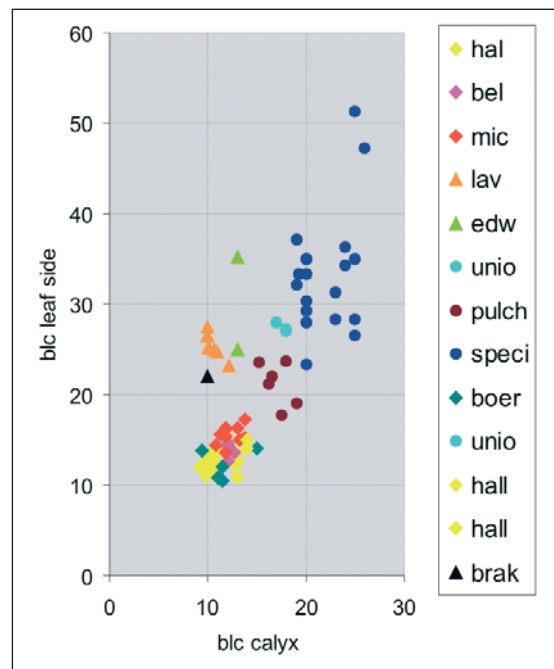


Diagram 1. Counts of bladder cells over one side of a leaf (b/c leaf side), usually one side of the lower leaf surface as that is exposed in dry material, are plotted against counts of bladder cells along the side of a calyx of flower or fruit (b/c calyx). Round symbols are used for species with smooth leaves and smooth calyces, triangles for species with uncinately leaves, and squares for species with rough leaf and calyx surfaces. The black triangle represents Hartmann & Bayer 34688, perhaps a new species. Note that *D. uniondalense* shares with *D. speciosum* and *D. pulchrum* the smooth leaves and smooth calyces, but also with *D. edwardsiae* and *D. lavisii* the uncinately leaf tips.

A similar colour pattern has also been found in *D. micans* (Figures 4 f, g in Hartmann, 2011), but that species exhibits more often a broad and bright middle zone of yellow in the petals (Figures 4 d, e in Hartmann, 2011). The same range of variation in petal colour pattern is expressed in *D. boerhavia*, well demonstrated in the type drawing of *D. strictifolium* (Figure 59), but orange in place of scarlet has also been observed.

D. hallii has been described with purely yellow petals, but it was known since long that some plants in yellow flowering populations can show scarlet petal tips (Hartmann, 2008: Figure 2c). In addition, some plants with ivory white petals (used here for the uniform and pale colour of young ivory) have been found in one of the ecological study areas in which so far only *D. hallii* had been reported. Next to a marked plant in the area burnt in April 2009 (Figure 9), a young plant with ivory white coloured petals was found in September 2010 that had not been noticed in 2009 and can be understood to represent a seedling established more slowly than others in the burnt area (*Le Roux* Brandbaan 5, Figure 29). Weather conditions did not permit close-up photographs, but in a near-by population, ivory coloured flowers were found: some possessed short black filamentous staminodes in low number (Figure 30), but few had no black elements at all (Figure 31).

A touch of richer yellow has been observed in so-called cream coloured petals of *D. bellum* (Figure 1c in Hartmann, 2008), often in combination with pink tips. The difference between the two types of whitish coloured flowers, however, lies obviously mainly in the structure of the flowers determined by the different forms the black filamentous staminodes (see below) and not in the somewhat variable colours, changing also with age.

In summary, it can be confirmed that neither petal colour alone nor the pattern of petal colouring permits the identification of species in the entire subgenus, as shown for *D. speciosum* and *D. pulchrum* earlier (Hartmann, 2008).

Black elements between petals and stamens

The possession of black filamentous staminodes has been understood to represent the synapomorphy of all members of *Drosanthemum* subg. *Speciosa*, assuming that they all have developed in the same way in the ontogeny of the flower (Hartmann, 2007). More detailed investigations and the examination of much more material require a re-consideration and re-assessment of the black elements found between true coloured petals and stamens.

At present, three different versions of black filamentous staminodes are known:

(1) Long black filamentous staminodes

In the opening bud, these long black filamentous staminodes overarch the shorter stamens in the centre (e.g. in *D. bellum* in Hartmann, 2008: Figure 1). They do not grow on with the repeated opening of the flower but are overtopped by the growing stamens in the centre, these pushing the black elements into an outer ring, as visible in the drawing of Dillenius (1732) of *D. micans* (Figure 1 in Hartmann, 2011) and in the type of *D. boerhavia* (*Ecklon* 2069 S!) as well. Different states are demonstrated in the drawing of *D. strictifolium*, a synonym of *D. boerhavia* (*Muir BOL* 17422 *BOL* Figure 59) and in *Hartmann & Bayer* 34478 (Figure 33) as well as in *D. micans* from habitat (Figures 4 d–g in Hartmann, 2011). *D. edwardsiae* (Figure 23) and *D. lavisii* (Figures 27, 28) show the same ontogenetic differences, but the flower of *D. uniondalense* is too incompletely known to permit a final assessment (Figure 63).

(2) Short black filamentous staminodes distinct from stamens

Even in the freshly opened bud, the black filamentous staminodes reach at most just the length of the stamens collected in the centre (Figure 32). They spread readily, showing well that they are flat organs, neither thread-shaped nor acutely pointed. Only in *D. speciosum* (Figures in Hartmann, 2008) and *D. pulchrum* such short black filaments are found, clearly separated from the stamens and in some way resembling extremely short petals.

(3) Short black filamentous staminodes merging into stamens

Whereas in both described types of black filamentous staminodes these organs are distinctly separated from the stamens, a transgression in colour and in the presence or absence of anthers has been observed in *D. hallii*. The outermost circle of black filamentous staminodes not longer than the stamens can be recognized in the young flowers; they are never numerous, however, and their numbers can vary even in one plant (Figure 34). With age, the spreading stamens hide the black filamentous staminodes, but as has been shown for ivory coloured samples, the number can be as low as zero from the beginning (Figure 31).

In a bud, it was observed that thinly and shortly stalked anthers emerge from below the rounded apex of the flat black elements, full of pollen or, alternatively, seemingly empty since they are pressed flat and lack pollen. Intensive checking of flowers reveals that various forms of transgression between black filamentous staminodes without any remains of anthers and purely white fertile stamens can be distinguished. Outer filaments can be as black as the adjacent



Figures 23–25. Flowers in *D. edwardsiae*. **Figure 23.** Image of the drawing of *D. edwardsiae* kept at BOL via JSTOR. Note the deep magenta colour and the black filamentous staminodes in the bottom row of elements. **Figures 24–25.** Different shades of magenta and purple in two plants of one population. *Schuetze-Vlok* s.n. **Figure 24.** The magenta is in tune with the type drawing as are the black filamentous staminodes. **Figure 25.** Bright scarlet red is seen in another plant from the same population.

filamentous staminodes, but more inner placed ones can be brown mainly, the actual base being white (Figure 35, showing the arrangement almost *in situ*). The white portions can be longer, but in the same flower, the longest outer filamentous staminodes can reach the shape of petals but keep at the same time a black tip (Figure 36). The white colouring at the bases of some elements may be related to the fact that stamens and petals always grow when the flower opens or closes. Yet, in the black elements of *D. pulchrum* no such growing has been observed.

In summary, it can be speculated that the differences in the formation of the black elements be-

tween petals and stamens in the subgenus *Speciosa* may have different ontogenies, suggesting further that the character state “black filamentous staminodes” may not be distinctive of a taxonomic group of mutual origin.

The numbers of black filamentous staminodes appear to differ between the three different groups described above. Long and short black elements distinctly separated from the stamens ((1) and (2) above) stand in several circles, forming a thick black ring in the medium old flower. Arrangements described under (3), however, are reduced to a single ring of elements that is regularly overarched by the stamens later (Figure 34).

As a consequence, the black elements are hardly visible in an older open flower. Only some counts are available giving about 20 filamentous staminodes for *D. hallii* and between 200 and 250 (also visible in Rust *et al.*, 2002: Diagram 1, red markings) for *D. speciosum*. More counts on clearly identified material will be needed to assess whether the number of elements can be understood as a distinctive criterion to identify a species.

Fruits: general features

Capsules of *D.* subg. *Speciosa* are easily recognized by the possession of five prominent lateral veins along the calyx base (Hartmann, 2008: Figure 8c) in combinations with their size (see below for detail), described as *D.*-SPECIOSUM-TYPE (Hartmann & Bruckmann, 2000: 103; Hartmann, 2007: Figures 32–37). It must be kept in mind, however, that, according to Hartmann (2008), members of *D.* subgenus *Lutea* without black filamentous staminodes are reported to possess the same fruit type, yet usually smaller in size. Further studies are needed in order to determine the relations between the two subgenera.

Species of *D.* subg. *Speciosa* differ in the number of bladder cells along these crests since they do not change in number after having been formed early in flower ontogeny, and counts can be made readily on ripe fruits (Diagram 1).

Features visible in the open capsule

Capsules of all species share the possession of firm yet flexible covering membranes ending distally in recurved or erect rims forming a more or less straight border over the locule (e.g. Figures 41–44), the free space being in most cases filled by seeds when wet, pushed up there by twisting funicles (e.g. Figures 37, 40). The radial contact line over a locule can be lifted like a roof, resulting in a somewhat concave distal edge per locule (e.g. Figures 38, 40)

The expanded valves expose rather narrow expanding keels, separated clearly from their bases inside the capsule and diverging further up to the middle of the valve length where they touch the edge of the valve (e.g. Figures 37–44), joining up here with the valve wings. These latter are almost rectangular in shape, often with a sharp end, reaching the tip of the valve in most cases (e.g. Figure 37), rarely a little longer (e.g. Figure 39).

Conspicuous differences are found in the shape and colour of the expanding sheets.

(1) Expanding sheets as thick cushions (Figures 37–40). In this formation, the expanding sheets are clearly and distinctly separated from the lighter coloured expanding keels, and they de-

velop a black colour with age, presenting a conspicuous sight when open in habitat in rain. Such prominent character states are typical of *D. bellum*, *D. boerhavia* (incl. *D. strictifolium*, type fruit in Hartmann & Bruckmann, 2000: 99), *D. hallii*, and *D. micans*. In young fruits, these expanding sheets are yellow-orange, turning dark brown to shiny black while thickening, a feature well visible in rain in habitat, but at any time they are thick and well separated from the adjacent expanding keels.

(2) Expanding sheets thin and merging into the expanding keels (Figures 41–44). These thin expanding sheets share in most cases the colour of the light brown expanding keels (Figures 41–43) and appear as a lining on the valve; only in *D. uniondalense* (Figure 44), the expanding sheets turn dark brown later; they remain thin, however, and merge laterally into the expanding sheets.

Capsules with closing bodies (Figures 45–49)

The absence of closing bodies characterizes most capsules of *Drosanthemum*, but some exceptions are known (e.g. in *D.* subg. *Ossicula*, Hartmann, 2007, with all members equipped with bone-shaped closing bodies). In *D.* subg. *Speciosa*, however, closing bodies have only been detected recently and in odd samples.

In *D. edwardsiae*, the closing bodies reach half the size of the expanding keels (Figure 45), leaving hardly any space for expanding sheets. They appear to be spongy and prominent in longitudinal section (Figure 46). White bodies sit also between the bases of the expanding sheets. On the other hand, however, the drawing of the fruit from type material lacks any closing body (Hartmann & Bruckmann, 2000: 98), suggesting at this point that the presence of thickened bodies on the outer wall of the locule needs to be checked in more material.

Another single sample has been found in a member of *D. hallii* (Figure 47), exhibiting smaller and bigger closing bodies in one fruit, suggesting that the development is not strictly kept up by a genetically directed program.

Even more complicated is the formation of a closing body in an unnamed sample (Hartmann & Bayer 34688), as is easily visible in the open fruit (Figure 48) since the bodies vary in size and extension. A section reveals that the expanding tissue lies on top of a thickened muscle-shaped tissue and below the expanding tissue (Figure 49).

Comparing the expanding sheets with the three different types of closing bodies, it is obvious that the thick black cushion of Hartmann & Bayer 34596 agrees completely with the four species placed under type 1 (Figure 47). The



Figures 26–28. Flowers of *D. lavisii*. **Figure 26.** Image of the drawing of *D. lavisii* kept at BOL via JSTOR. Note the scarlet red petals changing into a whitish colour towards their bases and the black filamentous staminodes a little longer than the stamens. **Figure 27.** Flower colours and black filamentous staminodes agree with the type drawing. *Hartmann & Bayer* 34643. Photo: Bruce Bayer. **Figure 28.** A stronger orange component is found in the petals of a different population of *D. lavisii*. *Bayer* 7498. Photo: Bruce Bayer.

unnamed population of *Hartmann & Bayer* 34688 has thinner expanding sheets (Figures 48–49), similar to type 2. The absence of expanding sheets proper in connection with additional bodies in capsules of *D. edwardsiae* places the species outside either type of expanding sheet, requiring further investigations.

Sizes of capsules

In the original descriptions, sizes are usually given for the flower base. These decrease in most cases when turning woody with the ripening of the capsule. Even if only measurements of ripe fruits are considered, striking differences can be found in diameters within a population and even on one plant, e.g. in *D. lavisii*: fresh fruits have been found to measure 6–7 mm, but old withered ones reach only 5 mm. The difference is due to the fact

that the calyx lobes and remains of petals decay over the dry season, leaving a much smaller fruit still on the plant when the next generation of capsules is ripe. This is obvious on branches that bear last season's fruit plus fresh ones from the present season, i.e. on one and the same individual.

Comparisons of sizes like diameters and height of capsules as well as height of the tops of plants collected in the same year and season show that differences between species can be found, but if the same population is collected and measured again in another year, these values usually differ clearly from the former ones. Measurements from one and the same plant over several years would be needed for all populations under study in order to establish reliable distinctions, which, however, seem apparent in the field.



Figures 29–31. Cream coloured flowers of *D. hallii*. **Figure 29.** Amongst a plant marked for study after the fire in 2009, a young plant with cream coloured flowers was detected on 16.9.2010. *Le Roux* Brandbaan 5. **Figure 30.** A flower of a plant near Brandbaan 5 with the typical merging of stamens into black filamentous staminodes in low number. **Figure 31.** Another flower of the same plant as in Figure 30, no black elements can be detected.

Overall, sizes of capsules of members of *D. subg. Speciosa* appear bigger than those of any other subgenera.

Seeds

Most species of *Drosanthemum* seen until now have orange to brown seeds and show a smooth surface in SEM, usually with undulate anticlinal cell walls and with more or less elevated cells in the region around micropyle and hilum, most samples have been assigned to the subgenera *Drosanthemum subg. Drosanthemum*, *subg. Vespertina*, and *subg. Xamera* (unpublished data). Members of *D. subg. Speciosa*, however, possess pronounced raised testa cells visible as a sparkling surface even to the naked eye, shaped like domes or balloons.

In the most prominently ornamented seeds of *D. speciosum* (Figure 50), a closer view reveals that the balloon-shaped elevations on the testa cells are separated by broad flat rims interlocked with the neighbouring cells by prominently undulate anticlinal cells (Figure 51). This condition has been confirmed in samples from six different populations of *D. speciosum* (numbers 25874, 26178, 30216, 34604, all HBG, see list of material seen in description), and it has been found in *D. uniondalense* as well. The seeds of the two species differ, however, in their micropyle shape: the inner integument is protruding in *D. speciosum* but almost hidden in *D. uniondalense* (Figure 65).

Less sparkling appear the seeds of all other species investigated until now, probably due to the more narrow placement of the elevated testa cells. In the example of *D. hallii* (Figure 53) the close arrangement can be seen with a lens already, and in bigger resolution, the outer walls of the testa are only moderately undulate, but the undulation reaches the top area of the cells (Figure 54).

The fine sculpture of the testa consists of a layer of finest rodlets (Figures 52, 55) that is rubbed off with aging, partially in the fruit already before dispersal takes place (note smooth areas on top of balloons in Figure 54). The spinulose epicuticular formations are most probably depositions, but their chemical composition is not known until now (Bittrich, 1987).

With only selected samples having been studied until now, no well-founded conclusions can be drawn regarding the constancy or variability of seed character expressions in the species of *Drosanthemum* nor of *D. subg. Speciosa*.

Ecology

Members of *D. subg. Speciosa* are common in a broad band of Renosterveld from Worcester to

Uniondale (Hartmann, 2007: 172). In the west, the highest density of populations settles in Breede Shale Renosterveld, while towards the east no such distinctive subunits of the Renosterveld have been recorded. The species in Renosterveld differ, however, in their actual habit. *D. uniondalense*, *D. hallii*, *D. boerhavii*, and *D. bellum* form shrub- or tree-like shapes in rather open places, never developing branches supported by neighbouring shrubs of other species. In contrast, *D. lavisii* and *D. micans* develop branches with longer internodes, making use of the support from other neighbouring shrubs regularly. Of all species, only *D. speciosum* and *D. pulchrum* have been found in Renosterveld and Succulent Karoo, with *D. speciosum* always in very open places but plants of *D. pulchrum* regularly near shrubs into which they lean their branches that otherwise decline to the soil. *D. edwardsiae* grows in a similar way, but it seems to be restricted to Coastal Fynbos on calcareous rocks where the plants settle in humus pockets (Limestone Fynbos, Canca Limestone Fynbos after Mucina & Rutherford, 2006: 170-174).

Most of the localities of members of *D. subg. Speciosa* are found on more or less weathered rocks of the Witteberg Geological Series (Gresse & Theron, 1992), most often on soils derived from shale, sandstone or quartzite. In addition, Bokkeveld shales have been recorded, but it must be remembered that the relevant layers are usually narrow and species preferences can hardly be determined. Conspicuous, however, is the fact that populations of *D. lavisii* grow often in places with much grass and many members of the genus *Restio* in areas covered with small quartz pebbles. These soils may be deposits hardened with age from silcrete or tertiary sands, the pebbles only placed on top by erosion of the surrounding fine material.

With the exception of *D. edwardsiae*, all species seem to tolerate different geological situations; in particular *D. speciosum* appears to be the least demanding species regarding the geology. It settles in transitional bands towards Table Mountain sandstone, in Bokkeveld Shale, Malmesbury Shale, conglomerate and silcrete, it can be seen regularly in disturbed road banks and even places full of rubble from road building. In consequence, it grows in Renosterveld as well as in Succulent Karoo. Trying to identify a common feature of all localities on geological grounds is impossible, but in a comparison over 27 known populations, the dominant factor seems to be the presence of open habitats in which this species can form conspicuous swarms over a relatively short period. Until now, no related studies about establishment of



such populations has been undertaken while data for species growing in Renosterveld and the re-establishment of those species are available based on succession studies after fire. Habitats of *D. speciosum*, however, are rarely burnt completely, hence other mechanisms must regulate settlement and expansion of these plants.

As far as rainfall regimes are concerned, members of *D.* subg. *Speciosa* appear also less strictly adapted than other taxa. In the west, winter rainfall dominates (Figure 70) with > 60% of annual precipitation in that season, and here the line of 500 mm p.a. is also crossed. Most of the area of the subgenus expects between 375 and 500 mm p.a. rainfall, however, and only the extreme east near Uniondale and a narrow band along the northern boundary reach areas with only 250 mm expected rainfall p.a. Only *D. uniondalense* and most populations of *D. speciosum* have been recorded for this region. In the south of the area of the subgenus, rainfall of 375 to 500 mm is also expected, mainly falling all year round. *D. lavisii* and *D. edwardsiae* occur here, in part also *D. boerhavia*; the distribution of the last species is not well known, and according to literature, it may also grow in the adjacent winter rainfall region.

The combination of winter rainfall and amounts of > 450 mm p.a. determines conditions in the very west where *D. bellum*, *D. hallii*, and *D. micans* predominate. *D. pulchrum* has been recently found in that area, too, but its main region of settlement seems to lie in the drier northwest where again less than 250 mm p.a. can be registered.

Geographical distribution

Within the rather wide area of the genus *Drosanthemum* (Hartmann, 2007: 172), *D.* subg. *Speciosa* is restricted to a broad band from west of Worcester to Uniondale (Figures 67–69), the number of known populations decreasing to the east. Remarkable is the occurrence of *D. uniondalense* inland in the east (Figure 67) and of *D. edwardsiae* at the Coast near Mossel Bay, both the only members of *D.* subg. *Speciosa* in that portion of the entire range. *D. lavisii* inhabits the southern

portion, also widely without any close-by members of *D.* subg. *Speciosa* (Figure 68). Comparing the areas of these three species, all with uncinately leaves, might hint at a common origin and subsequent allopatric speciation. No support for such a speculation has, however, been found until now in any other characters.

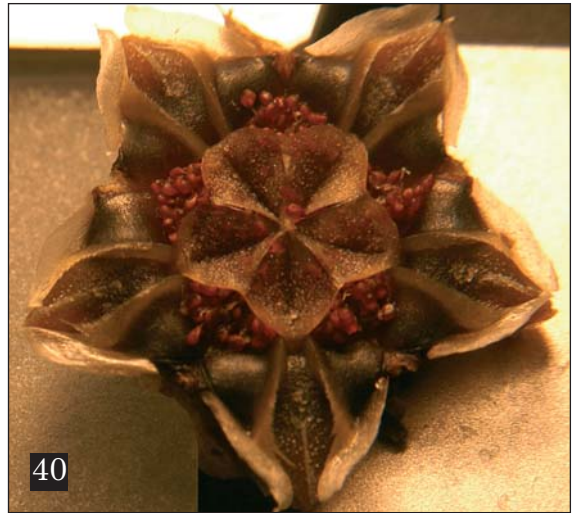
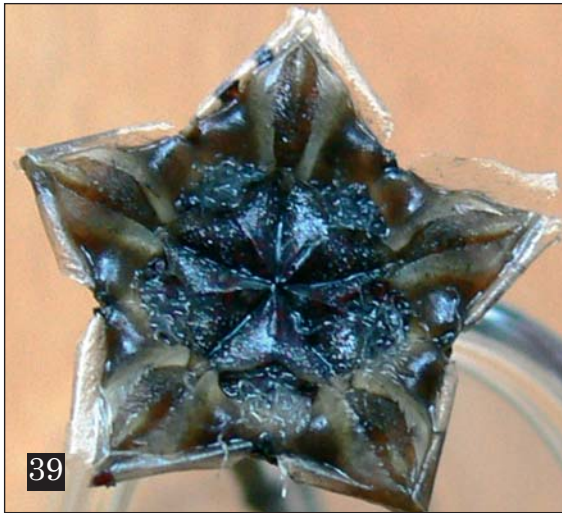
Samples of *D. boerhavia* are too scarce to permit any reproducible conclusions, especially since no populations near the old type locality between “Hauhoek and Caledon” have been found in spite of extensive searches. This may perhaps be due to the extensive ploughing in the area (Figure 56) from which the plants were able to retreat to rocky outcrops which are difficult to check over such a wide area.

The widest distribution area is reported for *D. speciosum* (Figure 67), a species found in most different soil types and also in disturbed places like road banks. This is also the most northern species, settling well into the Succulent Karoo, too.

A peak accumulation of species from all eight subgenera has been found in the Fynbos Biome, samples from all of them are placed in a square between 33 and 34 °S and 19 to 20 °E (Hartmann, 2009: 61). This area appears to be the hotspot within the subgenus, highlighted especially by the co-occurrence of five species in this square: *D. speciosum*, *D. pulchrum*, *D. hallii*, *D. bellum*, and *D. micans* (compare maps in Figures 67–69 around Worcester). For example, plants of *D. hallii* and *D. pulchrum* have been found within a single ecological plot, i.e. a square of 20 × 20 m, or of *D. hallii* and *D. micans*, or a close vicinity of *D. hallii* and *D. bellum*, the last couple the only one having been known since long because the differences in petal colour and characters of black filamentous staminodes are striking during flowering time.

Overall, the remarkable differences in density of distribution along the west-east gradient are worth further studies since they cannot be attributed to collecting. Clearly, the west seems to have more potential for speciation, i.e. the evolution of breeding barriers, at this date. This is reflected in the high peak with five species in a small area. In contrast, the allopatric species further east

Figures 32–36 (opposite). Different types of black filamentous staminodes. **Figure 32.** A young flower of *D. pulchrum* with the stamens still collected in a central column, the short black filamentous staminodes spreading sideways. Bayer 7560. Photo: Bruce Bayer. **Figure 33.** Two younger flowers of *D. boerhavia* with the black filamentous staminodes longer than the stamens, some twisting already while the stamens are expected to spread. Hartmann & Bayer 34478. Photo: Bruce Bayer. **Figure 34.** A bouquet of flowers of *D. hallii* with a low number of black filamentous staminodes not longer than the stamens. Le Roux Brandbaan 5. **Figure 35.** A dissected flower of *D. hallii* demonstrating the few black filamentous staminodes as long as the stamens as well as the apically recurved rough leaves and the glittering rough surface of the calyx base. Le Roux 72/1. **Figure 36.** A dissected flower of *D. hallii*, all elements from white stamens over differently darkened filaments to black filamentous staminodes. Le Roux Brandbaan 5.



Figures 37–40. Open capsules with thick cushion-shaped dark brown to black expanding sheets bordered distinctly against the expanding keels. **Figure 37.** In this fruit of *D. bellum*, numerous seeds can be seen at the opening of the locules. *Le Roux* 70/2. **Figure 38.** In the old fruit of *D. hallii*, all seeds have been dispersed. *Hartmann & Bayer* 34615. Photo: Ulrich Meve. **Figure 39.** An old fruit of *D. boerhavia* without seeds. *Hartmann & Bayer* 34697. **Figure 40.** A rather fresh fruit with seeds inside of *D. micans*. *Le Roux* 83/5.

might indicate a past speciation by fragmentation of areas which in turn suggest an earlier break-away of the relevant species, especially *D. edwardsiae* and *D. uniondalense*. The wider distribution of *D. speciosum* may be due to the fact that the species grows most often in recently established localities influenced by rather rapid changes like road banks.

Conclusions

The present study is based on the circumscription of *D. subg. Speciosa* by Hartmann (2007), which in turn is founded on a combination of character

states in the capsules, namely the prominent veins along the calyx base of the fruit, and of flowers, namely the possession of black filamentous staminodes in the flower.

Within this defined scope, it was possible to distinguish nine species for which an artificial key can be given. Whereas certain combinations of character states like the number of bladder cells along the calyx and over the side of the leaf suggest groupings within the subgenus (Diagram 1), these groups cannot be supported with other character states at present, e.g. the forms of testa cells. The five species with smooth leaf surfaces can

clearly be separated from the four species with rougher leaves, but while the first five mentioned species differ in their respective values, the four remaining species fall into a dense aggregation, asking for another type of distinctive features yet to be determined.

Nevertheless, the fact that three principally different types of black filamentous staminodes suggests that the colouring of the black elements may have evolved more than once. Yet another flowering season will have to be used for further studies in order to assess the evolutionary situation starting from the blueprint offered here.

Taxonomy

Drosanthemum* subg. *Speciosa H.E.K.Hartmann (*Bradleya* 25: 171, 2007)

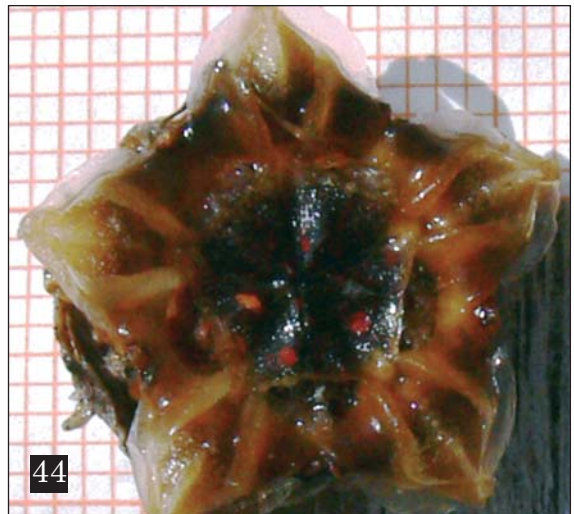
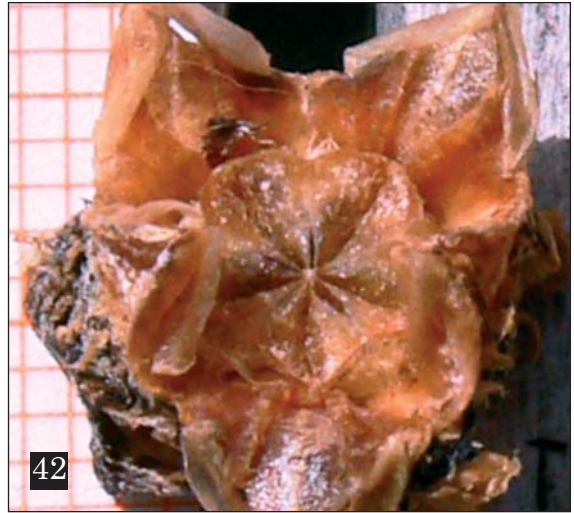
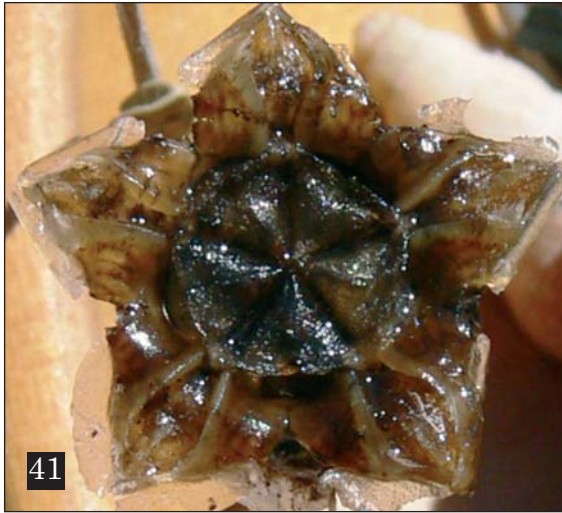
Shrubs with erect or spreading hard woody stems, up to 60 cm tall if supported by adjacent vegetation, diameters up to 50 cm. Internodes

rough from bladder cells, usually globose or elongated, often in one shape but two different size classes, agreeing with the section *Aspericaulia* of Haworth (e.g. *Miscellanea*: 20, 1803, and section 66; *Revisiones* : 79, 1821), maroon turning blackish with age. Leaves trigonous, more rarely semi-circular, apically rounded or acuminate, uncinata in some species, also bending backwards with age in some species; leaf surfaces glittering from bladder cells, either many and densely placed or more loosely arranged leaving the actual epidermis visible under a lens. Flowers always terminal and solitary, but numerous on a plant due to rich branching. Below the petals a ring of black filamentous staminodes, either short and erect or longer and initially overarching the stamens. Capsules robust and big, the base adorned with conspicuous bladder cells along the prominent veins, either dense and many or loose and fewer. Expanding sheets as thick later black cushions well separated from the expanding keels, or thin

Key to the species of *Drosanthemum* subg. *Speciosa*

Note that a number of plants have to be examined to assess the prevalent character state or several counts or measurements have to be undertaken.

- | | |
|--|-----------------------|
| 1. Smooth leaf surfaces: mean value in the number of bladder cells over one side of the leaf per population > 18; expanding sheets in fruit flat and merging into the expanding keels, yellow to orange or light brown | 2 |
| - Rough leaf surfaces: mean value in the number of bladder cells over one side of the leaf per population < 18; expanding sheets as thick black cushions in ripe fruit, distinctly separated from the expanding keel | 6 |
| 2. Leaves erect, the tip being the highest point of the leaf | 3 |
| - Leaves with a sharp permanent hook at the end, the leaf tip hence lower than the highest point of the leaf | 4 |
| 3. Leaves thickest in their middle, narrowing to base and tip, stout shrubs usually broader than wide; bladder cells along calyx base 19–26 | <i>D. speciosum</i> |
| - Leaves with parallel sides, tapering only moderately into a rounded tip; low shrubs with decumbent branches, also in other bushes; bladder cells along calyx base 15–18 | <i>D. pulchrum</i> |
| 4. Leaves thin and rather short: 10–14 mm long, 1,2–3 mm wide, 1,2–2.5 mm thick, i.e. usually wider than thick | <i>D. lavisii</i> |
| - Leaves as thick as or thicker than wide | 5 |
| 5. Calyx base smooth, about 18 bladder cells along the side | <i>D. unionalense</i> |
| - Calyx base rough, about 13 bladder cells per side | <i>D. edwardsiae</i> |
| 6. Calyx base with 10–15 long, hanging bladder cells on the sides of the calyx, changing into long papillae on the stalk | <i>D. boerhavi</i> |
| - Calyx base with 11–14 bladder cells along its side, no elongated hanging bladder cells, stalk with small globose bladder cells of two different size classes | 7 |
| 7. Means of bladder cells over a leaf side 14–17, appearing smoothly-shiny; mostly only one side branch formed per node, the angle usually < 45°; plants to 60 cm tall, mostly in other shrubs | <i>D. micans</i> |
| - Means of bladder cells over leaf side 10–15, appearing crystalline-shiny; usually two side branches from a node, the angle between the two 90° or more; plants up to 50 cm tall, mostly free in open places | 8 |
| 8. Flowers with many narrow acute filamentous staminodes covering the stamens in the early states of anthesis, the stamens clearly separated from the filamentous staminodes | <i>D. bellum</i> |
| - Flowers with relatively few broader apically rounded filamentous staminodes at most as long as the stamens when the anthesis starts, the stamens merging into the filamentous staminodes | <i>D. hallii</i> |



Figures 41–44. Open capsules with thin orange to ochre coloured expanding sheets merging into expanding sheets of the same colour. **Figure 41.** Sample from *D. speciosum*. Hartmann & Bayer 34600. **Figure 42.** Sample from *D. pulchrum*. Hartmann & Bayer 34712. **Figure 43.** Sample from *D. lavisii*. Hartmann & Bayer 34693. **Figure 44.** The sample from *D. uniodalense* developed darker expanding sheets than in the other three species, but the glittering of the merging region of both, expanding keels and sheets, can be clearly seen. Hartmann 34813.

and mostly orange with age merging into the expanding keels. Seeds with raised testa cells shaped like domes or balloons.

Ecology: In Succulent Karoo in Renosterveld on shale mostly, rarely on calcareous soils at the sea but common also in disturbed places with mixed gravel.

Distribution: In a band between 33°20' and 34°35' S parallel to the coast, but rarely at the coast, and from 19°15' to 22°45' E, in Western Cape Province, South Africa (Figures 67–69).

Drosanthemum bellum L.Bolus, *Notes on Mesembrianthemum* 2: 43. Holotype: Hutchinson BOL 18862 (BOL!).

Shrubs with more or less erect stout stiff branches, to 40 cm tall; the main stem mostly shorter than the soon developing side branches, the first of which are formed at the two basal nodes, resulting in mostly four equal lateral stems that branch in the same pattern as the main stem, namely from the bottom, spreading at angles < 45°; as tall as wide, about 25 cm in each dimension, or taller than wide. Internodes with rather

densely distributed round bladder cells in two different size classes, the bigger ones often on an elevated tiny hill of the epidermis; leaves erect or apically recurved, but the tip rather rounded and never uncinata, the 10–15 bladder cells per side arranged in conspicuous longitudinal rows, (7)–15–(25) mm long, 2–3 mm wide, 2–3 mm thick; pedicels similar to internodes, bladder cells mostly denser though; calyx base with about 11–14 bladder cells per side along the prominent ridges; petals pink to deep purple, the base regularly whitish to cream coloured, also cream coloured all along and rarely yellow at their tips, the thread-shaped black filamentous staminodes widely over-arching the stamens in the freshly opened flower (Hartmann, 2008: Figure 1), 80–140 per flower; the open fruit exposing thick broad prominent dark brown to black shining expanding sheets (Figure 37), capsule diameters about 9 mm, the height about 6 mm, i.e. the capsule distinctly wider than high.

Ecology: In Breede Shale Renosterveld, mostly in open patches, rarely close to other shrubs, on Witteberg shale-sandstone in stony shallow clay-loam expecting about 340 mm rainfall p.a. mainly in winter.

Distribution: Southwest of Worcester, 33°41' S and 19°25' E, Western Cape Province, South Africa.

Material seen: Hartmann & Bayer 34454 (HBG); Le Roux 70, 71 (NBG); Hutchinson 18862 (BOL).

Notes: The type specimen was reported to have come from the Ceres district, which seems to have been a mistake as until now material agreeing with the type, the drawing of it, and the description has only been found on a hill south of Worcester, amongst populations of *D. hallii* and *D. micans*.

D. bellum differs from *D. hallii* mainly in character states of flowers. The petals are predominantly pink to light purple and basally cream coloured or entirely cream coloured and at most apically yellow, and the long black filamentous staminodes overarch the stamens when the buds open and twist when aging, persisting longer than those of *D. hallii* and more numerous (> 80) and hence more clearly visible in old flowers or young fruits.

In all other character states, no reliable differences can be found, but it must be mentioned that plants in a population of *D. hallii* from near the type locality have also whitish coloured petals, yet a lighter whitish ivory and in combination with shorter and fewer black filamentous staminodes. These plants have been included in *D. bellum* earlier but are now considered not to belong there.

Drosanthemum boerhavii (Ecklon)

H.E.K.Hartmann **comb. nov.**

Basionym *Mesembryanthemum boerhavii* Ecklon, *Enumeratio plantarum africanae...3*: 318 (1837).

Drosanthemum insolitum L.Bolus 1958: 83, nomen illeg. Holotype: Ecklon 2069 (S!).

= *Drosanthemum micans* (Haw.) Schwantes var. *aureorubrum* L.Bolus, *Notes on Mesembryanthemum 3*: 154 (1939). *Drosanthemum aureorubrum* (L.Bolus) L.Bolus 1964: 38. Holotype: Hurling & Neil BOL 21848 (BOL!).

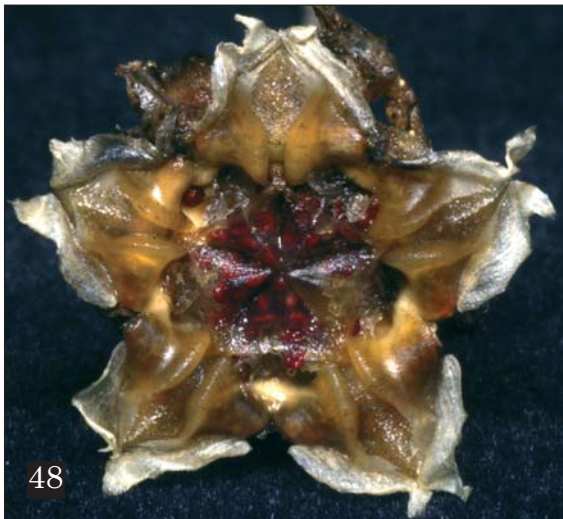
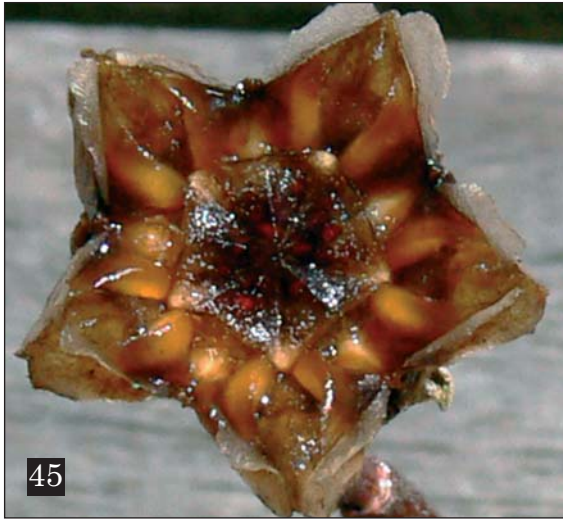
= *Drosanthemum strictifolium* L.Bolus 1953: t. 1152. Holotype: Muir BOL 17422 (BOL!).

Squarrose shrubs to 25 cm tall with more or less stiff erect branches appearing bundled towards the top, the side branches all along the main stem (Figure 5), the lower turning woody with age, losing their leaves completely (Figure 59), the upper with more leaves on them, but all side branches beginning at an angle of nearly 90° per node (as in the type of *D. strictifolium*, Figure 59); internodes very rough from round or almost hairy papillae often stiff and hirsute (Figure 58), the latter more prominent in young plants (as visible in the type plant, Figures 58, 60), diameters to 25 cm in the open; leaves erect or apically recurved, but the tip rather rounded and not uncinata, 10–15 bladder cells per side, i.e. belonging with the rough surface types in the subgenus, 18–24 mm long, 2–3.5 mm wide, 2.5–3 mm thick; pedicels similar to internodes, changing into big bladder cells of elongate drop-shape towards the calyx base, 9–15 per side along the prominent ridges (Figures 22, 57, 58); petal colours mostly pink at the base, followed by bright yellow or orange shorter elements and deep to purplish red in the longer outer elements, the colours can merge into one another along the petals (Figure 59); the thread-shaped black filamentous staminodes distinctly longer than the stamens in the young flower (Figure 33), later pushed to the outer edge by the developing stamens, forming a thick prominent ring (Figure 58); the open fruit exposing prominent thick dark brown to black expanding sheets distinctly separated from the expanding sheets (Figure 39), capsule diameters about 10 mm, wider than high.

Ecology: Mainly on Bokkeveld shale in Renosterveld, perhaps in a reduced area today after much of the ground has been ploughed (Figure 56), expecting 375–500 mm rainfall p.a. at all seasons, but perhaps also in the winter rainfall area.

Distribution: Between 33°55' and 34°15' S and 19°20' and 20°30' E, south west and south east of Worcester, Western Cape Province, South Africa.

Material seen: Ecklon 2069 (S); Hartmann &



Bayer 34478, 34697 (HBG); *Hurling & Neil BOL* 21848 (BOL); *Muir BOL* 17422 (BOL)

Notes: The present circumscription of the species rests on the possession of long and rather few bladder cells along the sides of the flower and capsules, including a transgression into rough hairs or at least prominent big bladder cells on the stalk. Furthermore, the thread-like black filamentous staminodes overarching the stamens in the young flower present a typical feature of the species.

Based on the combination of the described character states, two species are placed in synonymy here. In addition, a new combination has to be published because the description of *D. insolitum* (Bolus 1958) was superfluous as it was based on the validly described species *M. boerhavia* Ecklon (1837), the reference obviously having been overlooked by Bolus.

The type locality of Ecklon (1837) is given as “inter Hauhoek et Caledon”, but no younger records from that area are known. This may be due to the fact that the whole region has been ploughed up since many years; such an idea is supported by the fact that the two recent collections stem from an isolated rocky outcrop and from the roadside out of reach of cultivation or browsing.

Furthermore, it must be noted that the type plant of *D. boerhavia* is a young individual (Figure 60) most probably collected in its first season, while the type material of the two synonyms show woody adult plants with old woody branches, the side branches having turned into blunt but stout spines (Figure 59), a feature also observed in the two newly discovered populations.

Drosanthemum edwardsiae L.Bolus, *Notes on Mesembrianthemum* 2: 319 (1932). Holotype: *Edwards BOL* 19937 (BOL).

Low shrubs with sparsely leaved decumbent outer branches, 15–25 cm tall, diameters about 40 cm in the open (Hartmann, 2008: Figure 7b),

higher and straggly in other bushes, internodes rough from prominent bladder cells, like the pedicels with big and also distinctly smaller bladder cells, older big collapsed ones appearing like white ovals (Figure 15), often with a protrusion pointing downwards; leaves thickest in their middle, laterally compressed, hence trigonous in section, apex very sharply recurved (Figure 15, Hartmann, 2008: Figure 7a), i.e. uncinata, leaf surfaces smooth from small bladder cells, between 20 and 40 per side, hence greyish in appearance, length 14–17 mm, width 4.5 to 5 mm, diameter 5–6 mm; pedicels with round bladder cells in denser arrangement than on the internodes (Figure 15); calyx base rough from 11 to 13 prominent bladder cells along the ridges on the sides; petal colour described and figured as “rosy purple”, with a narrow yellow ring above a whitish base, the central eye inconspicuous and small, but in habitat, scarlet red has been documented as well with a similar pattern in yellow and white at the bases of the petals (Figures 24, 25), black filamentous staminodes at first overarching the stamens a little, soon spreading forming a dense ring (Figure 23); capsules on fresh material with distinct white spongy closing bodies (Figures 45, 46), leaving only a narrow brown expanding sheet visible that does not reach the pronounced shapes and colours of the group around *D. hallii* (see Figures 37–40), about 11 m wide and 10 mm high.

Ecology: Up to now, only known from humus pockets in calcareous outcrops and cliff edges above the sea shore in Limestone Fynbos, more specifically Canca Limestone Fynbos (FFI 3 after Mucina & Rutherford, 2006). The annually expected precipitation of c. 375 mm can fall at any time of the year.

Distribution: Near Mosselbay and Great Brak River, Western Cape Province, South Africa.

Material seen: *Edwards BOL* 19937 (BOL); *Hartmann & Court* 34648, 34651 (HBG); *Schuetten-Vlok* s.n. 26.10.2006 images seen.

Figures 45–49 (opposite). Capsules with closing bodies. **Figures 45–46.** *D. edwardsiae*. *Hartmann & Court* 34651. **Figure 45.** In the open capsule, the light ochre protrusions between the expanding keels of two adjacent valves and in the mouth of the locule show prominently. The expanding sheets are reduced, due to the thick closing bodies, hardly permitting an assessment of their shape. **Figure 46.** In section, the closing body appears as a bulge above the end of the placenta, derived from inner fruit wall tissue, appearing spongy in consistency. **Figure 47.** In one population of *D. hallii*, capsules with odd closing bodies have been found between dark cushion-shaped expanding sheets. *Hartmann & Bayer* 34596. **Figures 48–49.** Capsules of a *Hartmann & Bayer* 34688 possess irregularly shaped and placed closing bodies. **Figure 48.** In the open capsule, smaller and bigger closing bodies can be seen between the valves at the mouth of each locule while the expanding sheets seem to merge into the expanding keels. **Figure 49.** A longitudinal section through the closing body indicates that the swelling is filled by sclerenchymatic tissue.

Notes: Amongst the three species with uncinat leaf tips and smooth leaf surfaces, *D. edwardsiae* stands out by its loose growth with almost decumbent branches and its leaves thicker than wide (those of *D. lavisii* being more slender and wider than thick, those of *D. uniondalense* being almost always as thick as wide and longer than leaves of *D. edwardsiae*). Furthermore, it is only known from coastal calcareous rocks in a small area.

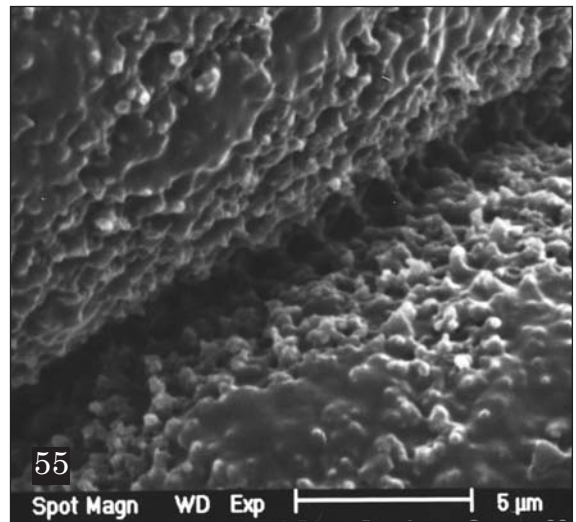
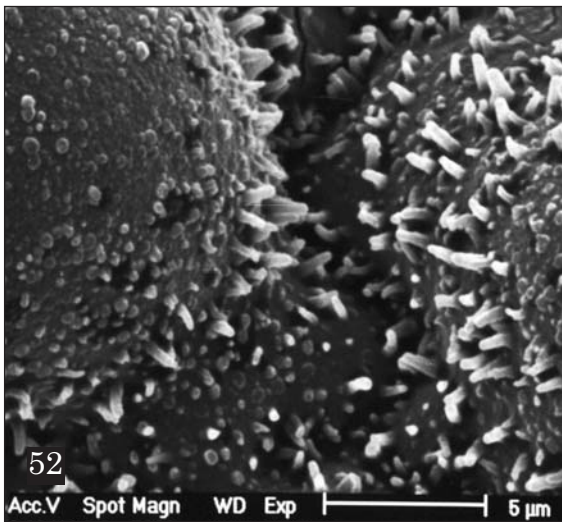
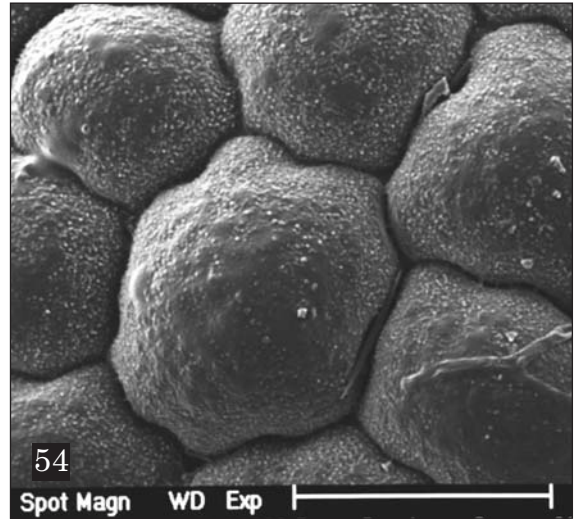
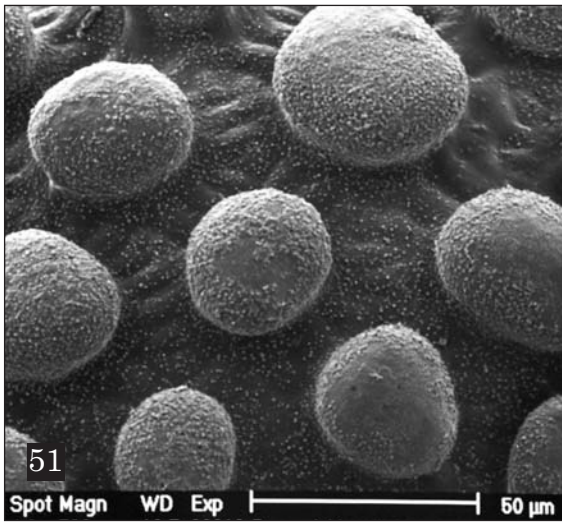
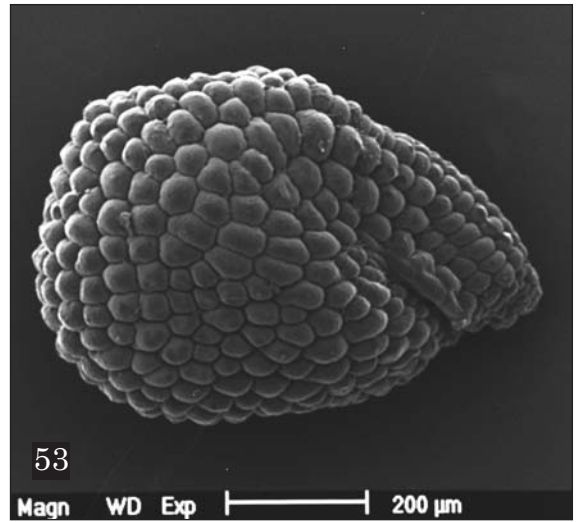
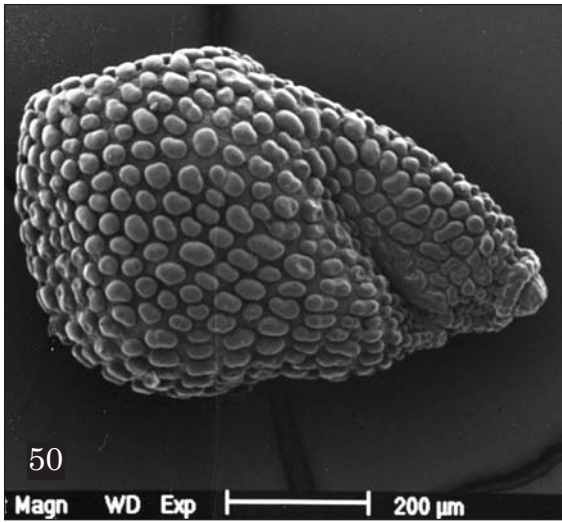
The “rosy purple” colour of the petals was reported for a single plant only, and most images of recent years possess scarlet to fiery red petals. These reports have led to misidentify the material as *D. lavisii*, a species occurring further to the west. Photographs of the range of colours from one locality taken in 2006 and being made available for this study by Schuette-Vlok, however, show clearly that both colour types occur in one population.

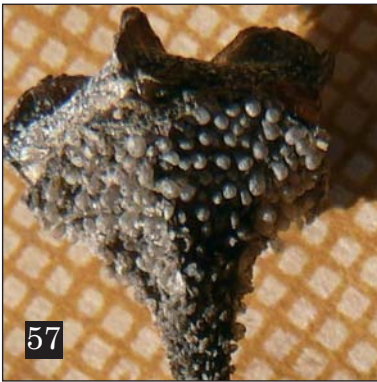
A fresh examination of the material drawn as *D. edwardsiae* (Figure 23) reveals that on that sheet, two numbers are involved: *BH* 19886 on top right hand side and the cited type number *BH* 19937 at the bottom left hand side at the drawing of the fruit. This capsule, however, lacks any closing bodies which have been found in the fresh material of *Hartmann & Court* 34651. Since no other species of *D.* subg *Speciosa* with the shown peculiar flower colour is known, the drawing must be considered authentic, and it could have happened that a wrong number has been applied. Alternatively, two collections may have been involved, but such an error cannot be traced. Neither can the question of the lacking closing body be solved, although in the light of recent new insight in the constancy of the colour of the expanding sheets a fruit from a different species may have been added to the material. Such a mixture has been found in other species of *Drosanthemum* as well. In summary, however, the true assemblage cannot be determined with certainty. On the other hand, no doubt exists that material found recently by Schuette-Vlok and by Hartmann & Court represents the true species.

Drosanthemum hallii L.Bolus, *J. S. Afr. Bot.* 33: 66 (1967). Holotype: *Hall 2119* (BOL).

Shrubs with erect to oblique stout stiff branches, the main stem shorter than the soon developing side branches, the first of which are formed at the two basal nodes, resulting in mostly four equal lateral stems that branch in the same pattern as the main stem, namely from the bottom (Figures 1, 2); in open places mostly as tall as wide, about 25 cm each dimension, taller in denser vegetation and sometimes flatter in the open; the angle between the two side branches from one node is usually about 90°, often wider; internodes with rather densely distributed round bladder cells in two different size classes, the bigger often on an elevated tiny hill of the epidermis (Figure 20); leaves erect or apically recurved, but the tip rather rounded and never uncinat, 10–15 bladder cells per side, arranged in conspicuous longitudinal rows (Figure 20), (7)–15.5–(25) mm long, (1.1)–2.5–(4) mm wide, (1.5)–2.2–(3.5) mm thick; pedicels similar to internodes, bladder cells mostly denser though (Figure 20); calyx base with 8–13 bladder cells per side along the prominent ridge; petals typically deep golden yellow (Figure 34), in some plants also with scarlet tips and outer surfaces, but usually one colour type per plant, rarely petals scarlet or reddish-orange with a yellow base or petals cream coloured (Figures 29–31); the thread-shaped black filamentous staminodes at most as long as the stamens in the freshly opened flower and few, i.e. only about one ring of 30 to 70 elements, rarely in single flowers up to 82; beside sterile black filamentous staminodes, black filaments bearing anthers have also been found, and several intermediate stages in colouring if the filaments and filamentous staminodes can be reported in various populations (Figures 35, 36); in the open fruit, the broad prominent dark brown expanding sheets are well developed (Figure 38), capsule diameters 9 mm, younger fruits up to 10.5, older ones as small as 7 mm wide, the height about 6 mm, i.e. the capsule distinctly wider than high. Seeds brown to golden, the inner integument short and truncate (Figure 53), glittering from elevated testa cells packed close together over the entire surface with softly undulating anticlinal walls (Figure 54), adorned with very short rodlets (Figure 55), appearing like

Figures 50–55 (opposite). SEM graphs of seeds. **Figures 50–52.** Seeds of *D. speciosum*. **Figure 50.** Side view of a seed showing the distant elevations that cause the distinct glittering of such seeds. Note the protruding inner micropyle. *Hartmann & Dehn* 26178. **Figure 51.** Close-up of the dorsal region: visible are central elevations and flat basal area around them, the anticlinal walls are deeply undulate. *Bruckmann & Hansen* 32448. **Figure 52.** Close-up of the testa cell surface adorned with single rodlets as fine sculptures. *Hartmann* 30216. **Figures 53–55.** Seeds of *D. hallii*. *Bruckmann & Hansen* 32457. **Figure 53.** Side view of a seed with elevated testa cells in a closed layer. Note the truncate inner micropyle in contrast to Figure 50. **Figure 54.** Close-up of the dorsal region showing the slightly undulate anticlinal walls of the elevations. **Figure 55.** Close-up of the fine sculptures on the testa cells, here as protrusions of less clear margins and lower than in Figure 52. SEMs: Jutta Krüger.





tiny grains in smaller resolutions (Figure 54), 0.66–0.86 mm long and 0.47–0.63 mm broad.

Ecology: On Witteberg shale or shale-sandstone in Breede Shale Renosterveld, rarely in Breede Quartzite Fynbos, in the open or rarely near other shrubs, also common in disturbed places on gravel and stones, expecting c. 500 mm annual precipitation in winter.

Distribution: South of Worcester, 33°40' to 33°52' S and 19°22' and 19°33' E, Western Cape Province, South Africa.

Material seen: Bayer 7274 (HBG); Bruckmann & Hansen 32457 (HBG); Hall 2119 (BOL); Hartmann 30210 (HBG); Hartmann & Bayer 34610, 34611, 34612, 34613, 34615 (HBG); Le Roux 4, 6, 15, 17, 26, 28, 38, 46, 50, 57, 66, 101, 102 (NBG).

Notes: The first description of the species was based on a sample with yellow flowers, hence all collections with yellow petals and black filamentous staminodes have at a time been named *D. hallii*. Since several years, however, repeated observations of flowers with red-tipped petals in otherwise yellow petalled populations have been reported, either as a simple deviation or identified as *D. micans*. The extensive recent study shows that plants are constant in their petal colouring pattern, but populations are not. They agree in all critical vegetative features with plants from the type locality (strictly yellow), but note must be made that other deviations like ivory coloured (Figures 29–31), orange, or red petals are also found on plants not differing from the type material in all other character expressions as well. Beside the low number of black filamentous staminodes, the species seems to be unique in showing a transition from white filamented stamens to black sterile filamentous staminodes, usually with a rounded flat tip below which an anther can sit, breaking off early in anthesis, these black elements often almost invisible in the older open flower, a character expression differing clearly from samples of *D. bellum* (compare description).

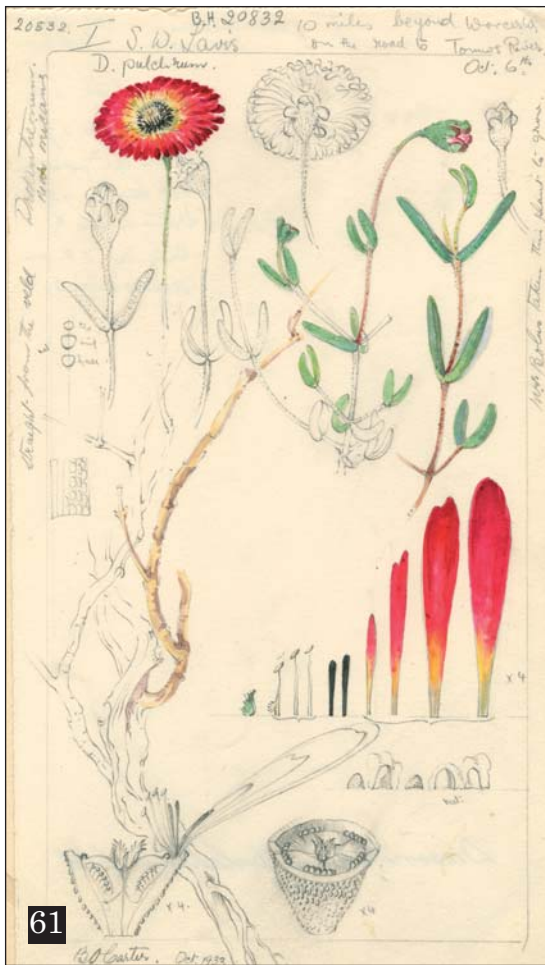
Both *D. bellum* and *D. hallii* differ distinctly from *D. micans* occurring also nearby in having

less than 15 bladder cells along the side of the leaf and more prominent bladder cells of two size classes on the internodes and pedicels, which appear stouter and rougher than those of *D. micans* to the naked eye. The remarkably thick distinct dark expanding sheets clearly separated from the expanding keels (Figures 37–40) are also found in *D. micans* and *D. boerhavia*.

Drosanthemum lavisii L.Bolus, *Notes on Mesembrianthemum* 2: 482 (1935) Holotype: *Lavis BOL* 21372 (BOL!).

Slender to spreading loosely growing shrubs to 25 cm tall with more or less erect thin branches supported by taller plants in near-by denser vegetation, the angle between the leaves from a node usually < 90°, side branches all along the main stem and again along the major lateral axes, diameters of plants to 30 cm in more open places (Figure 6); internodes finely rough from bladder cells, smaller ones globose and bigger ones oval, attached laterally, often in an elevated area of the leaf surface, leaving the epidermis proper visible, and more so on older internodes (Figure 12); leaves adorned with an apical mucro recurved to form a distinct hook, especially on young leaves (Figure 14), sometimes less prominent in older leaves, trigonous in section, 21–28 bladder cells per side, i.e. belonging with the smooth leaf surface type in the subgenus, the globose to oval bladder cells densely packed forming a secondary layer above the normal epidermal cells and the level stomata (Figure 14), leaves 10–18 mm long, 1.2–3 mm wide, 1.4–2.5 mm thick, i.e. appearing usually flattish; pedicels similar to internodes in possessing two different shapes and sizes of bladder cells, more densely arranged than on internodes, bladder cells uniform on the calyx base, 9–13 per side along the prominent ridges; petal colours mostly pink at the base, followed by bright yellow or orange and bright red in the outer parts of the elements, the colours can merge into one another along the petals, and orange can also dominate in the flower (Figures 26–28); the thread-shaped black filamentous staminodes distinctly longer

Figures 56–60 (opposite). *D. boerhavia*. **Figure 56.** View of ploughed lands from a rocky hill into which *D. boerhavia* seems to have retreated after the flatter areas with deeper soils have been used for agriculture. **Hartmann & Bayer** 34697. **Figure 57.** Close-up of the capsule base showing the prominent big bladder cells on the calyx merging into elongated cells on the pedicel. **Hartmann & Bayer** 34478. **Figure 58.** Close-up of the type plant of *Ecklon* 2069 (S) demonstrating the elongated bladder cells along the base of the calyx and on the upper pedicel. Photo: H.E.K. Hartmann with permission from S. **Figure 59.** Drawing of type material of *D. strictifolium*, now a synonym of *D. boerhavia*. Note the spiny old basal branches in the old plant and the long bladder cells on the calyx base. **Figure 60.** Image of the type plant of *D. boerhavia* kept at S. Note that the plant is young and probably in its first season. The piece near the basal left hand side corner is a different species, *D. calycinum*, as noted by Bolus already (note on sheet). Photo: H.E.K. Hartmann with permission from S.



Figures 61–62. *D. pulchrum*. **Figure 61.** Drawing of the type material kept at BOL and made available by JSTOR. Note the short black filamentous staminodes with rounded tips and the numerous small bladder cells along the sides of the calyx. With permission from BOL. **Figure 62.** A dissected flower illustrating the clear difference between the stamens and the black filamentous staminodes. *Le Roux* 76/1.

than the stamens in the young flower (Figures 27, 28), later pushed to the outer edge by the developing stamens, forming there a thick prominent ring (Figure 26); in the open fruit, the yellow-orange expanding sheets remain thin and flat, merging into the expanding keels (Figure 43), resembling conditions found in *D. speciosum*; capsule diameters usually about 8 mm (7–11), a little wider than high. Seeds with dome shaped testa cells, the elevations a little distant from one another, the micropyle flattish, about 0.7 mm long and 0.55 mm broad.

Ecology: On conglomerate with quartz pebbles, in shrubby vegetation, in disturbed places, and amongst *Restio* (Figure 6), expecting 375 to 500 mm rainfall p.a., distributed over the entire year. **Distribution:** Between 34° and 34°30' S and from 19°50' to 21°15' E, Western Cape Province, South Africa.

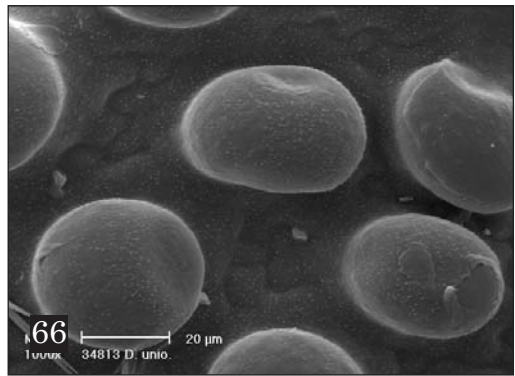
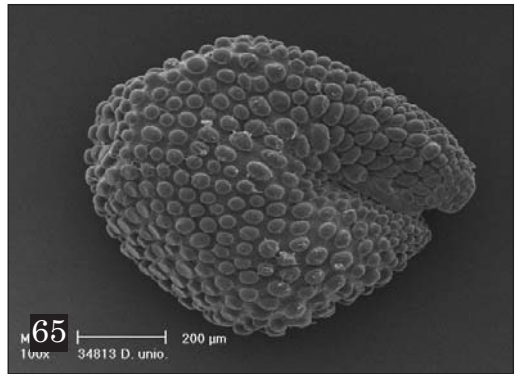
Material seen: Bayer 7465, 7493, 7498, 7570, 7572 (HBG); Hartmann & Bayer 34480, 34643, 34693, 34703 (HBG); Lavis BOL 21372 (BOL).

Notes: Together with *D. uniondalense* and *D. edwardsiae*, *D. lavisii* forms a group of species that can be recognized by the possession of uncinat leaf tips, i.e. the tip of the leaf is permanently and constantly recurved like a hook-shaped mucro, best visible in young leaves. All three species share their smooth leaf surfaces with *D. speciosum* and *D. pulchrum* (Diagram 1, see also Hartmann, 2008 for the latter and *D. edwardsiae*), standing in contrast to the “rough-leaved” species *D. hallii*, *D. bellum*, and *D. micans*. With *D. boerhavi*, *D. lavisii* shares the possession of rough calyx bases with 9–13 bladder cells per lateral ridge in the row. Still another grouping can be found in the mutual possession of yellow-orange expanding sheets placed like aligning on the valve in *D. lavisii*, *D. speciosum*, *D. pulchrum* and *D. uniondalense*.

Drosanthemum micans (L.) Schwantes, *Zeitschrift für Sukkulentenkunde* 3: 30 (1927). *Mesembryanthemum micans* L. (1753): 485 non Thunberg (1800): 91 nomen illeg. Lectotype: Dillenius (1732): f 282, t. 215 (designated by Hartmann, 2001). Epitype the figure of Dillenius 1732 coloured by himself at the Bodleian Library, Oxford (designated by Hartmann, 2011).

Description (Hartmann, 2011).

Notes: *D. micans* shares with *D. hallii*, *D. bellum*, and *D. boerhavi* the character states of rough calyx bases and rather rough leaf surfaces as well as the possession of thick cushion-shaped



Figures 63–66. *D. unionaldense*. **Figure 63.** Flower in cultivation in the greenhouse at HBG. Leaves tend to change their shape in shady cultivation. *Hartmann* 8825. Photo: Christiane Bruckmann. **Figure 64.** Close-up of the capsule base with numerous bladder cells. *Hartmann* 34813. **Figures 65–66.** Seeds of *D. unionaldense*. *Hartmann* 34813. **Figure 65.** Side view showing the distant central elevations of the testa, agreeing with the arrangement in *D. speciosum*, Figure 50. **Figure 66.** Close up of the dorsal region with testa cells in shape like those of *D. speciosum*, Figure 51.

expanding sheets distinctly separated from the expanding keels. Only with *D. hallii* it shares the low number of 30–70 black filamentous staminodes. It can best be distinguished by its relatively smooth leaf surfaces (Diagram 1) and the fact that the side branches grow predominantly erect, forming a broom in side view (Figures 7, 11). Furthermore, the plants are most often found settled close to other bushes into which they can scramble.

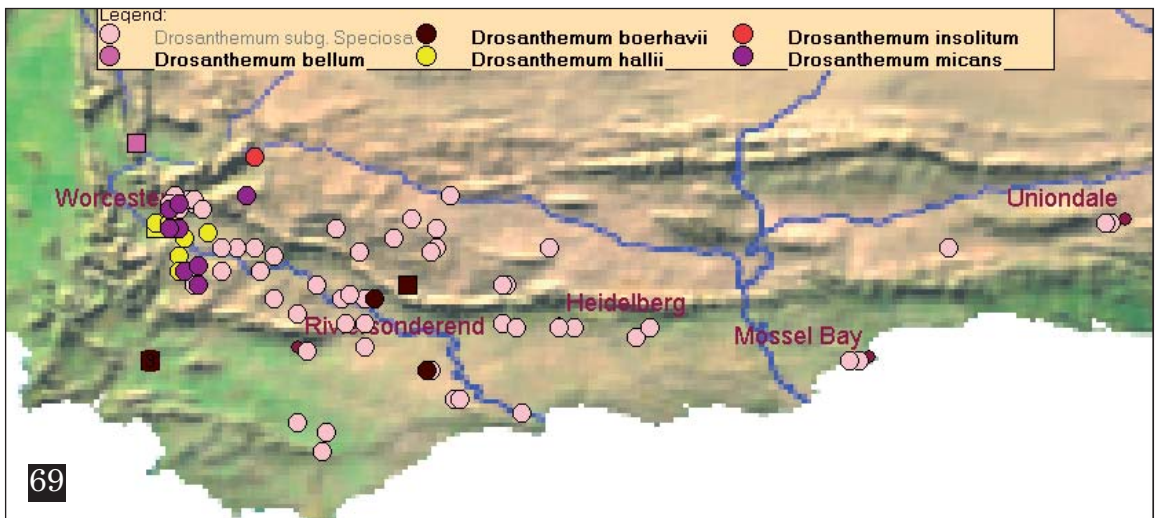
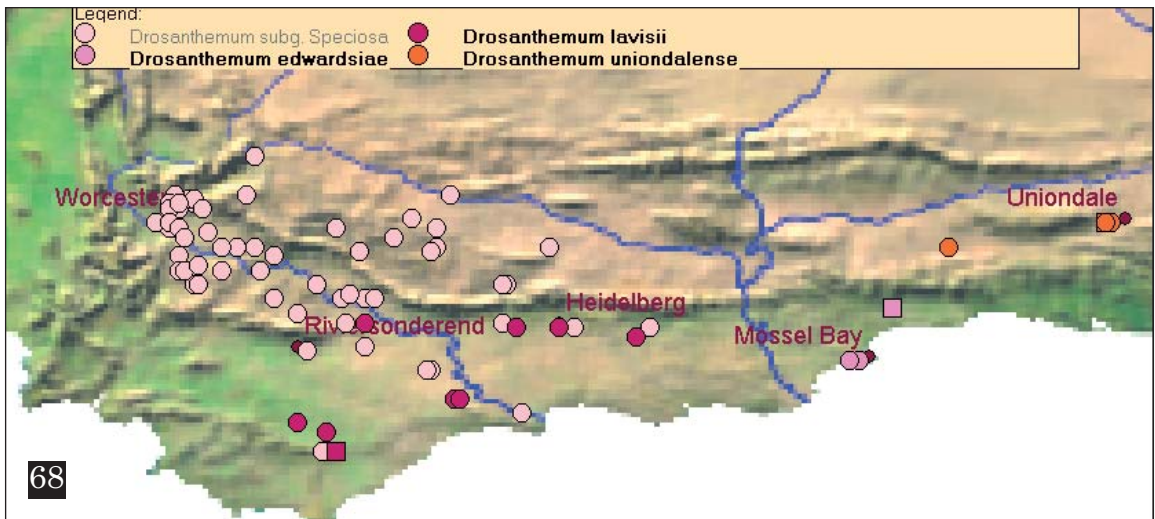
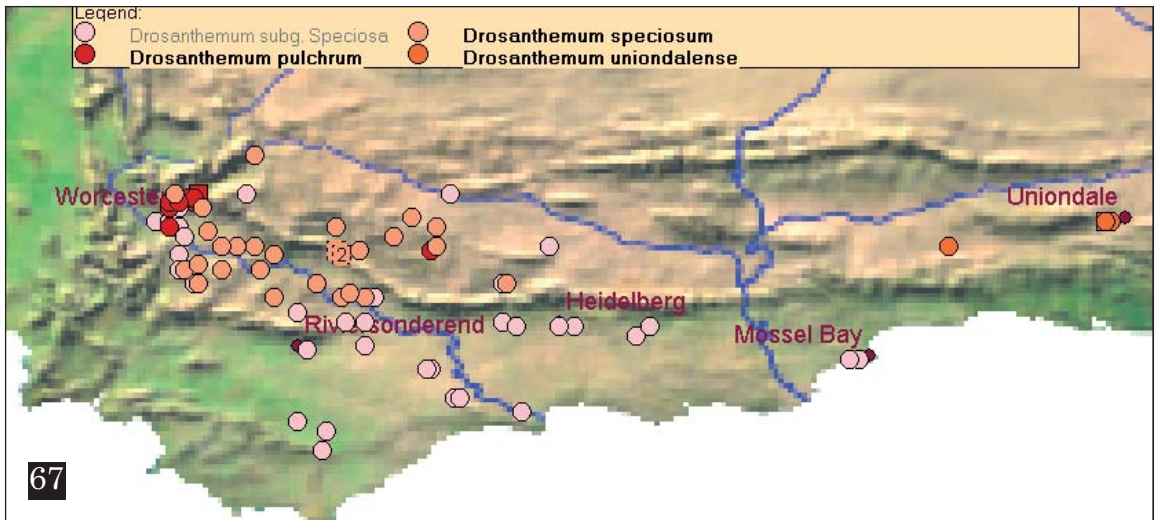
Drosanthemum pulchrum L.Bolus, *Notes on Mesembrianthemum* 2: 424 (1934). Holotype: *Lavis BOL* 20832 (BOL!).

= *Drosanthemum croceum* L.Bolus, *Notes on Mesembrianthemum* 2: 424 (1934).

Holotype: without collector *BOL* 21031 (BOL!).

Low broad shrubs 15–25 cm tall, diameters 60 to 80 cm in the open, taller and straggly in other bushes; internodes with inconspicuous ovate bladder cells, small and bigger ones in different size classes; leaves almost linear in side view, taper-

ing only moderately to the tip, almost semicircular in section, leaf surfaces smooth from 18–23 bladder cells per side of leaf, hence greyish in appearance, length 19–25 mm, width mostly 3 mm, diameter mostly 3 mm; calyx base smooth with 15–20 bladder cells along the prominent lateral veins, petal colours mostly deep orange to fiery red with yellow bases above a basal green ring, but also yellow or orange with a basal green circle, more rarely appearing longitudinally striped; the colours can merge into one another along the petals or appear sharply bordered, supporting the aspect of a central eye in the flower; the c. 110 flat black filamentous staminodes distinctly shorter than the stamens (Figure 61) and not merging into the stamens, the filaments white towards grey, but never black (Figure 62); capsules with thin orange or ochre coloured expanding sheets merging into the expanding keels (Figure 42); seeds with semiglobose elevations of the testa cells with only narrow undulate or omega-shaped anticlinal walls between them, 0.6–0.65 mm long and 0.45–0.5 mm broad in side view.



Ecology: Mainly on Malmesbury shale in Succulent Karoo Renosterveld, also on Witteberg shale-sandstone, often straggly in the shrubby vegetation, expecting between 250 and 375 mm rainfall p.a. mainly in winter.

Distribution: NE and SW of Worcester, Western Cape Province, South Africa.

Notes: *D. pulchrum* shares with *D. speciosum*, *D. lavisii*, and *D. uniondalense* the possession of thin expanding keels appressed to the valve like a lining and merging into the expanding sheets. Within this group, it agrees in having black filamentous staminodes shorter than the stamens from the beginning of the anthesis with *D. speciosum*, with which it has been confused in the past (Hartmann, 2008), but it can be distinguished by its more straggly growth and its almost terete leaves narrowing to the tip and the base.

Drosanthemum speciosum (Haworth) Schwantes, *Zeitschrift für Sukkulantenkunde* 3: 30 (1927). *Mesembryanthemum speciosum* Haworth *Observationes...*: 267 (1795). Neotype: designated by Hartmann (2007): Drawing of Duncanson 1824 (K).

= *Drosanthemum pickhardii* L.Bolus, *J. S. Afr. Bot.* 33: 66 (1967). Holotype: *Pickhard* NBG 2610/32 (BOL!).

= *Drosanthemum splendens* L.Bolus, *Notes on Mesembryanthemum* 2: 483 (1935). Holotype: *Pickhard* NBG 2609/32 (BOL!).

Stout shrubs 15–35 cm tall, diameters 25 to 60 cm in the open, very rarely higher and straggly in other bushes; leaves thickest in their middle, tapering to base and tip, distinctly trigonous with rounded margins and keel in section, the upper leaf surface collapsing forming a deep furrow when drying, leaf surfaces smooth from 24–52 small bladder cells, hence greyish in appearance, length 12–25 mm, width mostly above 4 mm, diameter mostly 5–6 mm, i.e. thicker than wide; internodes with rather small dispersed bladder cells in two different size classes, like the pedicels; calyx base of the solitary flower smooth from 18–25 bladder cells along the vertical sides; petal colours most variable as described by Hartmann (2008); capsules in most populations longer than wide, expanding sheets thin, often translucent, appressed to the valve, merging into the expand-

ing keels; seeds with almost globose distantly spaced knobs, hence appearing more glittering than other species under a lens, 0.65–0.8 mm long and 0.45–0.55 mm broad in side view.

Ecology: On shaly or gravelly gentle slopes of different origins like Malmesbury shale, quartzite, also on table Mountain Sandstone as well as Bokkeveld and Ecca shales, often on disturbed roadsides in almost monotypic stands in Succulent Karoo, more rarely in shrubby vegetation, expecting usually below 375 mm of rainfall p.a. in winter or with peaks in March and November.

Distribution: In a broad band from Worcester to Heidelberg (Figure 67).

Material seen: *Bayer* 7438, 7439, 7442, 7467, 7471, 7528, 7575 (HBG); *Bruckmann & Hansen* 32448, 32455 (HBG); *Hartmann* 29021; *Hartmann & Bayer* 34459, 34470, 34476, 34594, 34600, 3401, 34602, 34604, 34609, 34618, 34619, 34620, 34689, 34716 (HBG); *Hartmann et al.* 25874, 26178, 30216 (HBG).

Drosanthemum uniondalense H.E.K.Hartmann, *spec. nov.*

Fruticuli erecti ad 40 cm altitudinem et diametrum, anguli inter axes laterales de nodo minime < 90°, axes laterales ascendentes in fasciculum formati; internodiis cellulis vesicariis ovoideis et elongato-ovoides, in senectudine acutis et procumbentibus; foliis trigonis in sectione, apicibus uncinatis mucronatis, cellulis vesicariis circa 27 per latus, hinc paginis laevibus; basis calycis cum circa 18 cellulis vesicariis per porcam.

In glarea elevata juxta viam in vegetatione fruticosa aperta.

Prope Uniondale, Western Cape Province, South Africa.

Holotype: *Hartmann* 34813 (HBG).

Erect shrubs to 40 cm tall and about 40 cm in diameter with branches all along the main stem (Figure 4), the angles of a pair of side branches a little less than 90° to wider, curving into an erect position soon, in the end reaching a bundled or fasciculate condition (Figure 10); internodes rough from oval to elongate-oval bladder cells laterally attached (Figure 13) and, when dry and old, with a slightly raised extension like a flap, leaving the epidermis proper visible; leaves provided with an

Figure 67 (opposite). Distribution of *D. speciosum*, *D. pulchrum*, and *D. uniondalense*, all species with smooth leaf surfaces and smooth calyces; *D. uniondalense*, however, also with an uncinat leaf tip. **Figure 68**. Distribution of *D. lavisii*, *D. edwardsiae*, and *D. uniondalense*, all with uncinat leaf tips. **Figure 69**. Distribution of species with rough leaf surfaces and rough calyces: *D. bellum*, *D. boerhavi*, *D. hallii*, and *D. micans*, plus a population named “*D. insolitum*” that might have to be included in *D. hallii*.

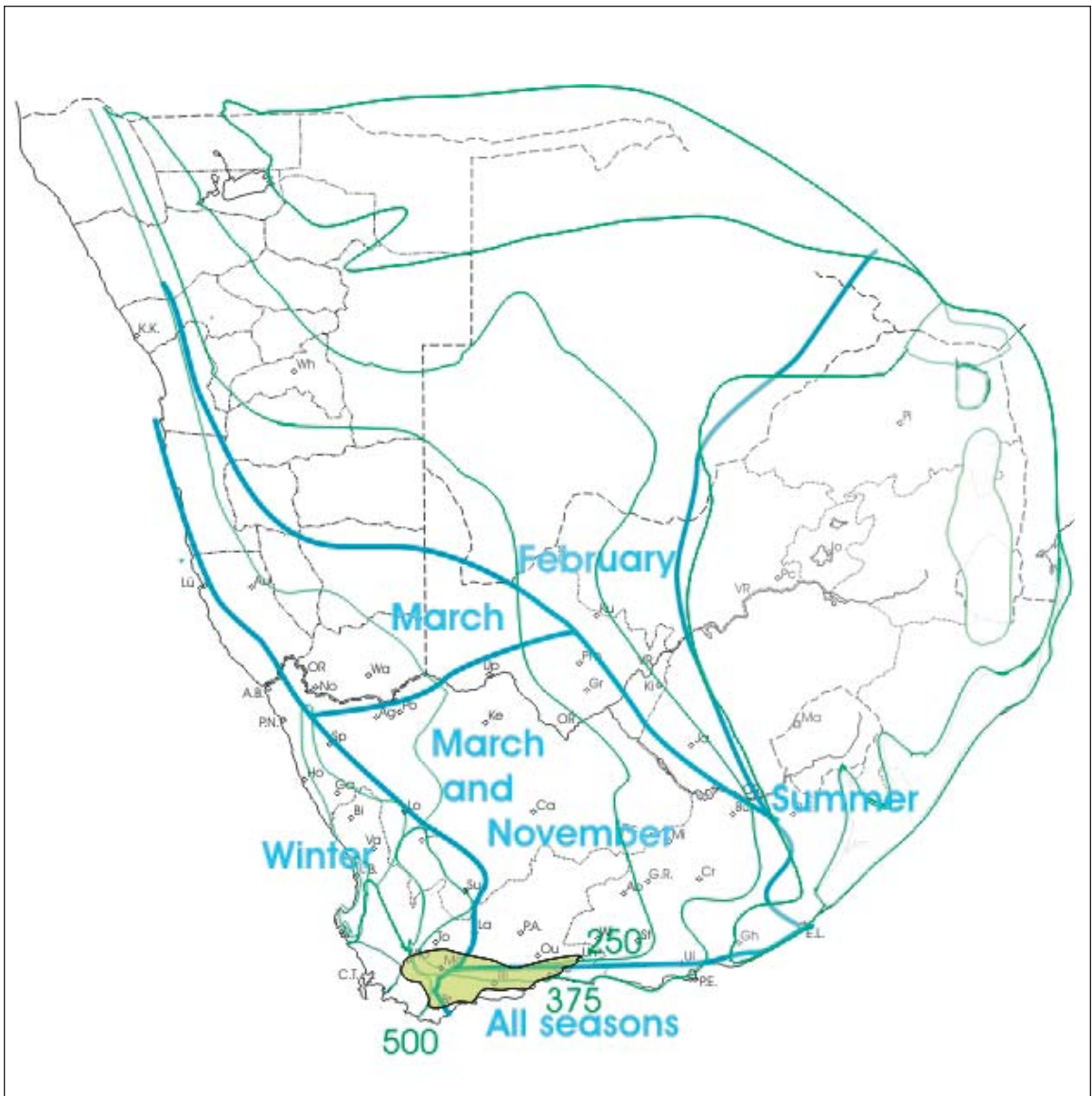


Figure 70. Rainfall patterns over Southern Africa, the area of *D. subg. Speciosa* marked in olive. Green lines mark boundaries of annual rainfall, blue thick line mark the areas in which certain rainy seasons prevail, base on about 60% of the annual precipitation.

apical mucro recurved to form a distinct hook, especially on young leaves, sometimes less prominent in older leaves (Figure 13), trigonous in section, about 27 bladder cells per side, i.e. belonging with the smooth surface types in the subgenus (Diagram 1), the globose to oval bladder cells densely packed forming a secondary layer above the normal epidermal cells and the level stomata, leaves 17 mm long, 3 mm wide, 3 mm thick, trigonous to triquetrous; pedicels similar to internodes, bladder cells on the calyx base about 18 per side along the prominent ridge (Diagram

1, Figure 64); petals deep yellow, base deep orange or white, about 80; the black filamentous staminodes at most as long as the stamens and narrowing to more or less acuminate tip, c. 210 (Figure 63), stamens up to 250; the open fruit exposing thin orange to brown expanding sheets merging into the lighter expanding keels, closing body absent, but in some cases a flat white spongy area between the valves can be recognized (Figure 44), capsule diameters usually 10–11 mm, about as wide as high; seeds with distant nearly globose elevations on the testa cells (Figure 65), leaving a

flat area around them, the anticlinal walls deeply undulate (Figure 66), the inner micropyle not protruding prominently but rather truncate (Figure 65), 0.7–1 mm long, 0.6–0.9 mm broad.

Ecology: On gravel or brown sandstone, in Uniondale Shale Renosterveld expecting 250 mm rainfall p.a. with an inconspicuous peak in March (Vegetation type Frs16 after Mucina & Rutherford, 2006).

Distribution: In the districts Uniondale and George, Western Cape Province, South Africa.

Material seen: Bayer 7547 (HBG); Hartmann 8825, 34813 (HBG).

Notes: With the smooth leaves, finely papillate calyx bases, and glittering seeds with high central elevations of the testa cells, *D. uniondalense* resembles *D. speciosum* most closely, differing from the latter in showing a pronounced apical recurved tooth or mucro and in the often darker expanding sheets as well as in branching patterns. The two known samples with seeds of the species possess the biggest seeds ever seen until now in the subgenus. The mucro is also present in *D. edwardsiae*, a species known until now only from the coast around Mossel Bay on calcareous cliffs, which differs further from the new species in having rough calyx bases with 10–13 bladder cells along the ridge of the capsule and a closing body inside the fruit. Further fieldwork will reveal whether the recorded strictly yellow petals are a distinct feature of the new species.

Acknowledgements

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Directors of herbaria BOL, K, OXF, and S are thanked for loans of sheets and further images, including permission to publish drawings available in JSTOR by BOL plus permission from the director of S to use a photograph taken of the type sheet while on loan at HBG.

The program taxo2map used to picture distribution from an ACCESS databank was developed by Marco Fischer.

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Drawing a line in the sand

Using natural materials to assist in the rehabilitation of badly eroded areas around the Brandvlei Dam near Worcester in the southern Western Cape

by Anso le Roux

The vast area currently covered by the Brandvlei Dam near Worcester was formerly part of an ancient floodplain to the south of the Breede River. This floodplain is characterized by thick layers of alluvial deposit and extends from south of the town of Worcester in the direction of Villiersdorp. Aerial photographs from 1942 portray a braided network of rivers and rivulets draining the mountains to the south of the Brandvlei Dam where the Holsloot- and Smalblaar Rivers originate. The lower reaches of these rivers historically flowed over the same floodplain in a northerly direction and became part of the Breede River in the area where the Brandvlei Dam is today. Winter run-off from these two rivers, stored in the Brandvlei Dam, supplies irrigation water to farms in the Robertson district.

A range of hills north of the dam is wedged between two floodplains, the above mentioned floodplain to the south, and the Breede River to the north. Over the ages, strong south-easterly and

north-westerly prevailing winds carrying alluvium sand from these floodplains resulted in the accumulation of windblown sand in several areas on the slopes of the hills north of the dam. Windblown sand deposits of various depths, from just a thin layer to several meters deep, on top of clay or loam soils derived from the Witteberg geological series of the Cape Supergroup, are characteristic of the area.

“A knowledge of sand tactics is essential”

Alluvial sand-transport to the environs of these hills is now minimal due to the transformation of vast areas of former floodplains into agricultural farmland, canalization of the former braided river systems and permanent inundation of the vast southern floodplain by the Brandvlei Dam. These factors facilitated the stabilization of the larger Breede River floodplain area as well as the wind-

ABOVE: An eroded four-wheel drive track leading down a steep slope towards the Brandvlei Dam, March 2006.

BELOW: The same track in April 2010 showing how the width and depth slowly improve as a result of sand accumulated by vegetation growth. Photos: Anso le Roux.





ABOVE RIGHT: Before: An extensively eroded track in March 2006.

ABOVE: After: The same track after the first rehabilitation attempt in September 2007.

RIGHT: Grass and restio species have become established in a badly eroded track three years after the start of rehabilitation. Photos: Anso le Roux.



accumulated sandy patches of the range of hills mentioned earlier, with vegetation colonizing the deposits. However, recently the natural vegetation of the area around the Brandvlei Dam has been considerably degraded, mostly from irresponsible recreational four-wheel driving. This damages the vegetation cover on the steep, sand-covered slopes, resulting in an extensive network of bare sandy tracks. Frequent driving, together with water and wind erosion, rapidly turned these tracks into deep, eroded trenches because the loose sand is so unstable and dependant on the protection that vegetation cover provides.

The area is also arid, so vegetation recovery is a long process. Strong prevailing north-westerly and south-easterly winds exacerbate erosion and prevent vegetation from establishing in the sandy tracks. As

the ditch becomes deeper it thus also becomes wider and wider as more sand is carried downwards along the slope. The trenches become longer as the vegetation at their upper end is undermined and collapses with consequential erosion of the trenches upwards.

Sand reclamation and stabilization has long been a problem. More than a century ago, the British geographer Dr Vaughan Cornish, who gained a special place in the scientific world for his study of waves, wave processes and landforms, stated that 'the reclamation of tracts of blown sand is a practical art destined to be of immense importance. For the development of the art, a knowledge of sand tactics is essential, but not in itself sufficient'.

In our case, urgent measures were needed to mitigate the continuous negative impacts on the network of bare sandy tracks.

We needed to:

- Stop the vehicle access to the area.
- Stabilize the sand where vegetation cover is damaged or destroyed and prevent the erosion trenches from becoming longer, deeper and wider.
- Create favourable conditions for the accumulation of dust and sand in the trenches.
- Create favourable conditions for seedlings of pioneer vegetation to settle and stabilize the sand for the establishment of perennial vegetation in the later stages of secondary succession.
- Stop further erosion by stabilizing and vegetating the trenches as the filling of deep trenches is not possible due to minimal sand being transported into the area.
- Advocate environmental awareness by pointing out how off-road driving damages vegetation cover, especially in sensitive environments.

The rehabilitation process

The scale of the erosion was assessed on a visit to the site in March 2006 where three areas were identified. We placed them in three categories – extensive, high and moderate. (See box on left)

Erosion category		
Extensive	High	Moderate
Vegetation completely destroyed, track clearly visible. Sand destabilized and highly mobile. Deep eroded trenches with exposed walls due to wind and water erosion as well as colluvium movement of sand down-slope	Vegetation completely destroyed track clearly visible. Sand destabilized and highly mobile.	Vegetation degraded, not completely destroyed, but track clearly visible. Sand destabilized, but not highly mobile due to remaining fragments of vegetation.

The main access road to the immediate erosion area was closed off using wooden poles and wire to create a barrier. An entrance gate at the main entrance to the dam was constructed to control access to the area and a signboard prohibiting off-road driving was requested and put up by the Department of Water and Forestry.

To minimize costs, we used natural materials in the form of brush packing, which consisted of tied brush-bundles (stakes tied into bundles of various sizes), as well as a packed layer of brush and mulching. These, we hoped, would help to decrease the mobility of destabilized sand, facilitate the accumulation of sand, stabilize the ditches and allow vegetation to grow. Brush-packing with natural material assists with soil moisture retention (which is very important when dealing with erosion in deep sand which drains well and dries out quickly; especially in frequent strong windy conditions as in our case). It also decreases soil temperature and thereby improves the microclimate for germinating plants. As soil and organic material particles collect against the network of branches and material lying on the surface, soil and humus movement in run-off (especially important in cases of erosion down a steep slope) is restricted. It protects the soil against the effects of wind erosion and serves to trap windblown sand grains. It eventually decays and contributes to the organic content of the topsoil. It traps wind-blown plant seeds and creates cover habitat for animals that contribute to soil and habitat condition.

This treatment on bare, exposed soil stimulates the protective effect of a plant cover which is the preferred goal of this rehabilitation project. Alien invasive Port Jackson (*Acacia saligna*) and Black Wattle (*A. mearnsii*), cleared from the sides of the tar road between Worcester and Rawsonville, were used for making the brush-bundles for primary packing into water retention furrows. Finer leaved Renosterbos (*Elytropappus rhinocerotis*), cut from a nearby strip intended for a firebreak, was used for secondary packing in between the brush-bundles. Branches of Renosterbos provide an excellent ground covering and mulch material as the fine leaved branches form a thin protective layer that traps dust, sand and seeds, retains moisture and protects the ground from wind exposure while letting sunlight and air through to ensure germination of seeds and successful plant growth.

Implementation

Loose sand is only stable at less than a certain angle of slope whereby an increase in the angle would trigger movement. Reduction of the angle to where the slope is stable and no movement of sand grains occurs (referred to as the angle of rest) is an important aspect when rehabilitating destabilized sand down steep slopes. The angle of rest depends on the grain size, grain size sorting and particle shapes under different conditions such as different moisture contents of the sand. Erosion takes place when,

at some point, the internal shear strength of the sand is overcome and the grains begin to move due to an exceeded angle of rest, or are carried in suspension by water, or lifted by wind. During gravity emplacement of sand down a slope, rainwater can support the moving of grains in such a way that the grains themselves may show behaviour similar to that of a fluid. The intensity of rain affects the mobility of sand.

Although the area normally receives rain in winter, co-inciding with the growing season when canopy cover diminishes the intensity of raindrops on the ground, rain intensity varies and thunderstorms may sometimes occur in autumn. Water retention furrows therefore need to be deep enough to provide stability to the brush-bundle, but not deep enough to accumulate water that could put pressure on the down-slope retention humps. The breaking of only one retention hump could significantly increase flooding down-slope and result in large amounts of sand being carried away in suspension, thereby destroying months of veld reclamation.

Branches of the cleared (seedless) alien invasive plants were cut into lengths equal to the width of the erosion trench, and tied with soft wire in brush-bundles of approximately 500 mm in cross section. For the deep trenches, thicker bundles were made.



ABOVE: The covering of packed brush-bundles and in-between mulch on a bare track with pioneer vegetation establishing after the first rehabilitation attempt.

BELOW LEFT AND RIGHT: A low-slope in March 2006 (left) and the same slope two years later, in December 2008 (right). Photos: Anso le Roux.



Water retention furrows were dug at more or less two metre intervals across the length of the erosion trenches. The depth of these furrows was made according to the depth of the specific eroded area and the thickness of the brush-bundles, assuring that approximately a third of the bundle fitted comfortably in the furrow. The sand from these furrows was positioned at the down-slope side of the furrow. The brush-bundles were pinned into the furrows with sticks and were secured to wooden poles driven in the sand across the ditch at regular intervals.

The brush was laid horizontally across the ditches in the slope, starting from the top working downwards. Where possible, the bundles were packed up to the height of the ditches, the idea being that windblown sand would accumulate with time to reduce the angle of slope in steep eroded areas and accomplish the specific angle of rest for this type and sorting of sand. Once the sand becomes stable the vegetation is given a chance to establish.

The bare open spaces between the brush-bundles were covered with *Renosterbos* branches, secured in the sand with pegs driven in deep enough to hold the brush mattress in place allowing windblown sand to settle and accumulate in the ditches. Seeds harvested from surrounding vegetation could have been sowed in the area, but the adjacent vegetation was deemed to be an adequate natural source. A piece of veld to the west of the study area was burned under controlled conditions in April 2009 and this burnt area acts as a firebreak to protect the slow process of veld reclamation in the rehabilitation site.

Monitoring

The progress of re-establishing vegetation at the site is monitored annually by noting and taking photographs. The veld was deemed satisfactory if pioneer plants had established a groundcover and the process of secondary succession had started, if sand mobility had been stopped or considerably reduced and if the rehabilitated area was in an advanced stage of secondary succession with perennial plants establishing themselves in the eroded parts.

If pioneer plants had not established a satisfactory groundcover and if the process of secondary succession had started, but was being impaired, the reclamation was regarded as being unsuccessful. If sand mobility had not been considerably reduced and was impairing the establishment of vegetation or if extensive bare areas still occurred, then the area was deemed in need of follow-up rehabilitation.

Overall success

The most important aspect of this rehabilitation attempt was the establishment of adequate vegetation cover. Vegetation cover stabilizes sand and prevents trenches from getting deeper as more and more sand moves down-slope, wider due to the sides caving in as the trench deepens, or longer due to damage to of vegetation and erosion at the upper end of the trench. None of the tracks, channels or deep trenches had deteriorated.



ABOVE AND BELOW: A deeply eroded channel in March 2006 (above) and in December 2008 (below) showing the brush-bundles totally covered with sand, and vegetation establishing well on the sides of the channel. Photos: Anso le Roux.



All plants accumulate more and more sand as they grow and the canopy cover that plants provide protects bare areas from wind as well as trapping moisture. Plant roots improve stability by binding the sand, especially so with species with creeping stolons such as *Ehrharta villosa* and *Cynanchum africanum*. Surprisingly, some of the deep areas are slowly but surely filling up as plants trap sand with consequential sand mounds growing as the plants grow. Although some of the deep trenches would still benefit from follow-up protection, the methods used proved to be sufficient. The goal of this reclamation project was largely achieved as loss of sand in the larger part of the area was stopped, and sufficient vegetation cover stabilized the trenches.

With time, most of the packed brush-bundles were covered with sand to various degrees (some completely covered), which emphasizes the outstanding sand-trapping capacity of secured brush packing and the positive contribution it made to veld reclamation under difficult circumstances.

A more detailed study of the rehabilitation operation is available from the author or from voget@kingsley.co.za.

GET CONNECTED

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WHAT DOES THAT MEAN?

alluvium (alluvial) A deposit of clay, silt, sand, and gravel left by flowing streams in a river valley or delta.

braided rivers A network of converging and diverging streams separated from each other by narrow strips of sand and gravel.

brush Branches with leafy material.

canopy The top layer of a forest or wooded ecosystem.

floodplain An area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

stolon A horizontal stem produced just below soil level from the base of the mother plant, resulting in a new plant at the tip.



New taxa in *Moraea* subgenera *Moraea* and *Vieusseuxia* (Iridaceae: Irideae) from Western Cape, South Africa



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ABSTRACT

We describe one new species and three new subspecies of the African and western Eurasian genus *Moraea* (Iridaceae) from Western Cape. *Moraea helicoidea* (subg. *Vieusseuxia*) from Worcester is known from a single small population on Dwyka Tillite overlying sandstones of the Witteberg Group of the Cape System. The long-lasting flowers have reduced inner tepals with short, obscurely trilobed limbs that place it in subg. *Vieusseuxia*, where it stands out in having two foliage leaves. Other species in the subgenus, except for *Moraea fergusoniae*, all have a solitary foliage leaf and we infer that *M. helicoidea* is most closely related to that species. In *Moraea tricuspidata* (subg. *Vieusseuxia*), we recognize two new subspecies: subsp. *parviflora* from the northern end of its range (Cedarberg, Cold Bokkeveld and Piketberg) and subsp. *cornifera* from the eastern end of its range (Kammanassie and Langkloof). Subspecies *parviflora* is distinguished by its smaller flowers with shorter and narrower tepals and is often a taller plant, up to 1.2 m, with up to four branches at each of three or four aerial nodes. Subspecies *cornifera* has flowers similar to those of subsp. *tricuspidata* in size but shorter, fully united filaments, and a prominent corm in the axil of the foliage leaf. It is in addition polyploid. We also recognize the Cedarberg and Cold Bokkeveld populations of the southwestern Cape *Moraea papilionacea* as the new subsp. *glabrescens*, distinguished from typical plants by its subglabrous foliage, smaller and exclusively yellow flowers, and smaller inflorescence spathes. In addition, we report modest range extensions for *Moraea fistulosa* (subg. *Polyanthes*) and *Moraea intermedia* (subg. *Umbellatae*), known until now only from their type localities.

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1. Introduction

The African, Mediterranean, and Middle Eastern genus *Moraea* Miller, now with some 230 species (Goldblatt and Manning, 2014a, b, c; Goldblatt et al., 2013), is centred in the southern African winter rainfall zone. The circumscription of the genus was greatly widened by Goldblatt (1998) to include all cormous Iridoideae with bifacial or secondarily terete leaves. *Moraea* is now taxonomically well understood as a result of the publication of a series of partial and regional revisions (e.g. Goldblatt, 1973, 1976a, 1979a, b, 1981, 1986, 1987, 1998). The recent publication of a new infrageneric classification for the entire genus based on molecular data (Goldblatt et al., 2013) has established the relationships among the species. New taxa in this large and diverse genus are, however, still being discovered, especially in Western and Northern Cape (e.g. Goldblatt and Manning, 2010, 2014a, b, c), and we describe a further four here.

A population of an unidentified species of *Moraea* was discovered in August 2014 near Worcester in Western Cape. Although unusually low in stature, it is otherwise typical of subgenus *Vieusseuxia* (D. Delaroche) Baker (Goldblatt et al., 2013) in having flowers lasting at least two days, with the limbs of the inner tepals reduced in size and obscurely 3-lobed. It is remarkable, however, in having two well-developed foliage leaves, whereas a single foliage leaf is characteristic of almost all members of the subgenus. The leaf blades are twisted or coiled in a loose helix and extremely narrow. Described here as *M. helicoidea* Goldblatt & J.C. Manning, the species is presumably allied to *M. fergusoniae* L. Bolus, the only other species of the subgenus that consistently has more than a single leaf, and also of low stature with similar inner tepals.

Populations of a tall species of *Moraea* discovered in October 2014 in the southern Piketberg of Western Cape could not immediately be identified. The plants were evidently closely allied to *Moraea bellendenii* (Sweet) N.E. Br and *Moraea tricuspidata* (L.f.) G.J. Lewis (subg. *Vieusseuxia*) but had smaller flowers than either species. Reviewing the variation in the two species in herbaria led us to associate the Piketberg plants with additional populations from the southern Cedarberg and Cold Bokkeveld currently referred to *M. tricuspidata*. Some individuals are unusually tall, reaching up to 1.2 m, with several

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branches per node. They match yellow-flowered *M. bellendenii* in the tall stature but more closely resemble the related *M. tricuspida* in the white to creamy white flowers, all parts of which are however smaller than until now recorded in that species. Plants from Paardeberg with flowers intermediate in size between these northern populations of *M. tricuspida* and the typical larger-flowered populations to the south and east suggest to us that the small-flowered populations are appropriately regarded as a subspecies of *M. tricuspida*, which we describe as the new subsp. *parviflora* Goldblatt & J.C.Manning. We also recognize the disjunct, eastern populations of *M. tricuspida* as an additional subspecies, subsp. *cornifera*, distinguished by the presence of a large cormlet in the axil of the single foliage leaf, and stamens often shorter than in subsp. *tricuspida* with filaments entirely united. Available chromosome counts for the species indicate that both subsp. *cornifera* and subsp. *parviflora* are tetraploid whereas the typical subspecies is diploid (Goldblatt and Manning, 2013). Subg. *Vieusseuxia* now comprises 46 species in three sections (Goldblatt et al., 2013).

We also describe a new subspecies of *M. papilionacea* (L.f.) Ker Gawl. (subg. *Moraea*) from the Cedarberg and Cold Bokkeveld Mtns, subsp. *glabrescens* Goldblatt & J.C.Manning, distinguished by its smaller stature, less hairy stems and leaves, smaller capsules, and short, usually inclined aerial stem. Chromosome counts indicate that subsp. *glabrescens* is dysploid, $2n = 16$, whereas subsp. *papilionacea* has a diploid number of $2n = 18$ (Goldblatt and Manning, 2013).

Finally, we provide second localities for both *M. fistulosa* (Goldblatt) Goldblatt (subg. *Polyanthes*) (Goldblatt) Goldblatt & J.C.Manning) and *Moraea intermedia* Goldblatt & J.C.Manning (subg. *Umbellatae* Goldblatt & J.C.Manning), representing modest range extensions for the species, known only from their type localities until now.

2. Materials and methods

The new species and subspecies were described and illustrated from fresh specimens collected in the wild. Additional herbarium material was examined from BOL, NBG, and SAM (herbarium acronyms following Holmgren et al., 1990).

3. Taxonomy

3.1. *Moraea helicoidea* Goldblatt & J.C.Manning, sp. nov. (subg. *Vieusseuxia*)

Type: South Africa. Western Cape, Worcester (3319): Farm Droogeriviersberg, SE of Worcester, in Breede Shale Renosterveld, 500 m, (–DC), 14 Sep. 2014, J. Manning & A. Le Roux 1172 (NBG, holo.; K, MO, iso).

Plants ± 50 –150 mm high. *Corm* \pm globose, 7–10 mm diameter; tunics of pale brown, netted fibers. *Stem* consisting of two aerial internodes, simple or 1-branched from aerial node, with solitary sheathing stem leaf 9–15 mm long. *Foliage leaves* 2, subequal, inserted at base of stem and exceeding it, suberect, blades linear, involute, ± 1 mm diameter when opened flat, distal half of blade loosely coiled to almost straight in shade. *Rhipidial spathes* green with dry brown apices, inner spathes 16–25 mm long, outer entirely sheathing and \pm half as long. *Flowers* predominantly white, speckled outside with brown, outer tepal limbs with large yellow nectar guide at bases, inner tepals brown with white margins, with light, fruity scent; tepals unequal, outer ± 16 –18 mm long, limb spreading, broadly obovate-orbicular, 10×10 mm, claws suberect, ± 7 mm long, inner 8–9 mm long, limbs much reduced, ± 4 mm long, \pm deltoid to obscurely 3-lobed with longer central lobe curving inward. *Stamens* with filaments ± 4.5 mm long, united in lower 3 mm in cylindrical column, free and diverging above; anthers appressed to style branches, ± 3 mm long, pale mauve, pollen white. *Style branches* petaloid, 4.5–5.0 mm long, suberect, crests erect, ± 5 mm long. *Capsules* \pm ellipsoid, 7–8 \times 5 mm. *Seeds* unknown. *Flowering time*: late August and September. Fig. 1.

Distribution and ecology: a localized endemic known only from the Farm Droogeriviersberg, ± 30 km SE of Worcester in Western Cape (Fig. 3). Plants occur in a transition zone between the Witteberg- and Dwyka geological Groups, growing in soil derived from the youngest formations of the Witteberg Group comprising micaceous shale, siltstone, mudstone, and sandstone (Gresse, 1997; Gresse and Theron, 1992). Annual rainfall at the site rarely exceeds 250 mm. Associated plant species include the asteraceous shrubs *Elytropappus rhinocerotis* (L.f.) Less., *Pteronia fasciculata* L.f., and *Pteronia paniculata* Thunb.; the succulent shrublets *Antimima stokoei* (L.Bolus) H.E.K.Hartmann, *Antimima microphylla* (Haw.) Dehn., and *Drosanthemum parvifolium* (Haw.) Schwantes; and the graminoids *Tenaxia stricta* (Schrad.) N.P.Barker & H.P.Linder and *Restio gossypinus* Mast.

Diagnosis: *M. helicoidea* is immediately distinguished in subg. *Vieusseuxia* by the presence of two subequal, loosely coiled, or sinuate foliage leaves inserted near the base of the stem (Fig. 1). More than one foliage leaf is rare in the subgenus and is otherwise characteristic only of *M. fergusoniae*, which has three to six foliage leaves, the blades shorter than the stem, 3–10 mm wide, and slightly twisted with undulate margins bearing minute cilia (Goldblatt, 1986). *Moraea tripetala* subsp. *violacea* Goldblatt & J.C.Manning sometimes has two foliage leaves but very different flowers, with free filaments and the inner tepals represented by minute cusps (Goldblatt and Manning, 2012). All other species of subg. *Vieusseuxia* have a solitary foliage leaf.

Flowers of *M. helicoidea* are predominantly white spotted with brown on the reverse with the outer tepals bearing large, deep yellow nectar guides at the base of the limb. The brown inner tepals have reduced, 3-lobed limbs as is common in the subgenus and are comparable in shape to those of *M. fergusoniae* which has either pale blue or white flowers. Branching in *M. fergusoniae* is usually basal whereas branches in *M. helicoidea*, when present, are produced from the first aerial node, thus cauline in origin.

M. helicoidea is immediately keyed out together with *M. fergusoniae* in subg. *Vieusseuxia* by the character of multiple leaves but the two are separated by leaf number and shape of the leaf blade. A complete key to *Moraea* will be included in an account of *Moraea* in *Iridaceae of southern Africa* (Goldblatt and Manning, in prep.).

Conservation status: although locally common, the type population of *M. helicoidea* covers an area of no more than 100 m², with an estimated 120 plants seen. There appears no threat to the population, which occurs in pristine Breede Shale Renosterveld (Rebello et al., 2006). We suggest a conservation status of Least Concern (LC).

3.2. Key to subspecies of *Moraea tricuspida*

- 1a Outer tepals 17–22 mm long with \pm elliptic limbs less than half as wide as long, 10–13 \times 6–10 mm; anthers 3.5–4.0 mm long; plants of the Cedarberg, Cold Bokkeveld, and Piketberg ... subsp. *parviflora*
- 1b Outer tepals 23–30 mm long with \pm orbicular limbs \pm as wide as long, 13–15 \times 13–15 mm; anthers ± 5 mm long; plants of the southern Western Cape and southern Eastern Cape:

 - 2a Foliage leaf without with axillary cormlet; style branches 6–7 mm long; filaments 6–7 mm long, free in upper third; plants west of Caledon ... subsp. *tricuspida*
 - 2b Foliage leaf axil usually bearing solitary cormlet; style branches 4–6 mm long; filaments 4–6 mm long, united \pm entirely; plants east of Oudshoorn ... subsp. *cornifera*

3.3. *Moraea tricuspida* subsp. *parviflora* Goldblatt & J.C.Manning, subsp. nov. (subg. *Vieusseuxia*)

Type: South Africa. Western Cape, Clanwilliam (3218): Piketberg, southern end of plateau, burned sandstone slope, 655 m, (–DC), 9 Oct. 2014, Goldblatt & Porter 14064 (NBG, holo.; K, MO, PRE, iso.).

Plants 500–1200 mm high. *Stem* \pm erect, simple, or several branched, often branching at all 3 or 4 aerial nodes with 2 to 6 slender,

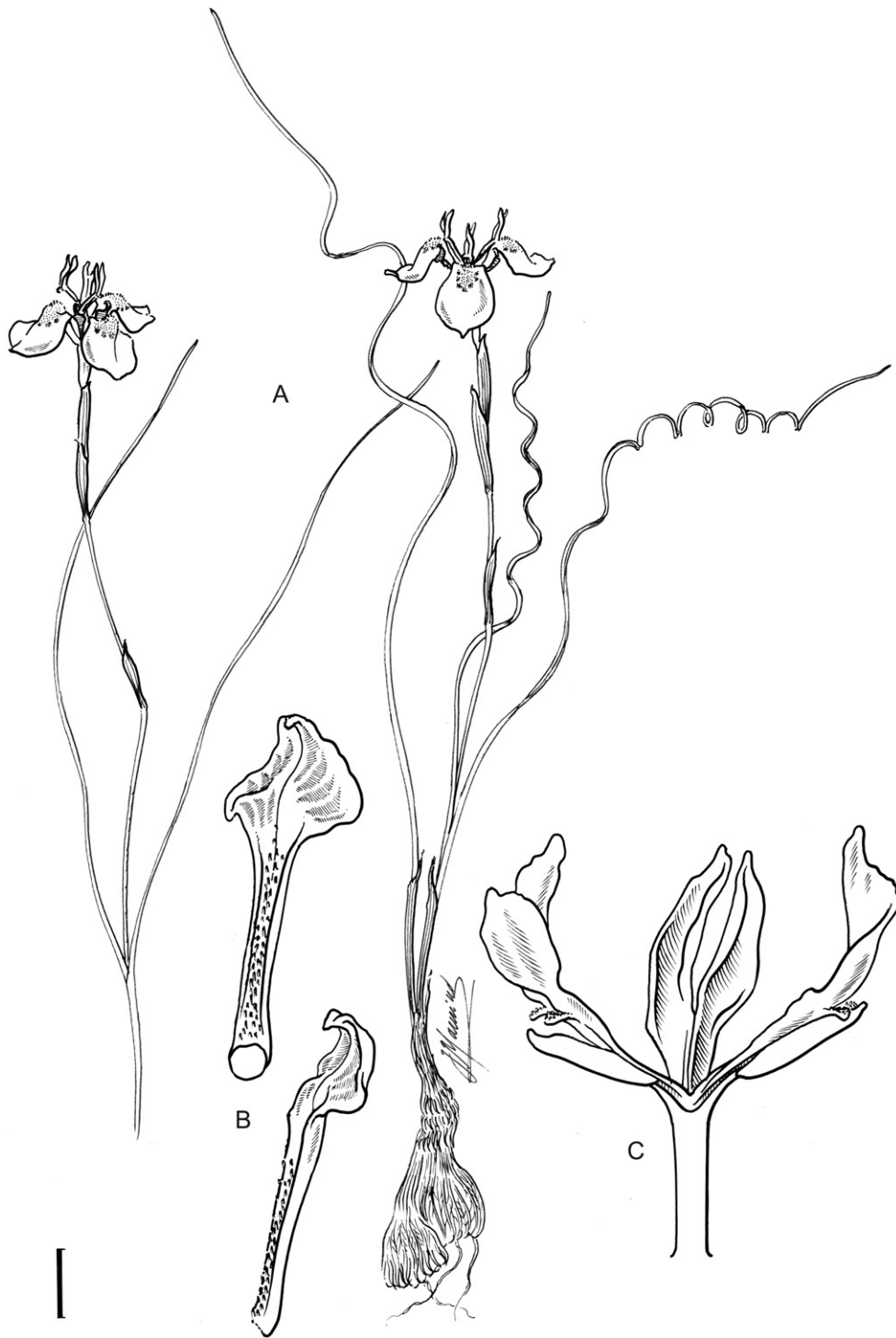


Fig. 1. *Moraea helicoidea*, Manning & Le Roux 1172 (NBG). (A) Flowering plants; (B) inner tepals in 3/4 and side views showing deltoid limb and narrow claw; (C) stamens and style branches, showing filaments partly united in a smooth column and anthers appressed to style branches. Plant in centre has two foliage leaves attached to the flowering stem and the solitary leaf to the left is from a separate, juvenile plant, its corm enclosed in a common corm tunic. Scale bar: (A) 10 mm, (B) 5 mm, (C) 1.5 mm. Drawn by J.C. Manning.

suberect branches at each node, sheathing leaves with dry, brown, attenuate tips, 50–70 mm long. *Rhipidial spathes*: inner 40–50 mm long, outer \pm half as long. *Flowers* white to creamy white, outer tepal limbs pale yellow at bases, claws darkly speckled on pale yellow ground, inner tepals brown with yellow tips; outer tepals 17–22 mm long, claws, ascending, 6–10 mm long, limbs elliptic, 10–13 \times 6–10 mm, inner tepals 8–12 mm long, 3-lobed, central lobe subulate, 1–3 mm long, straight, or twisted. *Filaments* 3.5–5.5 mm long, united below, free in upper 1–2 mm; anthers \pm 3.5 mm long. *Style branches* \pm

3 mm long, crests 4–6 mm long. *Capsules* 12–14 mm long. *Flowering time*: late September to mid November. Fig. 2.

Distribution and ecology: restricted to the northwestern mountains of Western Cape, on the Cedarberg and Cold Bokkeveld and the southern end of the Piketberg plateau (Fig. 3), mostly on stony sandstone slopes, flowering well after fire.

Diagnosis: subsp. *parviflora* is distinguished by the relatively small flowers with outer tepals 17–22 mm long and spreading limb 6–10 mm wide (less than half as wide as long), filaments united almost



Fig. 2. *Moraea tricuspidata* subsp. *parviflora*, Goldblatt & Porter 14064 (NBG). (A) Upper portion of stem with flowers; (B) detail of stamens and style branches with inner tepals. Scale bar: (A) 10 mm; (B) 2 mm. Drawn by J.C. Manning.

to apex in a column, and short style branches about 3 mm long (Fig. 2). The inner tepals are brown with yellow tips and shortly trilobed with a slender central cusp 1–3 mm long. Typical *M. tricuspidata* and related *M. bellendenii* have larger flowers with broader, orbicular outer tepal limbs about as wide as long (Goldblatt, 1986) (Table 1). Individuals

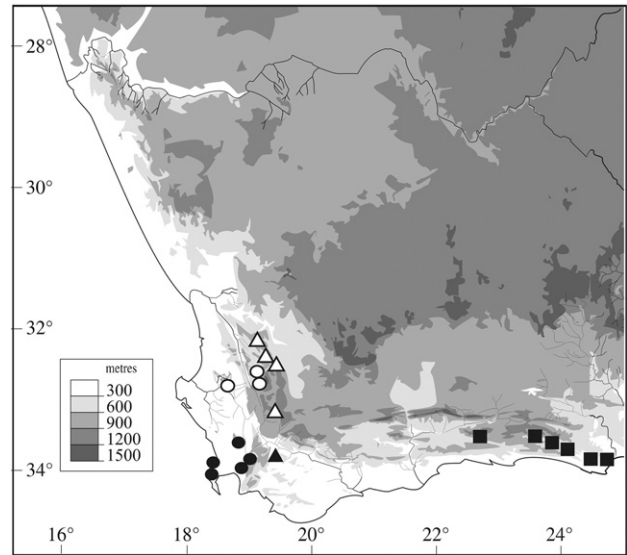


Fig. 3. Distribution of *Moraea helicoidea* (▲); *M. papilionacea* subsp. *glabrescens* (△); *M. tricuspidata* subsp. *parviflora* (○), subsp. *tricuspidata* (●), and subsp. *cormifera* (■).

with tall, willowy, several branched stems resemble *M. bellendenii* but this species has larger, pale yellow flowers, the inner tepals with the central lobe 3–5 mm long and obliquely coiled inward. Subsp. *parviflora* bears some resemblance to *M. unguiculata* Ker Gawl. in its small flower size and tepal shape but not in the style branches nor the inner tepals, 7–12 mm long, which although similar in length have a long slender inner cusp that is usually curved inward and never twisted (Table 1). The style branches of subsp. *parviflora* likewise do not accord with those of *M. unguiculata*.

After reviewing the variation in *M. bellendenii*, *M. tricuspidata*, and *M. unguiculata*, we conclude that the northern populations accord most closely with *M. tricuspidata* but merit recognition as a subspecies. Apart from differences in height and floral organs, subsp. *parviflora* has capsules 12–16 mm long, also smaller than those of subsp. *tricuspidata*, which were 18–24 mm long in plants freshly gathered for comparison.

3.3.1. Additional specimens examined

South Africa. WESTERN CAPE: **3218 (Clanwilliam)**: Piketberg, southern end of plateau, top of burned sandstone slope above type site, 663 m, (–DC), 11 Oct. 2014, Goldblatt & Porter 14073 (MO, NBG). **3219 (Wuppertal)**: Cedarberg, Matjiesrivier Valley, near Eikeboom, (–AC), 14 Nov. 1979, Goldblatt 5129 (MO, NBG). **3319 (Worcester)**: Gydo Pass, valley floor below Mollersberg, Skurweberg Mtns, 1005 m, (–AB), 27 Oct. 2005, Turner 1413 (NBG); Koue Bokkeveld, Elandsfontein 321, (–AB), 15 Oct. 2010, Helme 6730 (NBG); Laken Vlei, (–BC), 19 Oct. 1941, D.L. Olivier s.n. (NBG).

3.4. *Moraea tricuspidata* subsp. *cormifera* (Goldblatt) Goldblatt & J.C. Manning, comb. nov. *M. bellendenii* subsp. *cormifera* Goldblatt in Ann. Missouri Bot. Gard. 60: 236 (1973)

Type: South Africa. Eastern Cape, Grahamstown (3326): Atherstone, (–DA), [without date], Jacot-Guillarmod 6706 (GRA, holo.!; GRA, iso.!).

Plants 250–350 mm high. Stem 1- or 2-branched at the 2 or 3 aerial nodes with 1–3 branches at each node, bearing a single large cormlet in axil of foliage leaf. *Rhipidial spathes*: inner 30–60 mm long, outer ± half as long. *Flowers* white to creamy white, outer tepal limb bases and claws speckled brown to gold; outer tepals 23–30 mm long, limbs orbicular, 13–15 × 13–15 mm; inner tepals 11–15 mm long, 3-lobed, central lobe subulate, incurved or spirally coiled. *Filaments* 4–6 mm long, united to base of anthers; anthers ± 5 mm long. *Style branches* 4–6 mm long,

Table 1
Comparison of taxonomically significant floral and fruit characters of *Moraea tricuspidata* and related taxa.

Taxon	Outer tepal length (limb width) (mm)	Inner tepal length (mm)	Filament length (mm)	Anther length (mm)	Style branch length (mm)	Style crest length (mm)	Capsule length (mm)
<i>M. tricuspidata</i> subsp. <i>tricuspidata</i>	23–30 (13–15)	12–16	6–7	±5	6–7	5–7	18–24
subsp. <i>parviflora</i>	17–22 (6–10)	8–12	3.5–5.5	±4	±3	±4	12–16
subsp. <i>cormifera</i>	23–30 (13–15)	11–15	4–6	±5	4–6	5–6	12–13
<i>M. bellendenii</i>	20–33 (14–18)	10–12	3–5	4–5	±6	(3)4–8	12–25
<i>M. unguiculata</i>	12–24 (5–14)	7–12	4–6	3–4	±5	2.5–4.5	13–25

crests 5–6 mm long. Capsules 12–13 mm long. Flowering time: late September and October.

Distribution and ecology: extending from the Kammanassie foothills in Western Cape to Port Elizabeth and Grahamstown in Eastern Cape, mainly along the coast (Fig. 3), mostly on sandy loam in grassland.

Diagnosis: subsp. *cormifera* is immediately distinguished by the single, relatively large cormlet in the axil of the single foliage leaf, a feature rare in subgenus and not known in typical *Moraea tricuspidata*. The white to creamy white flowers are similar to those of subsp. *tricuspidata* in size and shape, the outer tepals limbs orbicular, 13–15 × 11–15 mm, thus as wide as long or almost so. The filaments, somewhat shorter than in subsp. *tricuspidata* (Table 1), are united for their entire length, whereas they are free apically elsewhere in the species. Capsules of subsp. *cormifera*, so far as known, are smaller than in subsp. *tricuspidata*, 12–13 mm long (vs 18–24 mm). Subsp. *cormifera* was first described in *M. bellendenii*, in which its white to creamy white flowers and short stature are discordant. The disjunction in the ranges of subsp. *cormifera* and subsp. *tricuspidata* appears true and not an artifact of inadequate collecting. The nearest populations of subsp. *tricuspidata* occur 300 km to the west near Ceres and Paarl in Western Cape.

We note that populations of subsp. *cormifera* are tetraploid, $2n = 24$ (two counted, including the type population), whereas subsp. *tricuspidata* on the Cape Peninsula is diploid, $2n = 12$ (Goldblatt and Manning, 2013).

3.4.1. Additional specimens examined

South Africa. WESTERN CAPE. **3322 (Oudshoorn):** Buffelsdrif, southern foothills of Kamanassie Mtns, (–DB), 5 Oct. 1985, Vlok 1176 (NBG). EASTERN CAPE. **3323 (Willowmore):** Long Kloof, Lauterwater, (–DC), Oct. 1933, Fourcade 5022 (K, NBG). 3324 (Steytierville): near Kareedouw, (–CD), 1 Oct. 1974, Goldblatt 2861 (MO, NBG). **3424 (Humansdorp):** flats west of Kromme River Mouth, (–BB), Oct. 1930, Fourcade 4457 (NBG); Humansdorp, (–BB), 5 Sept. 1958, Loubser 895 (NBG); Jeffrey's Bay, (–BB), 3 Oct. 1974, Goldblatt 2893 (MO, NBG); 5 km S of Humansdorp to Cape St Francis, (–BB), 23 Sept. 2003, Goldblatt & Porter 12350 (MO, NBG); Company's Drift, (–CC), 26 Oct. 1943, Fourcade 6176 (NBG).

Additional exsiccatae are cited in Goldblatt (1973).

3.5. *Moraea papilionacea* subsp. *glabrescens* Goldblatt & J.C.Manning, subsp. nov. (subg. *Moraea*)

Type: South Africa. Western Cape, Wuppertal (3320): Cedarberg, top of Cedarberg Pass, Driehoeks R. Valley, along seeps and streams, (–AC), 28 Sep. 1981, Goldblatt 6408 (NBG, holo.; K, MO, iso.).

Plants 60–100 mm high. Stem erect or inclined, with basal internode raised up to 30 mm above ground, sparsely hairy or subglabrous, with 1 or 2 aerial internodes above insertion of basal foliage leaf or leaves, and leaves and branches crowded at first aerial node, several branched from first aerial or second aerial node. Leaves 2 or 3, then uppermost much smaller, falcate, lowermost inserted shortly ground, narrowly channelled, hairless, main veins and margins thickened, abaxially papillate between veins, margins sparsely long-ciliate. Rhipidial spathes often with dry brown apices, subacute, hairless, inner spathes 23–30 mm long, outer ± 1/2 as long. Flowers pale yellow, outer tepal limbs with deep yellow nectar guides at base edged dark brown, scent unknown;

outer tepals 23–30 × 8–9 mm, spreading to weakly reflexed, inner tepals lanceolate, 18–20 × 5 mm, limb spreading. Stamens with filaments 3–4 mm long, united in lower 1/3 to 1/2; anthers ± 3.5 mm long, pollen yellow. Ovary 3.0–4.5 mm long, exserted; style branches ± 5 mm long, crests lanceolate, 6–7 mm long. Capsules ovoid, 5–8 × ± 3 mm long. Chromosome number $2n = 16$. Flowering time: late September to mid October.

Distribution: restricted to middle and higher elevations in the Cedarberg and Cold Bokkeveld Mtns as far south as Ceres in Western Cape (Fig. 3), on wet, peaty, sandy flats somewhat marshy in winter. Flowering takes place up to three or four years after fire, after which the habitat becomes overgrown with taller grasses and restiads.

Diagnosis: until now referred to the southwestern Cape *M. papilionacea* (Goldblatt, 1976a), subsp. *glabrescens* has the same distinctive habit, with the stem above the insertion of the lowermost leaves usually two and sometimes only one internode long, and with a small foliage leaf at the upper node. It is recognized by its smaller, consistently pale yellow flowers, the outer tepals 20–22 × 8–9 mm and the inner 18–20 × 5 mm (Table 2). Flowers of subsp. *papilionacea* are yellow, salmon-pink, or a combination of both colors, with outer tepals 23–30 × 9–15 mm and inner 23–24 × 8–10 mm (Table 2). The rhipidial spathes, style branches, crests, and capsules are consistently smaller than those of subsp. *papilionacea*. Both species have villous stems but those of subsp. *glabrescens* are sparsely so and glabrescent, whereas typical *M. papilionacea* has prominently and persistently pubescent stems. In addition, the leaves of subsp. *glabrescens* are narrowly channelled, hairless beneath with a pair of veins and the margins prominently thickened. The intervein epidermis is minutely papillate on the underside (under 10× magnification), an unusual feature that is occasionally weakly developed in subsp. *papilionacea*. Undersides of the leaves of subsp. *papilionacea* are usually prominently hairy on the veins, which are seldom thickened, and the leaf blades are shallowly channelled to ± flat in the distal half and slightly twisted with undulate margins rather than being channelled throughout. Both subspecies have ciliate leaf margins and nearly identical corm tunics of brown, woody segments, two of the several specialized characters that point to their close relationship. Chromosome number supports the recognition of subsp. *glabrescens*, which has a diploid number of $2n = 16$ while several counts for subsp. *papilionacea* are $2n = 18$ (Goldblatt, 1976b; Goldblatt and Manning, 2013).

Our review of the morphology of *M. papilionacea* has identified an unusual morph, evidently confined to seasonally inundated habitats in the near southwestern corner of Western Cape. Plants have narrow, hairless leaves, 2–3 mm wide, hairless spathes, and sparsely hairy stems, recalling those of subsp. *glabrescens* but the flowers are typical of *M. papilionacea*, although consistently salmon-pink as far as is known. It is not clear whether these plants merit taxonomic recognition but we provisionally treat them as an ecological race. This variant is parapatric with subsp. *papilionacea* virtually throughout its range.

Conservation: The several known populations occur in undisturbed, montane habitats, mostly in declared Wilderness areas and we suggest a conservation status of Least Concern (LC) for the taxon.

3.5.1. Additional specimens examined

South Africa. WESTERN CAPE. 3219 (Wuppertal): Cedarberg, Middelberg, vlakke, (–AC), 14 Nov. 1979 (fr.), Goldblatt 5136 (MO,

Table 2
Comparison of critical taxonomic floral and fruit characters of *Moraea papilionacea* subsp. *glabrescens* and subsp. *papilionacea*.

Taxon	Inner spathe length (mm)	Outer spathe length	Outer tepal length (mm)	Inner tepal length (mm)	Length of style branches (crests) (mm)	Ovary length (mm)	Capsule length (mm)
subsp. <i>glabrescens</i>	23–30	1/2 as long	20–22 × 8–9	18–20 × 5	5 (6–7)	± 4	5–8 × ± 3
subsp. <i>papilionacea</i>	(28–)40–60	± as long to 1/2 as long	23–30 × 9–15	23–24 × 8–10	6–8 (8–15)	± 5	7–9 × ± 5

PRE); Cedarberg, Driehoek R. Valley on road to Driehoek, 2,965 ft [904 m], (–AC), 1 Oct. 2009, *Goldblatt & Porter 13476* (MO, NBG); Cedarberg, S of Grootlandsvlakte on path to Welbedacht, 1300 m, (–AC), 17 Oct. 1999, *Low s.n.* (NBG). 3319 (Worcester): Ceres, mtns close to village, (–CD), Sept. 1924, *Marloth 6147* (NBG). Without precise locality: Cedarberg, Oct. 1929, *Thode A2075* (PRE).

4. Range extensions

4.1. *M. intermedia* Goldblatt & J.C.Manning (subg. *Umbellatae*)

When described in 2010, *M. intermedia* was known only from the type locality, the farm Ghoop, west of Springbok (Goldblatt and Manning, 2010). At the time, we had overlooked an earlier collection from the road to Wildepaardehoek Pass at Klipfontein, some 30 km southwest of Springbok. Although the site is only a moderate distance from the type locality, it is significant as representing only the second record of this distinctive species. The plants from Klipfontein have the first leaf borne well above ground at the first node above ground, and the stem bears short branches at this and the second node on the main axis, exactly as in the type collection. Flowers were described as dark yellow and the anthers orange, and the tepals with short claws and an extended filament column raising the anthers well above the tepal limbs. This accords with the type. The capsules, until now unknown, are ± 9 mm long and ± cylindrical. The seeds are too immature to accurately describe, and remain unknown.

South Africa. NORTHERN CAPE. 2917 (Springbok): Wildepaardehoek Pass road at Klipfontein 266/Voelklip 265 boundary at cattle grid, 1.1 km E of Komremap, 740 m, (–DD), 5 Oct. 1980, *Van Berkel 284* (MO, NBG).

4.2. *Moraea fistulosa* (Goldblatt) Goldblatt (subg. *Polyanthes*)

Moraea fistulosa was known until now from a single collection made in 1976 at the foot of the hills east of the road from Calvinia to Middelpos via Perdekloof (Goldblatt, 1979a). A second site for the species was located on the Farm Vanrhynshoek northeast of Calvinia in late September 2014. Soil at the site, at the eastern foot of the Hantamsberg, was heavy red clay among dolerite rocks. The single plant found was in a sterile state but is immediately identified by the unique leaf, which is solitary, terete, ± 3 mm diameter, hollow and tapering to a short point. The range extension is modest, some 40 km, but significant as only the second record of this rare plant of uncertain conservation status. The species blooms in December, when plants should be more conspicuous and might then more easily be located. Additional populations are likely to occur in similar habitats on the Bokkeveld Plateau and surrounding mountains.

South Africa. Northern Cape. 3119 (Calvinia): Hantamsberg, Farm Vanrhynshoek, dolerite clay slopes near gate to FM mast, 1126 m, (–BD), 25 Sep. 2014, *Goldblatt & Porter 14017* (NBG, sterile).

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Pelargonium conradiae (Geraniaceae), a new species in section *Ligularia* from Worcester, Western Cape, South Africa



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ABSTRACT

Pelargonium conradiae is a new species of section *Ligularia* from southeast of Worcester, allied to *Pelargonium hirtum* but characterised by its larger, unmarked white or pale pink flower with petals 15–20 mm long, and stipules adnate to the petioles for more than half their length. It is one of several locally endemic species from the northeastern foothills of the Riviersonderend Mountains that have been discovered in recent years. The new species is fully illustrated and we provide a revised key to the species of the *P. hirtum* group of sect. *Ligularia*.

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1. Introduction

The genus *Pelargonium* L'Hér. ex Aiton (Geraniaceae) includes some 280 species distributed among four subgenera and 16 sections (Bakker et al. 2004; Röschénbleck et al. 2014). *Pelargonium* sect. *Ligularia* Harv. sensu stricto currently comprises ten, mostly subshrubby species with pinnatisect leaves and often spinescent stipules, shortly pedicellate flowers with five petals and usually seven fertile stamens (rarely four or five), and a basic chromosome number $x = 11$ (Albers et al. 2000). The section was fully reviewed by Albers et al. (2000).

Within sect. *Ligularia* the three species *Pelargonium crassipes* Harv., *Pelargonium oreophilum* Schltr. and *Pelargonium hirtum* (Burm.f.) Jacq. comprise a well-defined group characterised by bi- or tripinnatisect leaves and short hypanthia less than 15 mm long. All are restricted to the West Coast and adjacent interior of Western Cape Province. Several collections of a member of this group from the southeast of Worcester constitute a fourth species characterised by its large, unmarked white or rarely pale pink flowers. We describe it here under the name *Pelargonium conradiae*. It is the latest of several endemic species to be described from the northeastern foothills of the Riviersonderend Mountains as a result of intensive collecting in the area by local ecologist Anso le Roux

(eg. Manning and Goldblatt 2001; Goldblatt and Manning 2010; Snijman and Manning 2013; Goldblatt et al. 2015). *P. conradiae* is evidently a highly local endemic, and we provided notes on its conservation status, as well as an updated key to the members of the *P. hirtum* group.

2. Materials and methods

We examined all relevant herbarium material at BOL, NBG and SAM (acronyms after Holmgren et al. 1990), the primary collections of species from southwestern South Africa, and studied the new species in the field.

3. Taxonomy

3.1. Key to species of the *Pelargonium hirtum* species group: subshrubs with bi- or tripinnatisect leaves, seven fertile stamens, and short hypanthia less than 15 mm long (adapted from Albers et al., 2000)

- 1a. Flowers white or rarely tinged pale pink, unmarked; petals 15–20 mm long; pedicels ± 1 mm long; plants from the Worcester area *P. conradiae*
- 1b. Flowers pink to mauve, posterior two petals with darker markings; petals 10–15 mm long; pedicels 1–8 mm long; plants from West Coast and adjacent mountains:

 - 2a. Leaf bases herbaceous and not persistent; stipules adnate to petioles for halfway or more, remaining papery; plants from coastal

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- granites from Velddrif to Faure and extending inland to Citrusdal and De Wet *P. hirtum*
- 2b. Leaf bases cartilaginous or woody and \pm persistent; stipules adnate to petioles for up to halfway, becoming indurated and hook-like; plants from Olifants River Mouth and Bokkeveld Mtns to Cederberg:
- 3a. Leaf bases very conspicuous, woody and persistent, sharply deflexed; posterior petals wider than anterior petals *P. crassipes*

- 3b. Leaf bases cartilaginous and semi-persistent, spreading or weakly re-curved; posterior petals \pm as wide as anterior petals ... *P. oreophilum*

3.2. New species

Pelargonium conradiae J.C. Manning & A.le Roux, *sp. nov.* Type: South Africa. Western Cape Province, Worcester (3319): Farm Droog

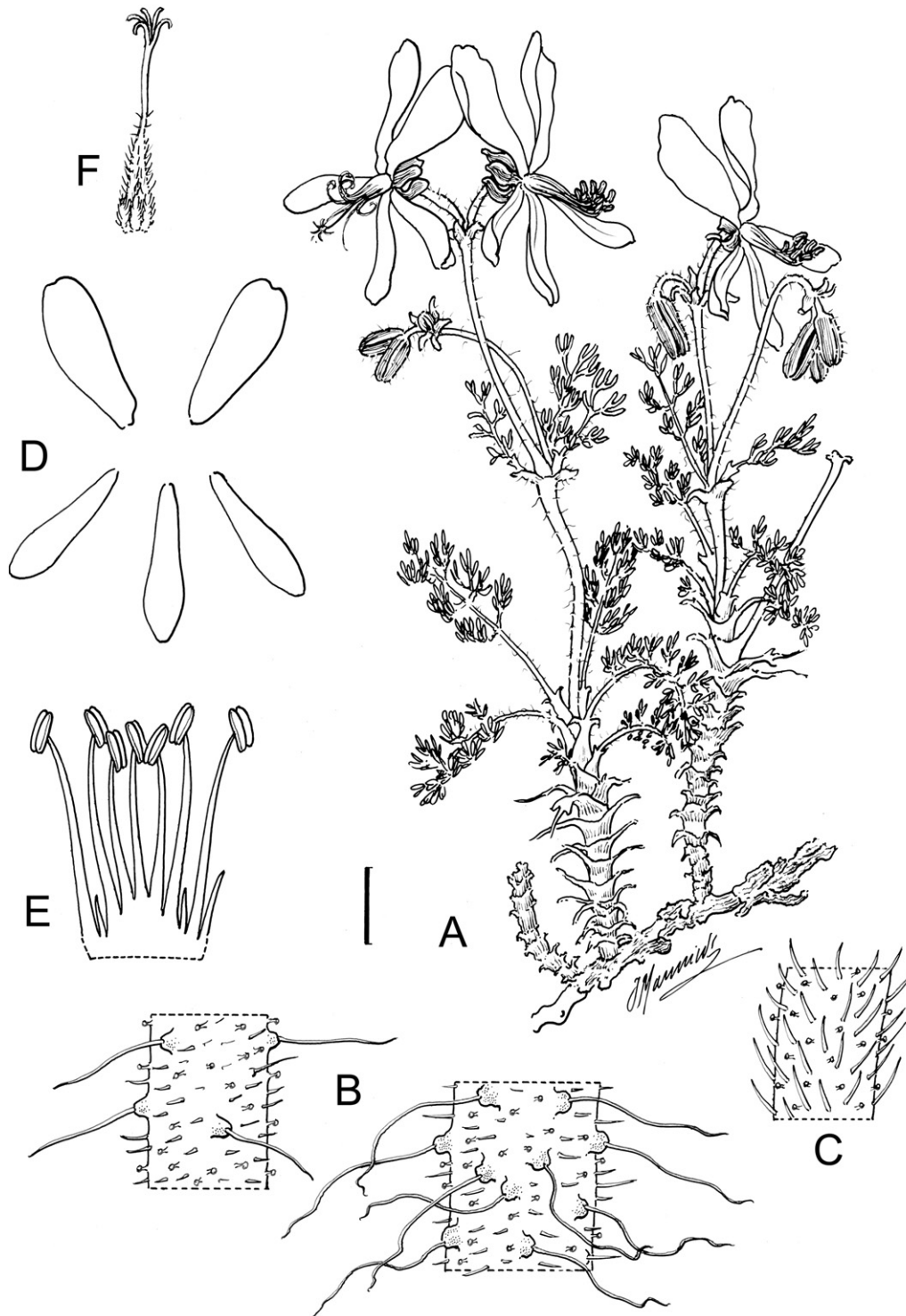


Fig. 1. *Pelargonium conradiae* (Le Roux 1150, NBG). A, Flowering stems; B, detail of peduncular indumentum; C, detail of foliar indumentum; D, detached petals; E, androecium spread out; F, gynoecium. Scale bar: A, D, 10 mm; B, C, 1 mm; E, F, 5 mm. Artist: J. Manning.

Riviersberg, SE of Brandvlei Cellars (–CB), Sept. 2014, A. le Roux 1150 (NBG, holo.; K, iso.).

Deciduous subshrub up to 300 mm high when in flower; stems erect or decumbent, fleshy when young but later woody, initially armed with persistent bases of petioles, later developing flaking bark. *Leaves* pinnate, green; blade oblong-lanceolate in outline, 10–30 × 8–10 mm, pinnae bipinnatisect, ultimate segments subulate, 2–4 mm long, puberulous and minutely glandular-haired, eglandular vestiture of short, sub-appressed hairs, interspersed with sparse, longer straggling hairs on petiole and rachis; petiole ± as long as lamina, base expanded, becoming cartilaginous and semi-persistent; stipules decurrent on petiole for half to three quarters their length, 4–12 mm long, glabrous with ciliolate margins, becoming cartilaginous and semi-persistent. *Inflorescence* with one axillary branch, bearing smaller foliar leaves at node; peduncle villous and glandular-haired, eglandular vestiture of moderately dense, short, spreading hairs up to 0.3 mm long mixed with markedly verrucose-based, straggling hairs ± 1–2 mm long; pseudo-umbels 2 or 3-flowered; pedicels ± 1 mm long; hypanthium 10–12 mm long, indumentum similar to peduncle but straggling hairs

up to 1 mm long. *Sepals* oblong, 8–9 × 2–3 mm, green tinged purple, ab-axial indumentum as on peduncle. *Petals* 5, pure white or faintly flushed pink, all unmarked, posterior two erect or reflexed, oblanceolate to obovate, 15–20 × 6–9 mm, obtuse or emarginate, anterior three narrowly oblanceolate, 13–18 × 3–4 mm, obtuse. *Fertile stamens* 7, filaments white, solitary posterior 11 mm long, two upper laterals 10 mm long, four anterior 12–13 mm long; anthers ± 2 mm long, reddish with yellow pollen. *Style* wine-coloured (see Figs. 1 and 2).

Etymology

The epithet honours Mrs. Hettie Conradie, owner of the farms Drooge Riviersberg and Sandberg on which the new species was collected, in recognition of her avid interest in the flora of the Worcester area, her affection for the veld, and her devotion to conservation farming.

Diagnosis

Pelargonium conradiae is a member of a small group of species allied to *P. hirtum* and characterised by a subshrubby habit, pinnate leaves with bi- or tripinnatisect pinnae, and white or pink flowers with short

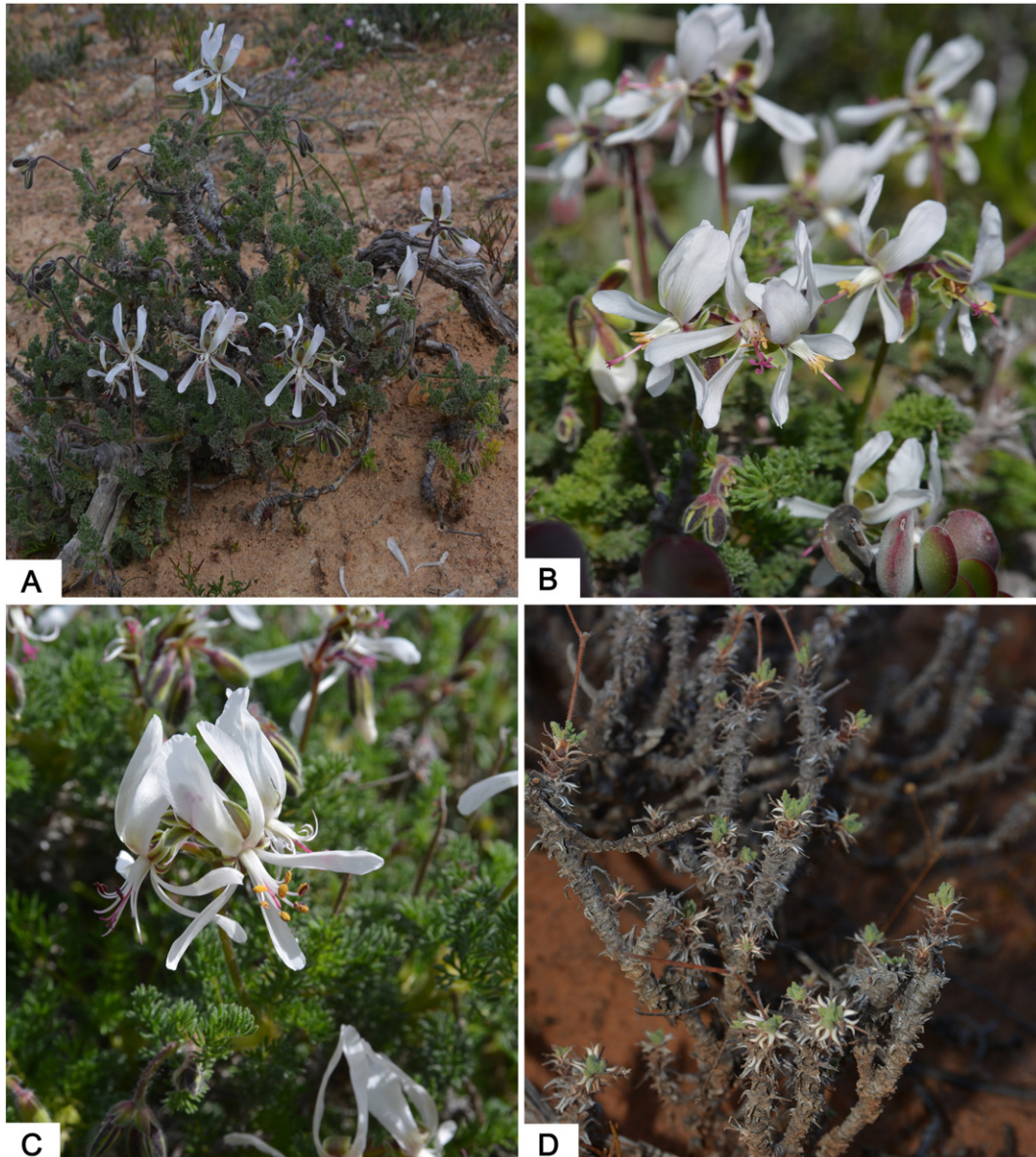


Fig. 2. *Pelargonium conradiae*. A, Flowering plant in habitat; B, C, flowers showing unmarked, white petals; D, stems at end of dry season with emergent new growth and cartilaginous, semi-persistent stipules. Photographs: A. le Roux.

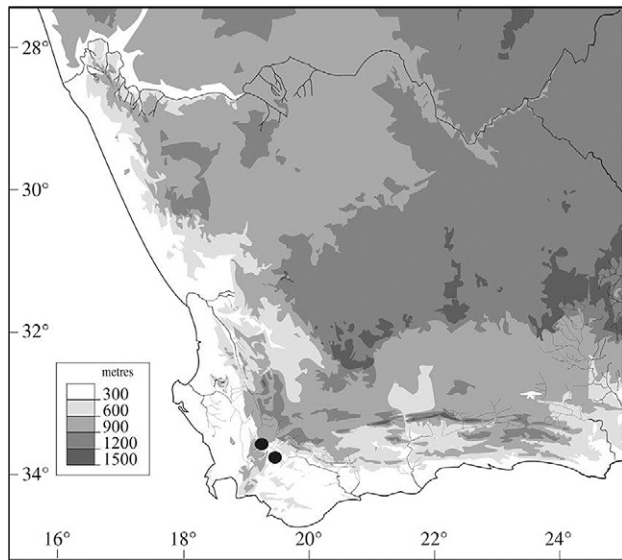


Fig. 3. Distribution of *Pelargonium conradiae*.

hypanthia less than 15 mm long and seven fertile stamens. It is distinguished from other members of the group by the semi-persistent petiole bases with the stipules adnate to the petiole for half their length or more, and the relatively large, pure white (rarely tinged pale pink) flowers with petals 15–20 mm long, the posterior two petals \pm twice as wide as the anterior three.

Pelargonium crassipes and *P. oreophilum* from the Bokkeveld Mountains and Cederberg share similar, \pm persistent petiole bases with *P. conradiae* but have smaller, pink to mauve flowers with darker markings on the posterior petals, and stipules that are adnate to the petioles for up to half their length only, becoming indurated and hook-like with age. *P. oreophilum* has characteristically narrow upper petals \pm as wide as the anterior petals, and *P. crassipes* has deflexed, woody, strongly persistent, spine-like pedicels and stipules. *P. hirtum*, with consistently small flowers with petals \pm 10 mm long, has herbaceous, scarcely persistent petioles, and often larger leaves, with blades and petioles mostly 20–50 mm long. All three of these species are fully illustrated in colour in Van der Walt (1977) and Van der Walt and Vorster (1981).

Distribution and ecology

A narrow endemic of the Breede River Valley southeast of Worcester in Western Cape Province, *Pelargonium conradiae* is known from two populations on the farms Drooge Riviersberg and Sandberg, and a third collection from the farm Alfalfa. Plants occur on the flats and lower slopes at the foot of spurs running out from the northern slopes of the Riviersonderend Mountains, in Succulent Karoo shrubland on clay and loamy clay soils derived from glacial tillite of the Dwyka Group of the Karoo Supergroup (Gresse and Theron 1992). Annual rainfall rarely exceeds 250 mm. On the farms Drooge Riversberg and Sandberg, *P. conradiae* is associated with the rare Worcester endemic *Annesorhiza radiata* (Apiaceae) (Magee et al. 2011) (see Fig. 3).

Conservation notes

Pelargonium conradiae was first collected on the farm Alfalfa in 1983 but additional populations have recently been found on the nearby farms Drooge Riviersberg and Sandberg. The species appears to be naturally rare, occurring in small groups numbering between three and ten individuals. Although the area is utilised for grazing (low intensity), the plants showed no signs of grazing. One of the stands of *P. conradiae* occurs partly under a transmission power line that runs through the area. Although Succulent Karoo vegetation is not fire-prone, management of power line servitudes by the South African national electricity supplier Eskom includes the periodic cutting of vegetation under such lines in order to ensure adequate access for maintenance as well as reduction of fuels for fires which may cause flashovers. Plants found in this area were smaller than the plants at undisturbed sites. It is uncertain how repeated cutting of the vegetation will affect the existence of *P. conradiae*.

Additional specimens examined

South Africa. Western Cape: **3319 (Worcester)**: Farm Alfalfa, SE of Worcester, in karroid broken veld, flowers white, (– DA), 30 Aug. 1983, D. Snijman 728 (NBG); Farm Sandberg (– DC), 17 Aug. 2015, A. le Roux & H. Conradie 1405 (NBG); 15 Aug. 2015, A. le Roux 1406 (NBG).

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Amphithalea ornata (Podalyriaceae, Fabaceae), a rare new species from the Western Cape Province, South Africa



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ABSTRACT

The new species, *Amphithalea ornata*, from the Worcester Valley in the Western Cape Province of South Africa, forms part of a group of four species with pedunculate inflorescences. Among these species it is most similar to *Amphithalea spinosa* but differs in its non-spinescent habit, shorter peduncles, and large, imbricate calyx lobes. *A. ornata* is restricted to the Breede River Valley where it occurs in Breede Shale Renosterveld at the southern foot of the Droëriviersberg, south of Worcester.

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1. Introduction

The genus *Amphithalea* Eckl. & Zeyh. comprises 42 species near-endemic to the Greater Cape Floristic Region of South Africa (Schutte, 2012; Campbell-Young, 2013). The genus was amalgamated with *Coelidium* Vogel ex Walp. by Schutte (1998), who presented a synopsis of all 42 species as part of a doctoral thesis (Schutte, 1995). Schutte (1998) argued that the maintenance of *Coelidium* on the basis of its monadelphous stamens was artificial and that the genus was embedded within *Amphithalea*. This was later confirmed by molecular phylogenetic evidence (Van der Bank et al., 2002; Boatwright et al., 2008).

Before being amalgamated, *Amphithalea* s.s. and *Coelidium* had been revised separately by Granby (1980, 1985), who recognised 20 and 19 species, respectively. An additional three species have since been described (Granby, 1987; Schutte and Van Wyk, 1991, 1992).

Within Podalyriaceae, *Amphithalea* is placed in the subtribe Xiphothecinae along with *Xiphotheca* Eckl. & Zeyh., based on the non-intrusive calyx base, obtuse keel petals, wing petals with a thickened abaxial lobe, and reduced ovule number (Schutte and Van Wyk, 1998).

In this paper a new species of *Amphithalea* from the Western Cape Province of South Africa is described, bringing the total number of

species in the genus to 43. It was discovered in 2013 during field surveys in the Trappieskraalkloof area between Worcester and Robertson.

2. Materials and methods

Morphological data on the new species were gathered through examination of herbarium material from NBG and *in situ* observations. The herbaria BOL, PRE and SAM were also checked for collections of this species. The new species was compared to the rest of those in the genus using the taxonomic key and species concepts of Granby (1980, 1985) and Schutte (1995). Drawings were prepared by the first author using a stereomicroscope (WILD M5) with a *camera lucida* attachment.

3. Species treatment

3.1. *Amphithalea ornata* Boatwr. & J.C.Manning, sp. nov.

Type: South Africa. Western Cape, Worcester (3319): Farm Keurfontein 143, south of Worcester, west of Robertson (–DC), Oct 2013 (fl.), A. le Roux 1029a (NBG, holo.).

Erect shrubs up to 1.2 m in height, sprouting from a woody rootstock after fire. Branches brown, glabrous to pubescent, twigs densely pubescent, older branches with light brown bark. *Stipules* inconspicuous, <0.5 mm long. *Leaves* alternate, simple, ovate to elliptic, 4–7 × 1.5–2.0–2.5 mm, oblong to obovate, auriculate, obtuse, without sculpturing. *Keel petals* 6–7 mm long; claw 2.0–2.5 mm long; lamina boat-shaped,

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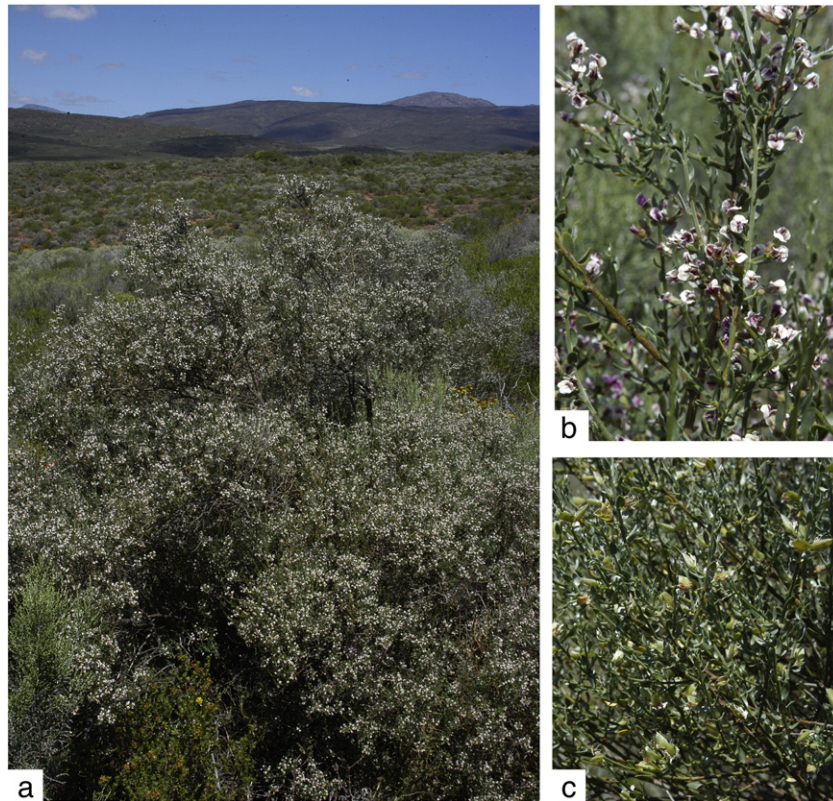


Fig. 1. (a) Habit, (b) flowers and (c) fruit of *Amphithalea ornata*. Photographs: A. le Roux.

upper margin convex, $4.0\text{--}4.5 \times 1.5\text{--}2.0$ mm, obtuse, glabrous, pocket present. *Stamens* monadelphous; anthers dimorphic, alternately basifixed and dorsifixed. *Pistil* subsessile, sericeous, ovary ovate, $2\text{--}3 \times \pm 1$ mm, 1-ovulate; style ± 5 mm long, curved upwards, glabrous. *Pods* shortly stipitate, obliquely oblong, laterally compressed, sericeous, $6\text{--}7 \times 4\text{--}5$ mm, 1-seeded, dehiscent, light brown. *Mature seeds* not seen. *Flowering time*: September–October. Fig. 1 and Fig. 2.

3.1.1. Diagnostic characters and relationships

Amphithalea ornata forms part of a small group of four species with pedunculate inflorescences, which includes *A. pageae* (L.Bolus) A.L.Schutte, *A. parvifolia* (Thunb.) A.L.Schutte and *A. spinosa*. It is most similar to *A. spinosa*, sharing with it sericeous leaves and two-flowered inflorescences, but differs in that it is not spinescent (Fig. 1) and has much shorter pedicels. However, the most diagnostic character of *A.*

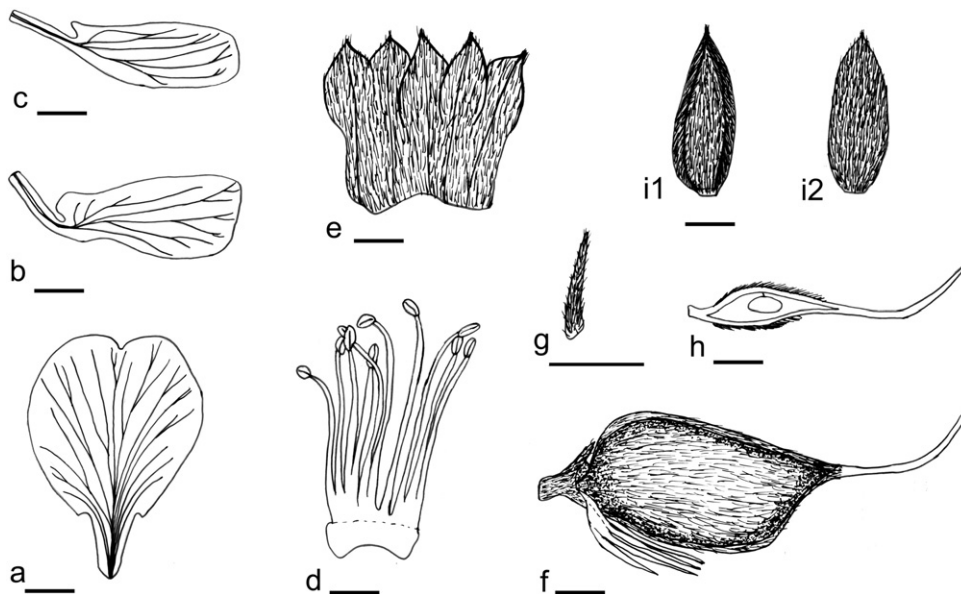


Fig. 2. Morphology of *Amphithalea ornata*: (a) standard petal; (b) wing petal; (c) keel petal; (d) androecium; (e) outer surface of calyx (upper lobes to the left); (f) pod in lateral view; (g) bract; (h) pistil; (i) leaf in (1) abaxial and (2) adaxial view. Vouchers: (a–d, g–i) *Le Roux 1029a* (NBG); (f) *Le Roux 1029b* (NBG). Scale bars = 1 mm.

ornata is the ornate, imbricate, ovate calyx lobes (Fig. 2e). The only other species in the genus with imbricate calyx lobes is *Amphithalea obtusiloba* (Granby) A.L.Schutte, but the latter has short, obovate calyx lobes, and sessile inflorescences.

3.1.2. Distribution and habitat

The species is currently known from a single locality and population between Worcester and Robertson, on the farm Keurfontein 143 at the southern foot of the Droëriviersberg, 1.2 km south–southwest of where the Trappieskraalkloof opens to the south (Fig. 3). The population comprises of at least three stands within a few hundred metres of each other, each including between three and ten shrubs.

Amphithalea A. ornata is associated with Breede Shale Renosterveld (FRs8; Mucina et al., 2005; Rebelo et al., 2006), in a plant community where other significant taxa include *Calobota cytisoides* Eckl. & Zeyh., *Elytropappus rhinocerotis* Less., *Eriocephalus africanus* L. var. *paniculatus*

(Cass.) M.A.N.Müll., P.P.J.Herman & Kolberg, *Euphorbia burmannii* (Klotzsch & Garcke) E.Mey. ex Boiss., *Lampranthus haworthii* N.E.Br., *Mohria caffrorum* (L.) Desv., *Oedera genistifolia* (L.) Anderb. & K.Bremer, *Pteronia incana* DC., *P. paniculata* Thunb., *Ruschia caroli* Schwantes, and *R. lineolata* Schwantes.

3.1.3. Etymology

The species is named for the relatively large, ornate calyx lobes which are unique in the genus.

3.1.4. Conservation status

The only known population, found on privately owned land, covers an area of about 2 ha and is estimated to be between 15 and 20 plants between the three stands. Although the area was utilised for grazing (low intensity) in the past, small stock farming was ceased in 1980 (Mr D du Plessis pers. comm.). The population

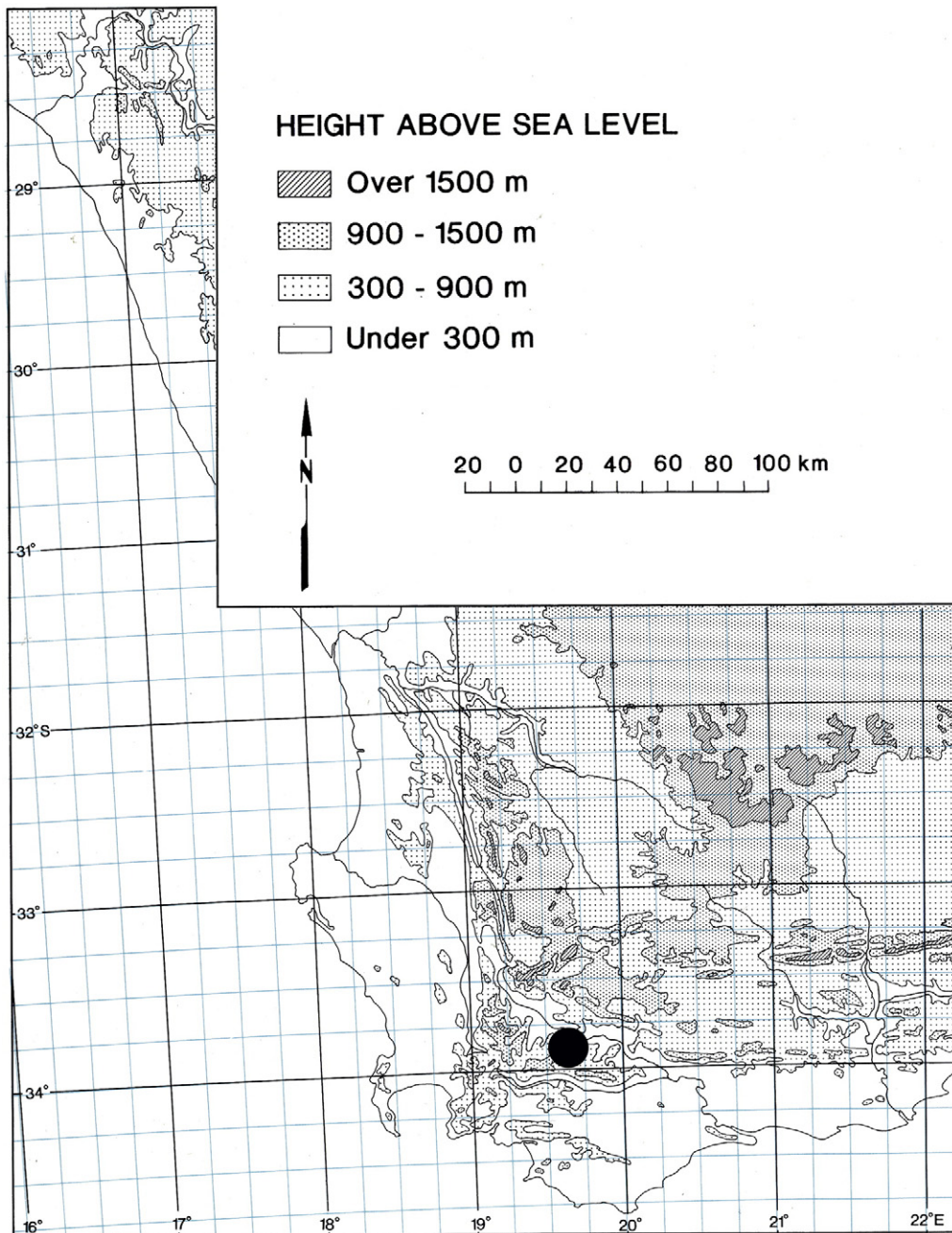


Fig. 3. Known geographical distribution of *Amphithalea ornata*.

is thus presently under no direct threat. It is, however, concerning that there are so few individuals and the conservation status of this species requires a proper assessment, taking into account environmental and ecological factors that might contribute to the survival of these plants.

3.1.5. Additional specimens

South Africa. WESTERN CAPE: 3319 (Worcester): Farm Keurfontein 143 (–DC), Nov 2013 (fr), *A. le Roux 1029b* (NBG).

4. Adjustments to species key of Schutte (1995) which incorporates the keys of Granby (1980, 1985)

1. Inflorescences distinctly pedunculate.....2
2. Peduncles longer than the leaves; branches thorny.....*A. spinosa*
2. Peduncles shorter than the leaves; branches not thorny.....3
3. Standard and wing petals white; flowers > 10 mm long; upper leaf surface densely sericeous, lower sparsely pubescent or glabrous.....*A. pageae*
3. Standard and wing petals pink or purple; flowers < 10 mm long; upper and lower leaf surfaces sericeous.....3a
- 3a Calyx lobes valvate, triangular-acute; plants from Swartberg, Outeniqua and Kouga Mountains.....*A. parvifolia*
- 3b Calyx lobes imbricate, ovate-cuspidate; plants from Worcester Valley.....*A. ornata*
1. Inflorescences not pedunculate.....4 (rest of *Amphithalea*)

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Breede Alluvium Renosterveld in the region of the Greater Brandvlei Dam, Southern Western Cape, South Africa.

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Abstract

Before long-term inundation of two floodplains of the Upper Breede River due to the construction of the Greater Brandvlei Dam, it is expected that the clayed soils derived from the basal mudrock layer of the Witteberg Group (exposed on the northern perimeter of the dam) as well as upper mudrock layers of the Bokkeveld Group (exposed at the eastern perimeter of the dam) supported alluvium renosterveld vegetation. Breede Alluvium Renosterveld is found in areas where the alluvium sand is relatively thin and loamy, such as at the lower slopes of the hills bordering the dam, while Breede Sand Fynbos is found on the deeper sand accumulations. This alluvium renosterveld plant community is most probably a remnant of larger tracts of Breede Alluvium Renosterveld that had been destroyed through the construction, and later enlargement, of the Greater Brandvlei Dam.

Key words: Brandvlei Dam, Breede Alluvium Renosterveld Vegetation

1. Introduction

The vast area currently covered by the Greater Brandvlei Dam (Brandvlei and Kwaggaskloof Dams) (Figure 1) in the Western Cape province of South Africa, encompasses parts of ancient floodplains of the upper Breede River, south of the town of Worcester. These particular floodplains extend from south of Worcester in the direction of Villiersdorp and are characterized by alluvial deposits overlying shale- and sandstone rocks of the Cape Supergroup (Thamm and Johnson 2006). Aerial photographs taken in 1942 (Department Rural Development and Land Reform 1942) portray a braided network of rivers and rivulets which carries runoff from the mountains to the south, the west and the east of the Greater Brandvlei Dam. These streams drain towards the Breede River as well as its former floodplains that are today inundated by the dam.



Figure 1: The Greater Brandvlei Dam, viewed from the north-eastern perimeter in a southerly direction towards Villiersdorp.

Before the area was permanently flooded as result of the construction of the dam walls, not only seasonal floods, but also the presence of a perennial thermal spring, had played a noteworthy role in the character and sustenance of the area (Figure 2).



Figure 2: A late 1800's image of the hot spring in the then 'Brand Valley' before the first dam was constructed illustrating the levelness of the floodplain and depicting how the streams flowed from the spring in an easterly direction towards the Breede River through the Matjieskloof (in which the first Brandvlei Dam wall was constructed).

This spring is found close to the western perimeter of the dam (where a dam wall protects it from being flooded when the dam fills up) (Figure 3) and is documented as the strongest and hottest in southern Africa (with water yield of 126 l/sec at a consistent temperature of 64 °C) (Kent 1949). Several of the early explorers visiting the spring recognised the remarkable yield thereof and note that the stream flowing from it is strong enough to turn a large mill (Barrow 1801; Lichtenstein 1812). Interestingly, the name 'Brandvlei' (direct translation "burning marsh") presumably originated from the steam rising from the spring and surrounding streamlets flowing from it (Figure 2; DWAF 1995; Forbes 1986; Olivier *et al.* 2008). Because the existence of a hot spring attracted the attention of botanists and other naturalists in the early days of the Cape Colony, several plant species new to science were described from this valley (Burchell 1822; DWAF, 1995; Forbes 1986; Le Roux *et al.* 2010).

Members of the De Wet family, who received the deed of transfer of the farm Brandvlei in 1756, remember the 'Brand Valley' prior to damming as a mosaic of streams, islands and marshes which became gradually drier towards the

lower slopes of the surrounding hills during the dry months. It was not uncommon in the rainy season for the Breede River to flow through the Matjieskloof (wherein the Brandvlei wall was later constructed) (Figure 3) where streams originating from the spring as well as runoff from the Holsloot River and from the Voorsorg area converged.

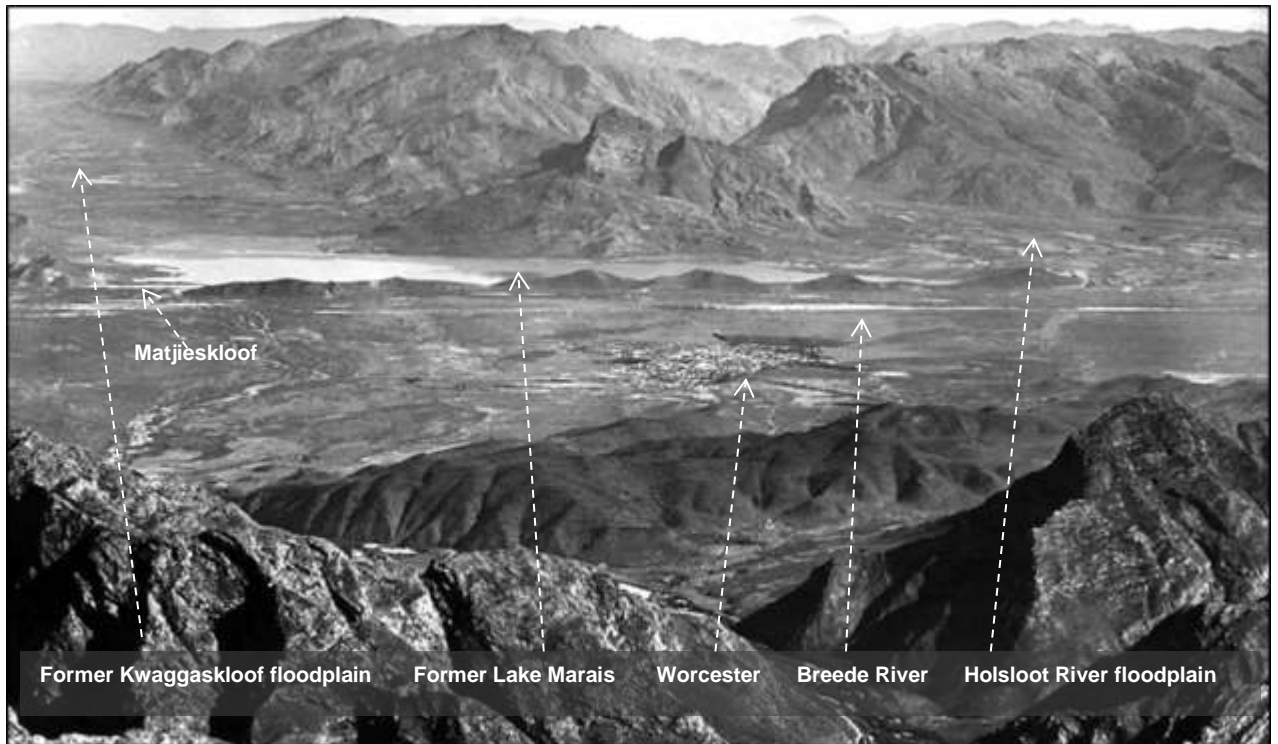


Figure 3: An image of the Greater Brandvlei Dam area (viewed from the Hex River Mountains in a southerly direction) in the 1930's after 'Lake Marais' (Brandvlei Dam), but before the Kwaggaskloof Dam was constructed (courtesy, Mr E. du Plessis).

This confirms the observation of Lichtenstein (1812) who notes that “at an hour’s distance the stream from this spring joins the Breede River.” The constant water supply delivered by the spring created a braided-stream wetland from where three rivulets flowed in north-easterly and easterly directions (Figures 2 and 3). This marsh formed the southern boundary of the first dam in the area, Lake Marais (Department Rural Development and Land Reform 1942; Mr P. de Wet pers. comm; Le Roux *et al.* 2010). To facilitate irrigation, a deep trench was initially dug through the marsh, but in later years, water was channelled to adjacent farms in furrows where it was used for irrigation as well for the sustenance of livestock. This shrank the original size of the marsh to almost half a hectare, the dimensions it still has today (Le Roux *et al.* 2010).

Irrigation with normal river run-off was practiced in the Breede River Valley as early as the Eighteenth Century, but the quantity of run-off water alone became inadequate in the Twentieth Century (DWAF 1995). The English statesman and writer Sir John Barrow (1764 –1848) may be one of the first people who recognised the damming potential of the “Brandt Valley.” He visited the valley between 1797 and 1798 and described the area “...having a surface as level as that of a bowling-green. By a strong stream passing from one end to the other, the whole might be laid under water, and converted into most excellent rice grounds” (Barrow 1801). The increased demand for irrigation water in the dry summer months led to the construction of Lake Marais (or Meer Marais) in 1922, 5 km to the south of Worcester (DWAF 1995) by building the Brandvlei dam wall on the north-eastern side (Figure 4).

In relatively the same way as today, two tributaries of the Breede River, the Smalblaar and Holsloot Rivers fed the first dam with winter runoff (Le Roux *et al.* 2010). Lake Marais was enlarged in 1950 to just more than double the original amount of water stored, a capacity of 95.3 million m³. Concurrent with this enlargement of Lake Marais, the suggestion to develop an additional dam close to Lake Marais was stated in a Whitepaper. This led to the construction of the Kwaggaskloof Dam (Figure 5), just south of the Brandvlei Dam, which is fed by the Waboom River (DWAF 1995).

Where these two dams previously were unconnected water bodies divided by a natural barrier of bedrock, another Whitepaper in 1972 announced the enlargement of both dams to form the Greater Brandvlei Dam as it is today (Figures 4 and 5), a government water scheme that consists of one large water surface with a capacity of 470 million m³ (Figure 6; DWAF 1995). The former boundaries of the two separate dams are shown in Figure 6.

Due to the absence of detailed records or narratives regarding the vegetation of the Greater Brandvlei Dam area prior to damming, available references merely include the accounts of early travellers and the recollections of local people.

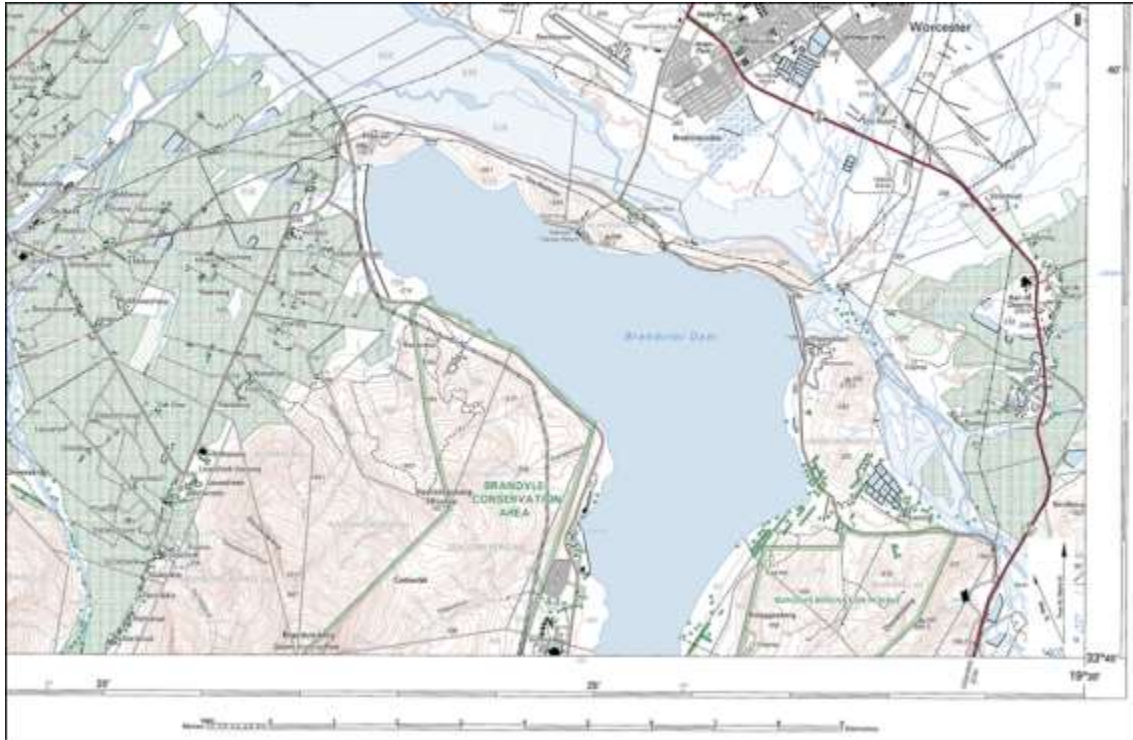


Figure 4: The locality of the specific Study Area A at the northern perimeter of the Brandvlei Dam part of the Greater Brandvlei Dam. Adapted from the 1:50 000 Topographical map (3319CB Worcester) (South Africa 2001a).



Figure 5: The locality of the specific Study Area B at the northern perimeter of the Kwaggaskloof Dam part of the Greater Brandvlei Dam. Adapted from the 1:50 000 Topographical map (3319CB Worcester) (South Africa 2001a)

As detailed vegetation studies were never before done in this specific area, the information provided by the current Vegetation Map of South Africa and Swaziland (Vegmap) (Mucina *et al.* 2005; Rebelo *et al.*, 2006) is based on broad characteristics of the area and on reports of similar vegetation types in other areas (Mucina *et al.* 2006).

2. The Greater Brandvlei Dam study area

2.1 Climate

Although the renosterveld areas of the Breede River Valley are included in the *East Coast Renosterveld Bioregion*, the larger study area is adjacent to the *Southwest Fynbos Bioregion* and the *Rainshadow Valley Karoo Bioregion* (Mucina *et al.* 2005; Rutherford *et al.* 2006). The climate of the area is predominantly Mediterranean, receiving rainfall mainly in the winter months. A steep moisture gradient is evident from west to east where the western part of the study area generally receives a higher amount of rainfall (Le Roux and Brown 2010; Le Roux in prep.). Long term weather data (obtained from the Agrometeorological programme at the Agricultural Research Council's Institute for Soil, Climate and Water – Agromet-ISCW) measured at the Aan de Doorns Wine Cellar, east of the study area, shows a fairly long dry season from mid-September to the end of April (the driest months being January, February and March) while the area receives most of its rain from late autumn through the winter months to early spring.

2.2 Geology

The Greater Brandvlei Dam area is underlain by rocks of the Table Mountain (Johnson *et al.* 1999), Bokkeveld (Theron 1972; Theron and Johnson 1991) and Witteberg Groups (Johnson *et al.* 2006) of the Cape Supergroup (Thamm and Johnson 2006). The Table Mountain Group (Table 1) consists mainly of light grey, medium-to coarse-grained quartzose sandstones and quartzites, building the impressive mountains to the south and west of the dam (Figure 6).

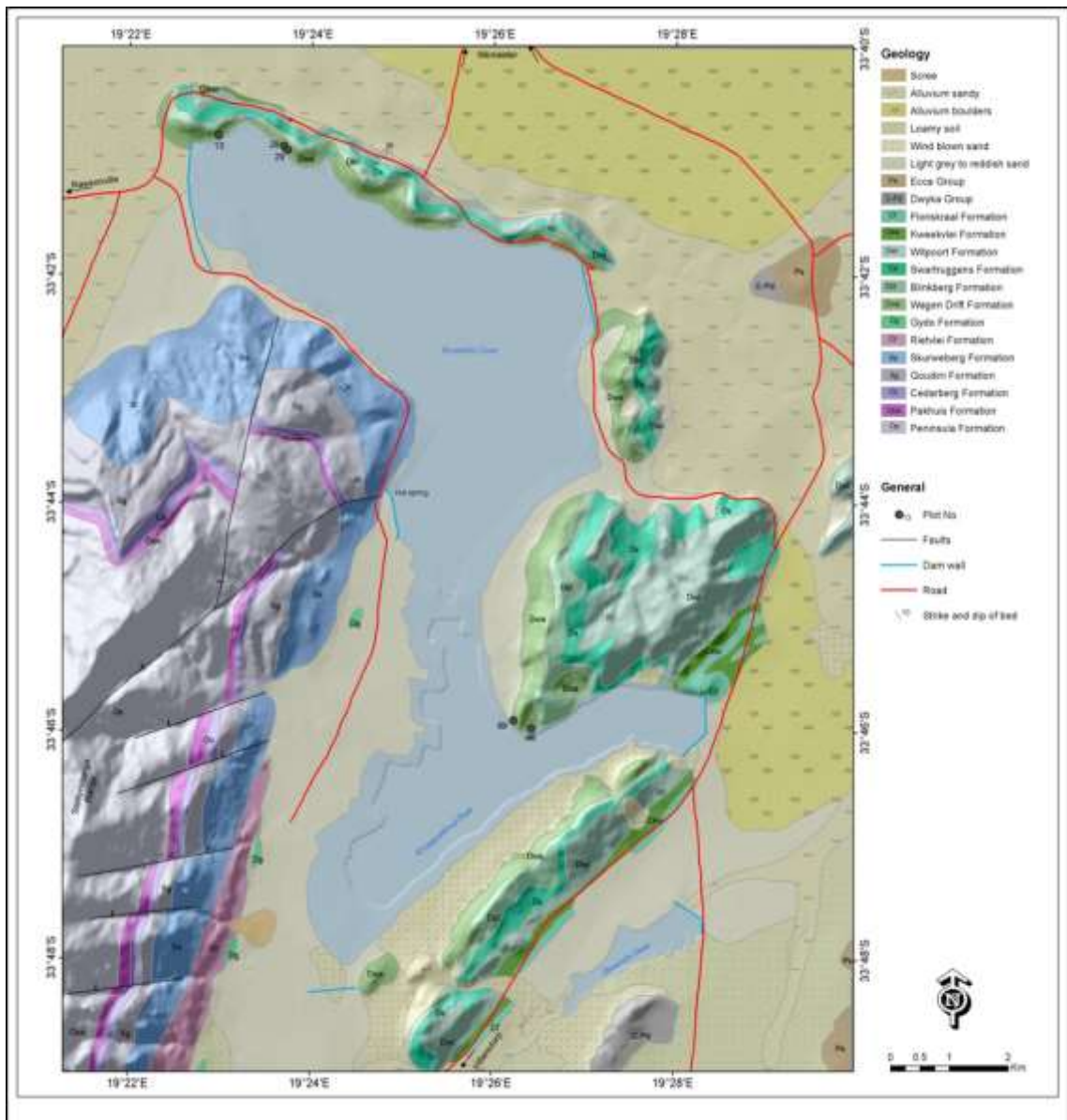


Figure 6: A map of the Greater Brandvlei Dam area, indicating the geological contact zones and specific study areas on the northern and south-eastern side of the dam (after Siegfried 1984).

A conspicuous mudrock-rich unit, the Cedarberg Formation, forms an important marker horizon almost in the middle of the group, dividing it into a lower Peninsula Formation and a upper Nardouw Subgroup (Table 1). The uppermost unit of the Nardouw, the Rietvlei Formation occurs on the southern and western boundary of the Greater Brandvlei Dam.

The depression occupied by the dam is largely underlain by the easily erodible mudrock-rich Bokkeveld Group. The Bokkeveld Group consists of alternating mudrock- and sandstone-rich units, but the greyish sandstones are generally

poorly developed and clay-rich (immature). The Bokkeveld Group generally weathers to clay-rich soils. The northern and eastern periphery of the dam is formed by low hills build by rocks of the more arenaceous (sand-rich) Witteberg Group, which also consists of alternating mudrock- and sandstone-rich units.

The Bokkeveld and Witteberg Groups were deposited in a sea with its most northerly position of the coastline approximately in a line from south of the town of Calvina eastwards towards the city of East London. However this coastline was moving respectively south- and northwards during periods of lower and higher sea-level stands. This is evident in the lithology and alternation of the different formations (Cotter 2000). Due to the fact that the basin was also deepening in a southerly direction, sediments tend to become finer grained in a basin-ward direction (coarse materials are deposited close to the coastline in shallower water while the lighter very fine sand and clay are deposited in quieter, deeper water).

Regionally, in both the Bokkeveld and Witteberg Groups the sandstone content and thickness of the individual sandstone units decrease appreciably from north to south in its outcrop area. In the Brandvlei area this wedging out of the sandstones with subsequent increase in mudrock are already evident (Gresse 1997).

The geological map (Figure 6) shows accurate outcrops of the formations marking the position of a NE-plunging anticline (arch), with its eastern limb dipping steeply eastward, and its western limb dipping moderately towards the northwest at the northern end of the Stettynsberg Mountain Range. This structure is also expressed prominently by the sandstone ridge of the succeeding Witteberg Group, which swings abruptly from N-S to E-W near the wall of the Brandvlei Dam. The folding of the strata and associated faults had fracture and displaced some of the outcrops.

Varying thicknesses of alluvial sand and mud covers to a large extend the outcrops of the Bokkeveld Group where it is not covered by the dam's water, while colluvium and shallow soils cover most of the slopes build by the Witteberg Group. Hill slope soils are generally very gravelly, consisting in places of up to 90% of gravel size material. Aeolian sands, blown up from the

alluvium during the dry spells, blanket some of these deposits, such as along the eastern and south-eastern shores of the dam (Figure 6). The southern part of the fringe of the dam is largely covered by fine to coarse sand washed down from the sand-rich slopes of the Settynsberg Mountain, complemented with finer grained windblown sand.

Table 1: Stratigraphy and lithology of the Cape Supergroup in the Greater Brandvlei Dam area (Figure 6). The formations relevant to the larger study area are highlighted in green and blue. The formations relevant to the specific study areas are highlighted in blue.

Age	Supergroup	Group	Subgroup	Formation	Dominant Lithology (in type area)
Permian	Karoo	Ecca			Mudrock
Carboniferous		Dwyka		Elandsfontein	Diamictite
	Cape	Witteberg	Lake Mentz	Waaipoort	Mudrock
				Floriskraal	Mudrock/Sandstone
Kweekvlei				Mudrock	
Witpoort			Sandstone		
Weltevrede		Swartruggens	Mudrock/Sandstone		
		Blinkberg	Sandstone		
Devonian		Bokkeveld	Bidouw	Wagen Drift	Mudrock/Sandstone
				Karooport	Mudrock
				Osberg	Sandstone
				Klipbokkop	Mudrock
	Ceres	Wuppertal	Sandstone		
		Waboomberg	Mudrock		
		Boplaas	Sandstone		
		Tra-Tra	Mudrock		
		Hex River	Sandstone		
		Voorstehoek	Mudrock		
Silurian	Table Mountain	Nardouw	Gamka	Sandstone	
			Gydo	Mudrock	
Ordovician	Table Mountain		Rietvlei	Sandstone	
			Skurweberg	Sandstone	
			Goudini	Sandstone	
			Cedarberg	Mudrock	
			Pakhuis	Diamictite	
			Peninsula	Sandstone	

2.3 Vegetation

The study area is located in the Fynbos biome (Cowling *et al.* 1997) and is part of the Cape Core Subregion (CCR) of the Greater Cape Floristic Region (GCFR) (Manning and Goldblatt 2012). The vegetation associated with the interior, low-rainfall areas in the mountains of the Fynbos biome are commonly described as renosterveld and karroid shrublands (Campbell 1986). Acocks (1988) recognised two dominant vegetation types in the study area, namely,

Mountain Renosterveld and Karroid Broken Veld. Low and Rebelo (1996) described the vegetation of the area as Central Mountain Renosterveld (dominated by members of the Asteraceae and the vegetation that is usually found between Fynbos and Succulent Karoo vegetation types) as well as Mountain Fynbos, which is characterised by the presence of Proteas, Ericas and Restios (Low and Rebelo 1996).

Renosterveld is a low to mid-high evergreen, fire-prone, Mediterranean-type vegetation of the Fynbos biome which is dominated by small-leaved, asteraceous shrubs and especially *Elytropappus rhinocerotis* (renosterbos). Renosterveld is furthermore characterised by an understory of grasses and geophytes (Cowling *et al.* 1997). The vegetation is associated with the fertile shale derived soils of lower mountain slopes, interior valleys as well as coastal forelands and occurs in areas that receive between 250 – 600mm of rain, primarily in the winter months (Cowling *et al.* 1997; Krug 2004; Low and Rebelo 1996). As mentioned earlier, the renosterveld component of this winter rainfall flora lacks Fynbos characteristics such as Proteaceae and Ericaceae or having more than 5 – 10% cover of Restionaceae (Low and Rebelo 1996; Moll *et al.* 1984; Rebelo *et al.* 2006). Succulent Karoo vegetation types replace renosterveld in areas where the rainfall is less than 250 – 300 mm per year (Low and Rebelo 1996; Manning and Goldblatt 2012).

The study area forms part of what Rebelo *et al.* (2006) termed the “inland renosterveld of the Mountain Centre” that tends to be more xeric and generally has a lower vegetation cover (determined by moisture) in comparison with the coastal renosterveld types. Mountain Renosterveld is marked by a higher proportion of succulents and is dominated by renosterbos (*E. rhinocerotis*) and *Oedera* spp., while C₄ genera grasses may be prominent (Moll *et al.* 1984; Rebelo *et al.* 2006). According to Rebelo *et al.* (2006), very little is known about renosterveld ecology.

Mucina *et al.* (2005) and Rebelo *et al.* (2006) describe the following vegetation types around the Brandvlei Dam (the range of the respective vegetation types can be seen by following their respective codes in Figure 7):

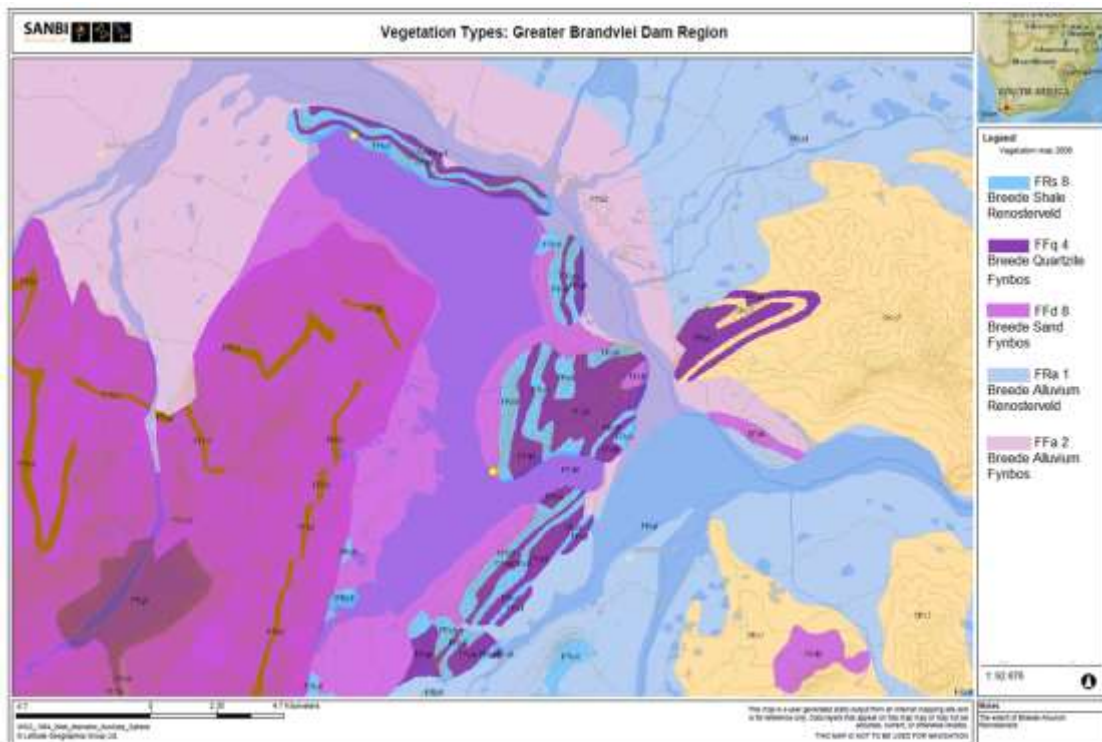


Figure 7: The range of the vegetation types that occur within the study area, as indicated by the interactive National Vegetation Map of South Africa (adapted from SANBI Biodiversity GIS). Red dots indicate the location of the specific study areas.

- Breede Shale Renosterveld – FRs 8
(A poorly studied vegetation unit; conservation status: vulnerable)
- Breede Quartzite Fynbos – FFq 4
(A poorly studied vegetation unit; conservation status: least threatened),
- Breede Sand Fynbos – FFd 8
(A poorly studied vegetation unit; conservation status: vulnerable),
- Breede Alluvium Renosterveld – FRa 1
(conservation status; endangered)
- Breede Alluvium Fynbos – FFa 2
(A poorly studied vegetation unit; conservation status; endangered).

Breede Shale Renosterveld (on predominantly clay soils) and Breede Quartzite Fynbos (on predominantly sandy soils) occur on the hills to the north and east

of the dam (Figures 6 and 7). According to Mucina *et al.* (2005) Breede Sand Fynbos is indicated as the vegetation type of alluvial areas around the dam (Figure 7). Breede Alluvium Renosterveld occurs in the low-lying areas to the east, and southeast of the dam. Breede Alluvium Fynbos is associated with the floodplains of the Breede River and its tributaries (Figure 7).

3. The specific study areas

The two specific study areas relevant to this paper are indicated in Figures 3, 4, 5, 7, 8 and 9. The one, Study Area A, is located on the northern perimeter of the dam east of the Pokkraal wall (Figures 3, 5 and 7), and the other, Study Area B, is located on the eastern perimeter of the dam west of the Kwaggaskloof wall (Figures 4, 5 and 7). The altitude of the study areas ranges between 202 – 212 meters above sea level.

According to Vegmap (Mucina *et al.* 2005; Rebelo *et al.* 2006; SANBI Biodiversity GIS) Breede Shale Renosterveld is found in specific study Area A, and Breede Sand Fynbos in specific study Area B.

Rebelo *et al.* (2006) describe Breede Shale Renosterveld as the vegetation of “low hills, slightly undulating to undulating plains and lower mountain slopes” that makes out most of the valley floor between the towns of Tulbagh and Wolseley with isolated small patches to the vicinity of the town of Worcester from where it irregularly continues towards the towns of Ashton and Swellendam. This shrubland dominated by renosterbos is found on clay and loam soils which are among other, mostly derived from Bokkeveld- and Witteberg Group shales (Rebelo *et al.* 2006). Rebelo *et al.* (2006) list numerous important taxa for Breede Shale Renosterveld such as *Elytropappus rhinocerotis*, *Dodonaea viscosa* var. *angustifolia*, *Pteronia incana*, *Euphorbia burmannii*, *Aloe microstigma*, *Restio gaudichaudianus*, and *Geissorhiza ornithogaloides* subsp. *ornithogaloides*.

Breede Sand Fynbos is described to occur on “dune plumes and dune seas in the valley bottoms primarily south of the Breede River, and extending up the sides of adjacent hills. It has similarities with other sand-fynbos vegetation such

as Leipoldtville Sand Fynbos (Rebello *et al.* 2006) and the vegetation is an open proteoid tall shrubland combined with an open to medium dense restioid herbland in undergrowth” (Rebello *et al.* 2006). Amongst important taxa listed for Breede Sand Fynbos (Rebello *et al.* 2006) are *Leucospermum rodolentum*, *Protea laurifolia*, *Metalasia densa*, *Euchaetis pungens*, *Aspalathus heterophylla*, *Lachnospermum fasciculatum*, *Ruschia caroli*, *Pelargonium senecioides*, *Romulea setifolia*, *Ehrharta villosa* and *Willdenowia incurvata*.

3.2 Methods

The larger study area was delineated in visibly distinctive broad habitat units using aerial photographs (Spot 5 2005, DWAF). Permanent sampling plots of 400m² were placed in stratified random manner (Brown *et al.* 2013) in representative vegetation of each of the delineated units. The specific sampling plot size used was indicated by the minimal area from a species-area curve, which was determined in nested quadrants (Barbour *et al.*, 1987) during a pilot vegetation survey.

Vegetation surveys were conducted following the Zurich-Montpellier (Braun-Blanquet) School of total floristic compositions (Westhoff and van der Maarel, 1978; Barbour *et al.*, 1987). Floristic data collection includes:

- Species composition: Data was recorded for all species noticed within the sampling plot (400m²) at the time of sampling. Plant species noticed on the perimeter of the sampling plot (not occurring within the boundaries thereof) were noted separately.
- Cover: Canopy cover, or “the percentage of plot area beneath the canopy of a given species” (Barbour *et al.* 1987), was estimated according to the modified Braun-Blanquet cover abundance scale. This was done for all species noticed within the plot.
- The geology of the area was studied by means of information from various reference works as well as assessment during field surveys.

- The Breede Alluvium Renosterveld to the east of the Greater Brandvlei Dam was explored to determine possible comparisons between the vegetation and that of the mentioned specific study areas.

3.3 Results and Discussion

The results discussed in this paper are a part of a larger study of the vegetation ecology of the hills and footslope areas around the Greater Brandvlei Dam (Le Roux Ph.D. thesis in prep.).

3.3.1 Geology of the specific study areas

Only the relevant formations outcropping along the northern and eastern shores of the dam pertinent to the specific study areas will be discussed in any detail and are given in Table 1.

No rocks of the Bokkeveld Group are currently exposed above the water level of the dam (Figure 5) but, mudrock belonging to the uppermost unit of the Bokkeveld Group was mapped along the eastern shore of the dam, just south of the dam wall (Siegfried 1984). Although currently covered by water and surficial deposits, poorly exposed, mudrock outcrops are present during low water levels. It consists of medium to dark-grey mudrock (when fresh), weathering to a light grey or reddish colour. The uppermost unit of the Bokkeveld Group is the Karooport Formation (Table 1) but since the underlying sandstone-rich Osberg Formation is not developed in the Brandvlei Dam area (due to the decrease in sandstones southwards) it now forms part of a thicker mudrock dominated Klipbokkop Formation (Gresse 1997; Gresse and Theron 1992).

The Wagen Drift Formation is the basal unit of the Witteberg Group overlying the Karooport/Klipbokkop Formation. In its type area to the north, the Wagen Drift Formation is 165 m thick consisting of alternating beds of grey to black mudrock, siltstone and lithic sandstone with sporadic thin, light-grey, micaceous sandstone beds. Towards the south, as with the other units, the sand content

and grain size of the formation diminishes and it is also mudrock dominated. In the Brandvlei Dam area only relics of the interbedded micaceous sandstone units are still present and the sandstone beds that are present are lenticular. The rocks of the formation weather yellow to red brown or light grey. In effect this means that the geology of the area from below the current water level of the dam up to the overlying Blinkberg Formation to consists largely of mudrock. Rocks of this unit are poorly exposed due to the negative weathering of this zone, forming clayed soils, but a large percentage of gravelly material, originating from the sandstones of the Blinkberg Formation higher up, are incorporated in these soils. Being exposed to strong north-westerly winds, it is also overlain by variable thicknesses of windblown sand at the eastern margin of the dam. Likewise is windblown sand found in areas at the northern margin of the dam owing to the area being exposed to strong south-easterly winds.

3.3.2 Vegetation of the specific study areas

Before long-lasting inundation of the floodplain as a result of damming, it is expected that the clayed soils derived from the basal mudrock layer of the Witteberg Group (exposed on the northern side of the dam) as well as upper (younger) mudrock layers of the Bokkeveld Group (exposed at the eastern side of the dam) (Figure 6) supported alluvium renosterveld vegetation at the bottom of these slopes in the areas where the alluvial covering was/is relatively thin. Aerial photos from 1942 show the braided river system that characterised the floodplain on the north-western perimeter of the former Lake Marais (Figures 3 and 8), as well as the west-east extending floodplain in which the Kwaggaskloof Dam wall was constructed (Figures 3 and 9). According to the composition and texture of the sand (pertinent to if the accumulations were deposited by wind or by water), the depth of sand overlying mudrock, moisture, drainage, as well as the extent and period of inundation (which determine the degree of leaching), it is believed that these floodplains supported a mosaic of vegetation mapped by Mucina *et al.* (2005) as Breede Shale Renosterveld, Breede Alluvium Fynbos, Breede Alluvium Renosterveld as well as Breede

Sand Fynbos vegetation before the dams were constructed (Figures 3, 8 and 9).

The enlargement of Lake Marais included the construction of the Pokkraal wall on the north-western side (Figures 3 and 4), which resulted in further inundation westward from the Brandvlei wall in the east. As the fairly gentle sloping lower parts of the south-facing slopes on the northern side of the dam (where the specific Study Area A is located) is characterised by clayed soils (Table 1; Figure 10), it is speculated that Breede Alluvium Renosterveld likely occurred and that most of the alluvium vegetation at the bottom of these slopes was lost due to inundation as a result of damming as well as erosion due to wave action caused by strong south-easterly winds.

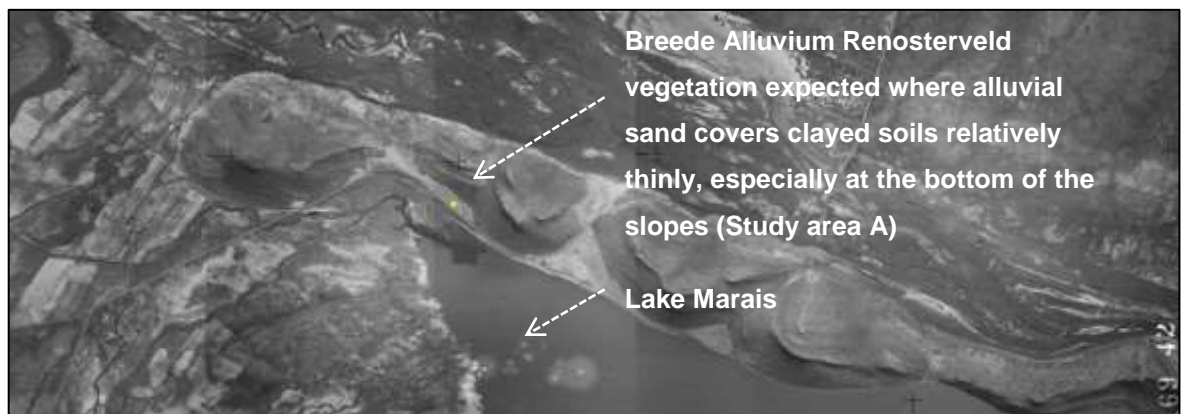


Figure 8: An aerial photo (1942) shows the expected former range of alluvium vegetation on the northern perimeter of the earlier Lake Marais. As illustrated by Figure 5, considerable amounts of alluvium vegetation were lost with the enlargement of Lake Marais. The red dot indicates the location of specific Study Area A (Department of Rural development and Land Reform 1942).

The former Kwaggaskloof floodplain (later inundated by the Kwaggaskloof Dam) (Figures 3 and 9) was fed by runoff from the Voorsorg- Brandvlei- Wabooms-, Kweekkraal- and Stettyns Mountains to the west and southwest as well as the De Wetsberg and Kwaggasberg to the east and the mountains of the Moddergat and De Hoek areas to the southeast (Figures 5 and 9).

The Kwaggaskloof floodplain is underlain by mudrock of the Klipbokkop and Wagen Drift Formations (Table 1). This floodplain historically extended from the Wabooms Mountains in the west (Figure 5), in an easterly direction to where

the braided network of streams flowed through opening in the Kwaggasberg (in which the Kwaggaskloof wall was constructed) (Figure 9) to where it joined the lower floodplains of the Hoeks- and Doorn Rivers to meet the Breede River just east of where the Kwaggaskloof wall is today (Figure 5). The Kwaggaskloof wall now blocks most of the runoff originating from the catchment adjacent to the former Kwaggaskloof floodplain from reaching the Breede River (Figures 5 and 9). This caused the inundation of the larger part of the mentioned floodplain with consequent loss of the natural vegetation which was formerly supported by the shale soils blanketed by sand to various extents (Figures 5 and 9).

As the lower parts of the west- and south-facing slopes of the Kwaggasberg (where the specific Study Area B is located) are characterised by loamy sand (Figure 11), it is speculated that Breede Alluvium Renosterveld most likely was one of the types of alluvium vegetation to be expected at the bottom of these slopes (Figures 6 and 11).

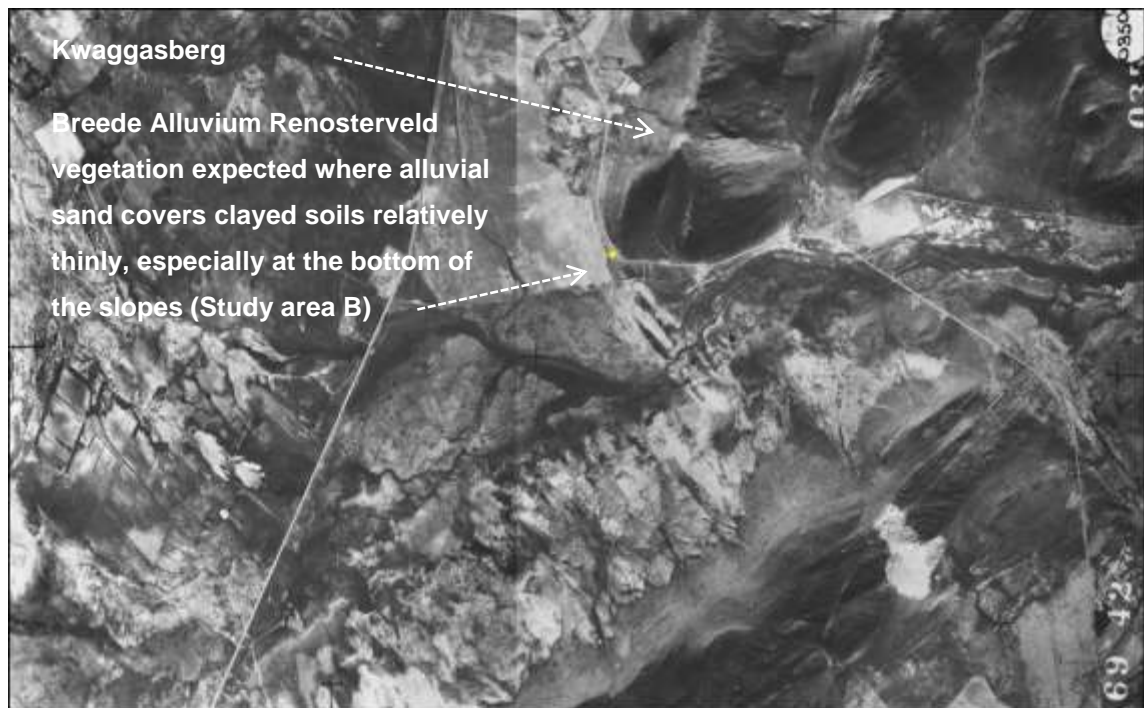


Figure 9: An aerial photo (1942) shows the expected former range of alluvium vegetation on the northern perimeter of the earlier Lake Marais. As illustrated by Figure 5, considerable amounts of alluvium vegetation were lost with the enlargement of Lake Marais. The red dot indicates the location of specific Study Area A (Department of Rural development and Land Reform 1942).

Both the specific study areas, Area A (Figure 10) and Area B (Figure 11) are characterised by gravelly red/yellow to grey clay soils, thinly covered with finer grained loamy alluvial sand. The clay soils in these areas are derived from the shale band that is exposed at the northern and south-eastern shorelines of the dam, and which likely forms part of the contact- or transitional zone between the Witteberg- and Bokkeveld Groups in this area (Figure 5).



Figure 10: The vegetation and soil characteristics of Study Area A; believed to be a relic of Breede Alluvium Renosterveld, on the northern perimeter of the Greater Brandvlei Dam.

For Breede Shale Renosterveld (Figure 12), National Soil Classes indicate the presence of “lithosols (shallow soils on hard or weathering rock) which are described as “soils with minimal development, usually shallow, on hard or weathering rock, with or without intermittent diverse soils” (SANBI Biodiversity GIS). As depicted by Figures 5, 8 and 9, the lower slopes on the perimeter of the dam are characterised by seasonally wet alluvial terraces associated with drainage ducts that had previously fed tributaries of the Breede River. These

waterways in the rainy season, as well as strong prevailing winds in the dry season, carried and deposited the finer grained alluvium covering that is associated with an alluvium renosterveld vegetation (Figures 10 and 11). A renosterveld plant community (which corresponds with Breede Shale Renosterveld) (Figure 12) was found to occur higher up on the slopes and although this unit shares some characteristics with Breede Alluvium Renosterveld as far as both vegetation units being supported by clay soils derived from mudrock of the Bokkeveld and Witteberg Groups, and have similar dominant plant species such as renosterbos, the soil supporting a *Selago triquetra*–*Elytropappus rhinocerotis* renosterveld plant community (which corresponds with Breede Shale Renosterveld) in the low lying alluvium areas is more sandy with typical plant species such as *Chenolea convallis* and *Mesembryanthemum caudatum*.

For Breede Sand Fynbos vegetation in the larger study area, National Soil Classes indicate “soils with negligible to weak profile development usually occurring on deep alluvial deposits” (SANBI Biodiversity GIS).



Figure 11: The vegetation and soil characteristics of Study Area B; believed to be a relic of Breede Alluvium Renosterveld, on the eastern perimeter of the Greater Brandvlei Dam

Field data from a recent detailed vegetation study (Le Roux in prep.) confirm that in the Greater Brandvlei Dam environment, the *Leucospermum rodolentum*–*Thamnochortus bachmannii* *Willdenowia incurvata*–*Thamnochortus bachmannii* communities (belonging to the *Thamnochortus bachmannii* sandveld which correspond to Breede Sand Fynbos) occurs in areas characterised by thick alluvial sand as well as on aeolian sand accumulations in several areas on the perimeter as well as up the slopes around the dam.



Figure 12: The vegetation and soil characteristics of Breede Shale Renosterveld on the southern slopes of the hills on the northern perimeter of the Greater Brandvlei Dam.

In the larger study area, the alluvium renosterveld vegetation (Figures 10 and 11) is distinguished from bordering sandveld vegetation (Figure 13) by the deep moist sand deposits and the occurrence of restioid fynbos that characterise the latter (Figure 13; Le Roux in prep.; Rebelo *et al.* 2006). Based on geology, soil and plant species composition, the vegetation of the respective specific study areas (A and B) were found to bear a resemblance to Breede Alluvium Renosterveld rather than to Breede Shale Renosterveld or Breede Sand Fynbos as described by Rebelo *et al.* (2006) (Figure 13).

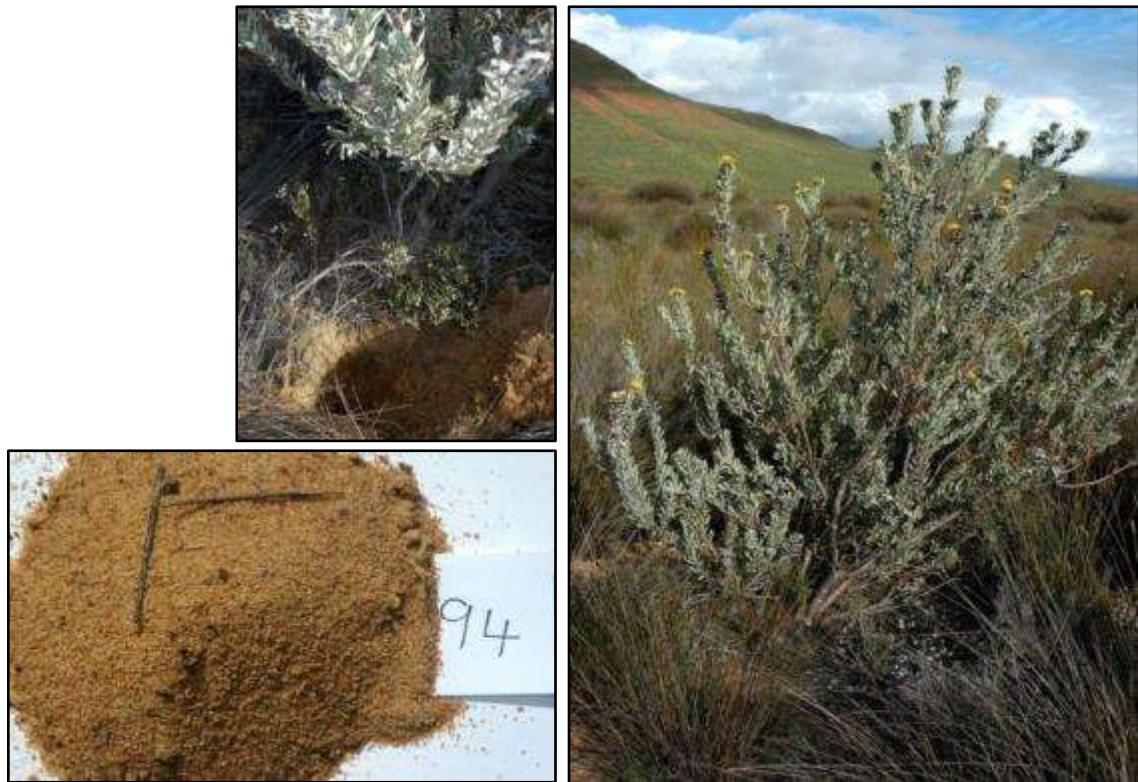


Figure 13: The vegetation and soil characteristics of Breede Sand Fynbos growing on thick sand accumulations in the region of the Greater Brandvlei Dam.

Le Roux (in prep.) found the following vegetation communities at the respective study areas:

3.3.2.1 Study area A

Study area A supports the *Selago triquetra*–*Elytropappus rhinocerotis*–*Limonium amoenum* sub-community of which important species include: *Wurmbea marginata*, *Moraea virgata*, *Hesperantha radiata*, *Itasina filifolia*, *Lotononis rigida*, *Limonium amoenum* and *Tribolium echinatum* where the last two species are diagnostic.

Constant species include *Limonium amoenum*, *Antimima microphylla*, *Aspalathus submissa*, *Babiana patula*, *Bulbine frutescens*, *Chrysocoma ciliata*, *Cyanella hyacinthoides*, *Drosanthemum parvifolium*, *Ehrharta capensis*, *Elytropappus rhinocerotis*, *Eriocephalus africanus*, *Helichrysum rutilans*, *Heliophila coronopifolia*, *Heliophila pendula*, *Hesperantha radiata*, *Restio capensis*, *Itasina filifolia*, *Microloma sagittatum*, *Mohria caffrorum*, *Moraea*

inconspicua, *Moraea virgata*, *Oedera squarrosa*, *Pentameris airoides* ssp. *airoides*, *Ruschia species*, *Satyrium erectum*, *Selago triquetra*, *Stipa capensis*, *Thesium subnudum*, *Trachyandra muricata*, *Tribolium echinatum*, *Tribolium hispidum*, *Ursinia anthemoides* and *Wurmbea marginata*. *Antimima microphylla*, *Ehrharta calycina*, *Elytropappus rhinocerotis* and *Ursinia anthemoides* are dominant species (Le Roux in prep.).

3.3.2.2 Study area B

Study area B supports the *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community of which important species include: *Euphorbia tuberosa*, *Lotononis hirsuta*, *Gazania krebsiana* ssp. *arctotooides*, *Mesembryanthemum caudatum*, *Romulea hirsuta* var. *cuprea*, *Tribolium uniolae*, *Lessertia herbacea*, *Ficinia indica*, *Lampranthus scaber*, *Cyphia incisa* var. *cardamines*, *Aizoon sarmentosum*, and *Senecio anthemifolius* (Le Roux in prep). *Aizoon sarmentosum*, *Cyphia incisa* var. *cardamines*, *Heliophila descurva* and *Senecio anthemifolius* are diagnostic while constant species include *Aizoon sarmentosum*, *Antimima microphylla*, *Arctopus echinatus*, *Aspalathus muraltioides*, *Aspalathus spicata*, *Babiana patula*, *Bulbinella triquetra*, *Chrysocoma ciliata*, *Corymbium africanum* ssp. *scabridum* var. *scabridum*, *Crassula subulata* var. *subulata*, *Cyphia incisa* var. *cardamines*, *Drosanthemum parvifolium*, *Drosera cistiflora*, *Ehrharta capensis*, *Ehrharta villosa*, *Elytropappus rhinocerotis*, *Eriospermum graminifolium*, *Euphorbia tuberosa*, *Ficinia indica*, *Ficinia nigrescens*, *Gazania krebsiana* ssp. *arctotooides*, *Geissorhiza ornithogaloides* ssp. *ornithogaloides*, *Helichrysum incarnatum*, *Helichrysum rutilans*, *Heliophila descurva*, *Heliophila pusilla*, *Indigofera heterophylla*, *Restio capensis*, *Restio gaudichaudiana*, *Lampranthus scaber*, *Lampranthus spiniformis*, *Lessertia herbacea*, *Lotononis hirsuta*, *Tenaxia stricta*, *Microloma sagittatum*, *Mohria caffrorum*, *Montinia caryophyllacea*, *Moraea vuvuzela*, *Moraea virgata*, *Nenax hirta*, *Nylandtia spinosa*, *Oedera genistifolia*, *Othonna pinnata*, *Oxalis depressa*, *Oxalis pulchella* var. *tomentosa*, *Oxalis purpurea*, *Pelargonium rapaceum*, *Pharnaceum aurantium*, *Mesembryanthemum caudatum*, *Romulea hirsuta* var. *cuprea*, *Rumex*

sagittatus, *Satyrium erectum*, *Selago triquetra*, *Senecio anthemifolius*, *Struthiola confusa*, *Thamnochortus bachmannii*, *Thesium dissitiflorum*, *Thesium subnudum*, *Trachyandra muricata*, *Tribolium hispidum*, *Tribolium uniolae*, *Ursinia anthemoides*, *Wachendorfia paniculata* and *Wiborgia mucronata* are constant. Dominant species for *Struthiola confusa*–*Elytropappus rhinocerotis*–*Senecio anthemifolius* sub-community include *Elytropappus rhinocerotis* and *Eriocephalus africanus* (Le Roux in prep.).

4 Conclusions

According to Vegmap (Mucina *et al.*, 2005), Breede Shale Renosterveld and Breede Sand Fynbos (Mucina *et al.*, 2005) occur on the northern and eastern fringes of the Greater Brandvlei Dam (Figure 7). The findings of this study provide proof that the geology of the lower part of the hills bordering the dam on the northern, eastern and southern sides, from below the current water level of the dam up to the overlying Blinkberg Formation consists largely of mudrock (Table 1; Figure 5) covered by alluvium sand supporting renosterveld vegetation. An alluvium renosterveld plan community is found in areas at the lower parts of slopes where the blanket of alluvium sand is relatively thin and loamy (Figures 10 and 11), while Breede Shale Renosterveld (Figure 12) is found higher up the slopes where no alluvial sand is evident and Breede Sand Fynbos (Figure 13) grows on the deeper alluvial sand accumulations (Figure 13) in some areas at the bottom of slopes, but also on deep windblown sand deposits in other areas around the dam.

Although the plant communities do not precisely correspond with Breede Alluvium Renosterveld as described by Rebelo (2006), because of the alluvial character of the specific study areas (Figures 5, 8 and 9), as well as some resemblance regarding the plant species composition, it is proposed that the renosterveld of the mentioned specific study areas is classified as Breede Alluvium Renosterveld, rather than Breede Shale Renosterveld or Breede Sand Fynbos (compare Figures 10 and 12 and 11 and 13). Just as the Brandvlei and Pokkraal dam walls divided former floodplains, the construction of the Kwaggaskloof wall created a barrier in the floodplain that extended eastwards

towards the Breede River through the opening in the Kwaggasberg (Figures 3, 4, 7, 8 and 9). It is believed that this alluvium renosterveld most likely was one of the alluvium vegetation types of the Brandvlei Valley (Figures 8 and 9) which have been destroyed through construction of the Brandvlei and Kwaggaskloof Dams, as well as the joining of these two dams to the Greater Brandvlei Dam as it is today. The alluvium renosterveld plant community at the lowermost footslopes of the hills around the dam is most probably a remnant of larger tracts of Breede Alluvium Renosterveld vegetation which still occur to the east of the larger study area (Figure 5).

Considered a threatened vegetation type, the Breede Alluvium Renosterveld has a high conservation value (Raimondo *et al.* 2009; SANBI 2009). This is exemplified by other species of conservation concern that occur in the alluvium renosterveld vegetation in the Greater Brandvlei Dam area (le Roux in prep.). Since recently, the only population of an interesting species of the Chenopodiaceae, *Chenolea convallis* was known from just above the current water's edge on the eastern side of the dam (Snijman and Manning, 2013). Although a new population was recently found in the Breede Alluvium Renosterveld (which is similar to the vegetation of Study Area B) about five kilometres east of the type population (Figure 7), Snijman and Manning (2013) suggested that *C. convallis* should be classified as Critically Endangered according to the South African Red List categories and criteria (Raimondo *et al.* 2009).

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