The Phytogeography of the Sneeuberg, Nuweveldberge and Roggeveldberge (Great Escarpment): Assessing Migration Routes and Endemism

A thesis submitted in the fulfilment of the requirements for the degree of

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Dedication

"For by Him were all things created that are in heaven and that are on earth, visible and invisible…All things were created through Him and for Him. And He is before all things and in Him all thing consist"

Colossians 1:16–17

This thesis is dedicated to the Lord Jesus Christ, Who knows unequivocally what actually has gone on on this planet in ages gone by (!)

Abstract

The Great Escarpment forms a semi-continuous mountain system 5 000 km long, stretching from Angola in the north-west, south through Namibia, and into western, southern and eastern South Africa, including Lesotho and Swaziland. It is composed of a wide variety of geological suites but is unified in representing the edge of the African plateau and the passive Gondwanan continental margin. The Great Escarpment falls into all major climatic zones on the subcontinent, is a repository of palaeo- and neo-endemics, hosts more than half of southern Africa's centres of plant endemism, and has a rich suite of endemic fauna. In addition, the Great Escarpment is believed to be both a refugium and corridor for biological diversity. Despite the biological richness of the Great Escarpment, research to date has been fragmented and many sections of the Great Escarpment have not been studied.

The aim of this study is to contribute to research on the Great Escarpment by undertaking a detailed floristic study of the southern Great Escarpment (the Sneeuberg, Nuweveldberge and Roggeveldberge). Together these mountains comprise approximately 1 000 km (one fifth) of the Great Escarpment, and occupy a transition zone between the summer rainfall zone in the east and the winter rainfall zone in the west. They are also the sections of Great Escarpment most closely situated to the Cape Floristic Region (CFR) and would thus be involved in hypothesised migration routes for lineages that also occur further north through the Drakensberg Alpine Centre (DAC) to the East African mountain chain.

Detailed fieldwork of the southern Great Escarpment was undertaken over a period of four years in all seasons. Approximately 8 000 specimens were collected. Particular emphasis was placed on areas that may represent refugia, i.e. the highest plateaux and peaks, mesic areas and cliff-lines. An overview of each mountain range, together with their endemic plant species and phytogeography, is provided. Approximately ten new species have been discovered during this study, two of which have been

described to date. Numerous endemics only known from their types have also been rediscovered. The Sneeuberg is defined as a new centre of plant endemism on the Great Escarpment (endemism of 2.3%), and the role of the Boschberg and Groot-Bruintjieshoogde (part of the Sneeuberg) as a nexus for floristic migration routes is discussed. The Nuweveldberge is shown to have low endemism despite a floristic tally similar to the Sneeuberg, while the Roggeveldberge are confirmed to be the most endemic-rich section of the southern Great Escarpment.

The field data collected was augmented by available data in taxonomic revisions, and floras for the Sneeuberg, Nuweveldberge and Roggeveldberge were compiled. In order to floristically compare the southern Great Escarpment with other sections of the Great Escarpment and the CFR, a database of some 12 000 taxa was created using available floristic data for the CFR, DAC and Great Winterberg–Amatolas, together with the data collated for the Sneeuberg, Nuweveldberge and Roggeveldberge. These data were analysed using phenetic methods and Parsimony Analysis of Endemicity (PAE). The results indicate stronger linkages in the east, particularly between the Sneeuberg and Nuweveldberge, and between the Sneeuberg and the Great Winterberg–Amatolas. The relationship of the Roggeveldberge with the rest of the southern Great Escarpment remains ambiguous.

In order to refine notions of connectivity and migration routes, 19 well-sampled phylogenies were assessed for sister-taxon disjunctions to explore CFR–Great Escarpment connections. Palaeo-connectivity between the CFR and southern Great Escarpment is most strongly supported for the south-eastern (SE) connection, and less so for the north-western (NW) and Matjiesfontein connections. There is support for the current (or recent) use of these three connections from numerous species that occur on both sides of the connections. Results of these analyses indicate that the southern Great Escarpment is a palaeo-corridor, the functioning of which has been broken by the aridification of the Nuweveldberge since the Last Glacial Maximum (LGM). Floristic connectivity is strongest in the east, from the Nuweveldberge to the DAC, and is less so in the west between the Nuweveldberge and the Roggeveldberge – a finding attributed to the transition from a reliable winter rainfall regime on the Roggeveldberge to an unpredictable moisture regime on the Nuweveldberge. The mountains of the southern Great Escarpment are thus a series of refugia from a previous moister, cooler climate and are a corridor between the eastern and western components of the Great Escarpment. The SE connection is the primary link between the CFR and the eastern Great Escarpment Afromontane region in southern Africa.

The implications of this research are that accurate conservation assessments and Red Data listings for many of the previously poorly-known endemics can now be made, and appropriate conservation measures implemented. Climate change remains the primary threat to these endemics and montane taxa in general, while degradation of wetlands is the primary threat to the water catchment service provided by the southern Great Escarpment. Future detailed research on the Great Winterberg–Amatolas and Stormberg – and a comprehensive flora of the Hantam–Roggeveldberge – will further enhance our understanding of the floristics of the southern Great Escarpment, and provide the necessary data for comprehensive GIS-based models of proposed climate change scenarios for local, regional and national conservation planning.

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Declaration

This thesis is the result of the author's original work except where acknowledged or specifically stated in the text. It has not been submitted for any other degree of examination at any other university or academic institution.

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V.R. Clark

Preamble

This thesis represents the first phytogeographical analysis of the southern Great Escarpment, southern Africa. This region is part of the Great Escarpment, which – despite being such a prominent component of the sub-continent – is not a well-studied entity. Importantly, more than half of the recognised centres of floristic endemism in southern Africa are associated with the Great Escarpment. This study contributes substantially to filling in missing floristic data, and the recognition of one new centre of endemism and the delimitation of one other centre.

This thesis therefore commences (Chapter 1) with an overview of the Great Escarpment in terms of its origins, physical characteristics, biodiversity and endemism, as well as research opportunities and conservation, and sets the context for the main body of this thesis, being the southern Great Escarpment.

The main body of the thesis focuses on three main components of the southern Great Escarpment, namely the Sneeuberg mountain complex, the Nuweveldberge, and the Roggeveldberge. Together these mountains comprise roughly 1 000 km (one fifth) of the 5 000 km-long Great Escarpment. The phytogeography of each of these regions is presented as Chapters 2–5. These chapters provide a physical and floristic overview of each of these mountains, with particular emphasis on endemism and floristic connectivity ("connectivity" is here defined as the actual or perceived floristic relatedness – historically and currently – between two or more orographic entities, viz. the various components of the southern Great Escarpment, the DAC and the CFR in this thesis; "hub" refers to an orographic entity through which connections or links with various other orographic entities passed or pass; "track" refers to the southern Great Escarpment track or montane corridor between the Hantam–Roggeveld in the west and the DAC in the east). Although part of the Sneeuberg mountain complex and broadly included in Chapter 2, a more detailed consideration of the Boschberg and Groot-Bruintjieshoogde is provided in Chapter 3, given their pivotal biogeographical location in the Sneeuberg mountain complex as part of the SE connection to the CFR.

These chapters represent the result of 36 individual fieldtrips over a period of four years in all seasons, amounting to approximately 2 000 man hours in the field and 21 700 km of road mileage. A total of some 8 000 specimens were collected from these mountains, representing the first comprehensive and systematic botanising for much of these areas.

Chapter 6 synthesises the floristic data and observations presented in Chapters 2–5 to paint a floristic and phytogeographical picture of the southern Great Escarpment, by considering the relationship between its various montane components, and with the DAC and the CFR. The main aim of this Chapter is to consider both endemism and connectivity between the Great Escarpment and CFR and the role of the Great

Escarpment as a corridor for Cape elements between the CFR and DAC, hypotheses first presented by Weimarck (1941). In this chapter, a combination of numerical floristic analysis, multivariate analysis and phylogenetic analyses of various plant groups are used to explore aspects of endemism, connectivity and phytogeographic relatedness. The results are then weighed against current and palaeoclimatic data to interpret the floristic patterns and results of the analyses.

Format of this thesis

Each chapter has been prepared with the intention to submit each as a separate publication (Chapter 2 has already been published as such, see below). When reading each chapter, some repetition of information presented in preceding chapters may thus be encountered, but for the purposes of this thesis, an effort has been made to limit this. The reader's indulgence is appreciated where such repetition has been retained – it has been done for the sake of re-emphasis or intentional re-iteration to address a point that is considered relevant.

Plant author names for species contained in the floras (Appendices 2–5) are not repeated in the text. The appendices for each chapter have been included at the end of each chapter respectively as a convenience to the reader. Appendix 6.1 is contained on a compact disc, as a hardcopy of the data would run into over 800 pages.

Previously published work

Some of the work presented in this study has been published previously and is contained in the Additional Appendices at end of the thesis:

- Clark, V.R., Barker, N.P., Mucina, L., 2009. The Sneeuberg: A new centre of floristic endemism on the Great Escarpment, South Africa. South African Journal of Botany 75, 196–238.

- Nordenstam, B., Clark, V.R., Devos, N., Barker, N.P., 2009. Two new species of *Euryops* (Asteraceae: Senecioneae) from the Sneeuberg, Eastern Cape Province, South Africa. South African Journal of Botany 75, 145–152.

Chapter 1: The Great Escarpment of Southern Africa.

1.1. Introduction

What is an escarpment? Matmon et al. (2002) define an escarpment as separating a lower elevation plain (coastal or otherwise) from a relative plateau highland. In this regard the Great Escarpment in southern Africa comprises the rim of the inland African plateau (Van Zinderen Bakker, 1983; White, 1983; Birkenhauer, 1991; Burke et al., 1998; Moore et al., 2009) that dominates the interior of southern Africa (McCarthy and Rubidge, 2005). It forms a series of mountain ranges and scarps between the plateau and the coastal lowlands and extends for some 5 000 km from northern Angola in the north-west south through Namibia to the Western Cape Province in South Africa, then east and north through Lesotho and the eastern provinces of South Africa to the highlands of eastern Zimbabwe/western Mozambique (White, 1983; Birkenhauer, 1991; Eitel et al., 2004; Hahn, 2005; Burke et al., 1998; Figs 1.1 and 1.2).

What makes the southern African Great Escarpment a truly fascinating system is the concept of a semi-continuous montane system/upwarped plateau margin consisting of numerous different geological suites in varying climatic conditions (White, 1983; Moore and Blenkinsop, 2006), but with some consistent geomorphology as a plateau margin (Van Zinderen Bakker, 1983) and with numerous centres of biological diversity (Van Wyk and Smith, 2001). The aim of this chapter is to provide an overview of the Great Escarpment – both in terms of origins, physical environment and biodiversity – and to outline research opportunities and initiatives as well as conservation priorities. A photographic overview of the Great Escarpment is presented in Fig. 1.2.

In defining what should be included in an overview of the Great Escarpment, it is sometimes difficult to know what to leave out, particularly as numerous other southern African mountain ranges lie adjacent to the principal Great Escarpment or are clearly biogeographically related. A more conservative approach has been opted for, and the Soutpansberg (Limpopo Province, South Africa; Fig. 1.1) has been excluded as it had a different orogeny than that of the Great Escarpment (Schönhofer, 2008). The Witwatersrand, Magaliesberg and Waterberg systems (South Africa), Otavi–Waterberg mountains (Namibia) and Mashonaland plateau (Zimbabwe), although clearly biogeographically related to the Great Escarpment (Moore et al., 2009), have been excluded for similar reasons. The Karasberge in southern Namibia (Fig. 1.1) have also been excluded, even though they were no doubt connected to the Great Escarpment prior to incision of the (Namibian) Fish River. Similarly, the KwaZulu–Natal (KZN) Midlands are a high-altitude area with obvious biogeographical affinities to the Great Escarpment (as they in many places exceed 2 000 m in altitude), but are here also excluded.

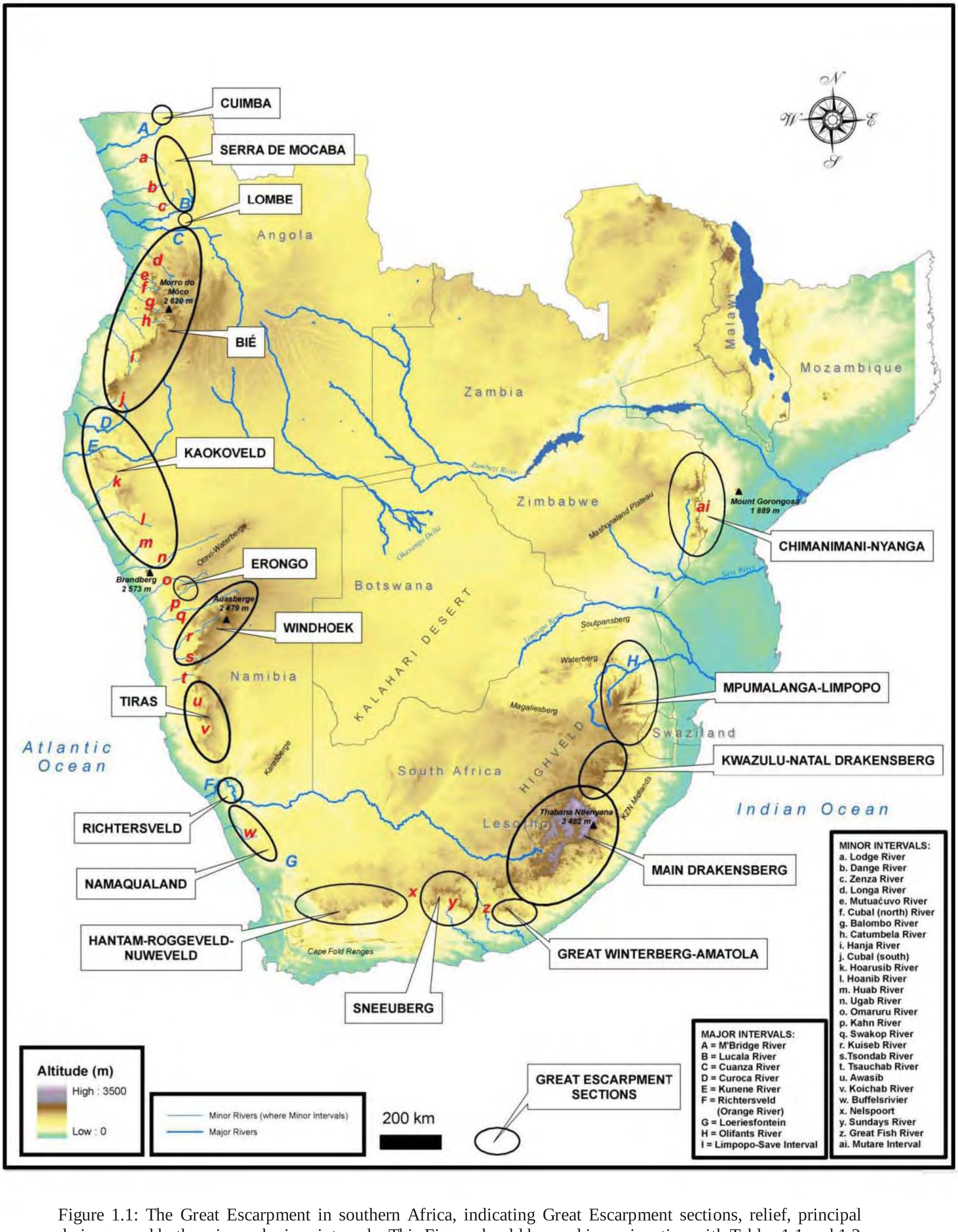


Figure 1.1: The Great Escarpment in southern Africa, indicating Great Escarpment sections, relief, principal drainage, and both major and minor intervals. This Figure should be used in conjunction with Tables 1.1 and 1.2 and Appendix 1.1. GIS data sources: GeoNetwork (2000), Atlas of Namibia Project (2002) and Geo Community (2009). Base relief map generated by G. Keevey (Department of Botany).

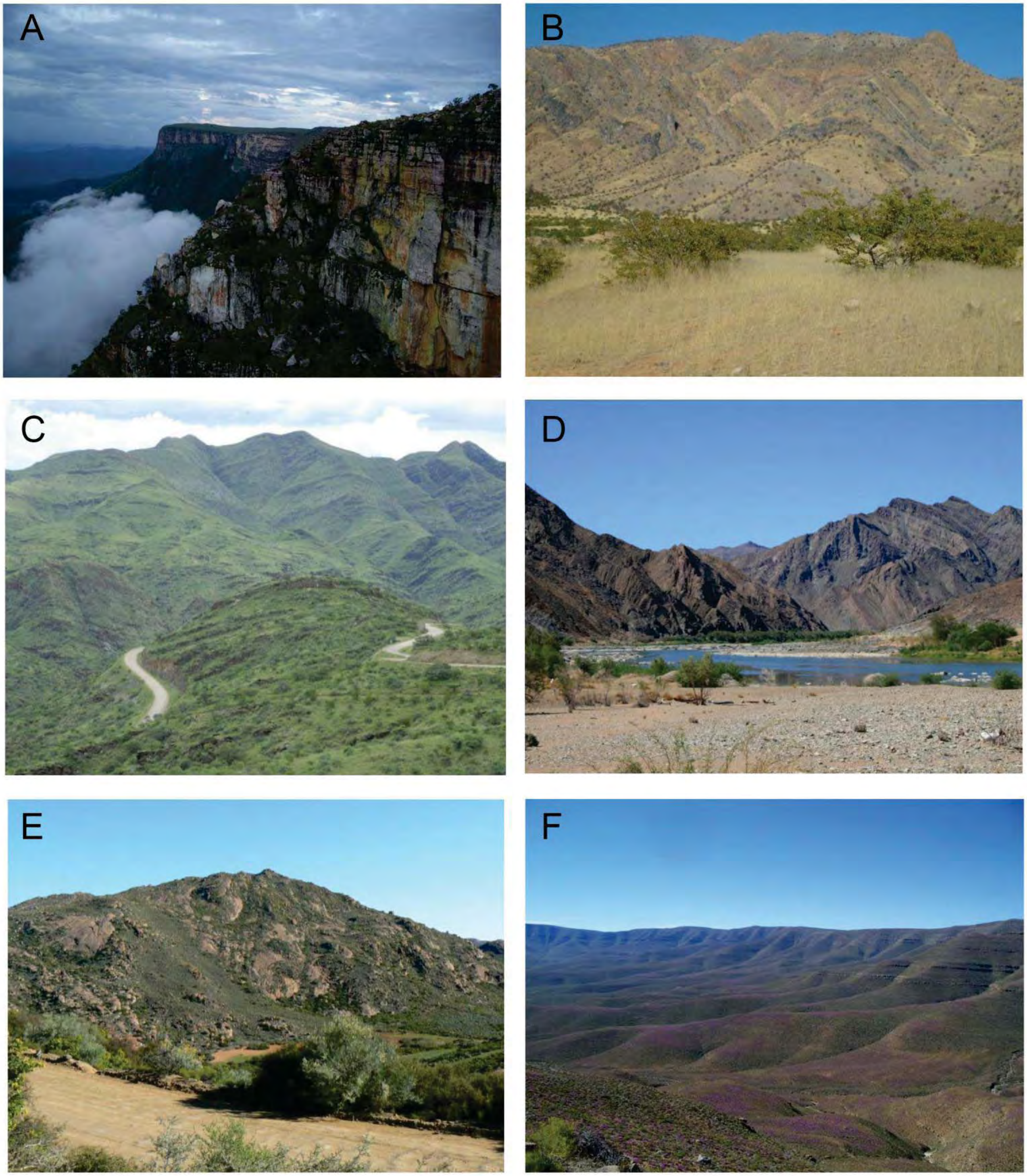


Figure 1.2: A selection of photographs from the Great Escarpment in southern Africa: (A) The southern part of the Bié Escarpment near Lubango, southern Angola; (B) The Kaokoveld Escarpment near Warmquella, northern Namibia; (C) A section of the Khomas Hochland, part of the Windhoek Escarpment, central Namibia; (D) The Richtersveld Escarpment, with the Orange River in the foreground, western South Africa; (E) The Kamiesberg, on the Namaqualand Escarpment, western South Africa/southern Namibia; (F) The Ouberg Pass on the Roggeveldberge, Hantam–Roggeveld–Nuweveldberg Escarpment, south-western South Africa. Photos from: (A and F) V.R. Clark; (B) Carl Huchzermeyer; (C) Colleen Mannheimer; (D) Syd Ramdhani; (E) Gareth Hempson.

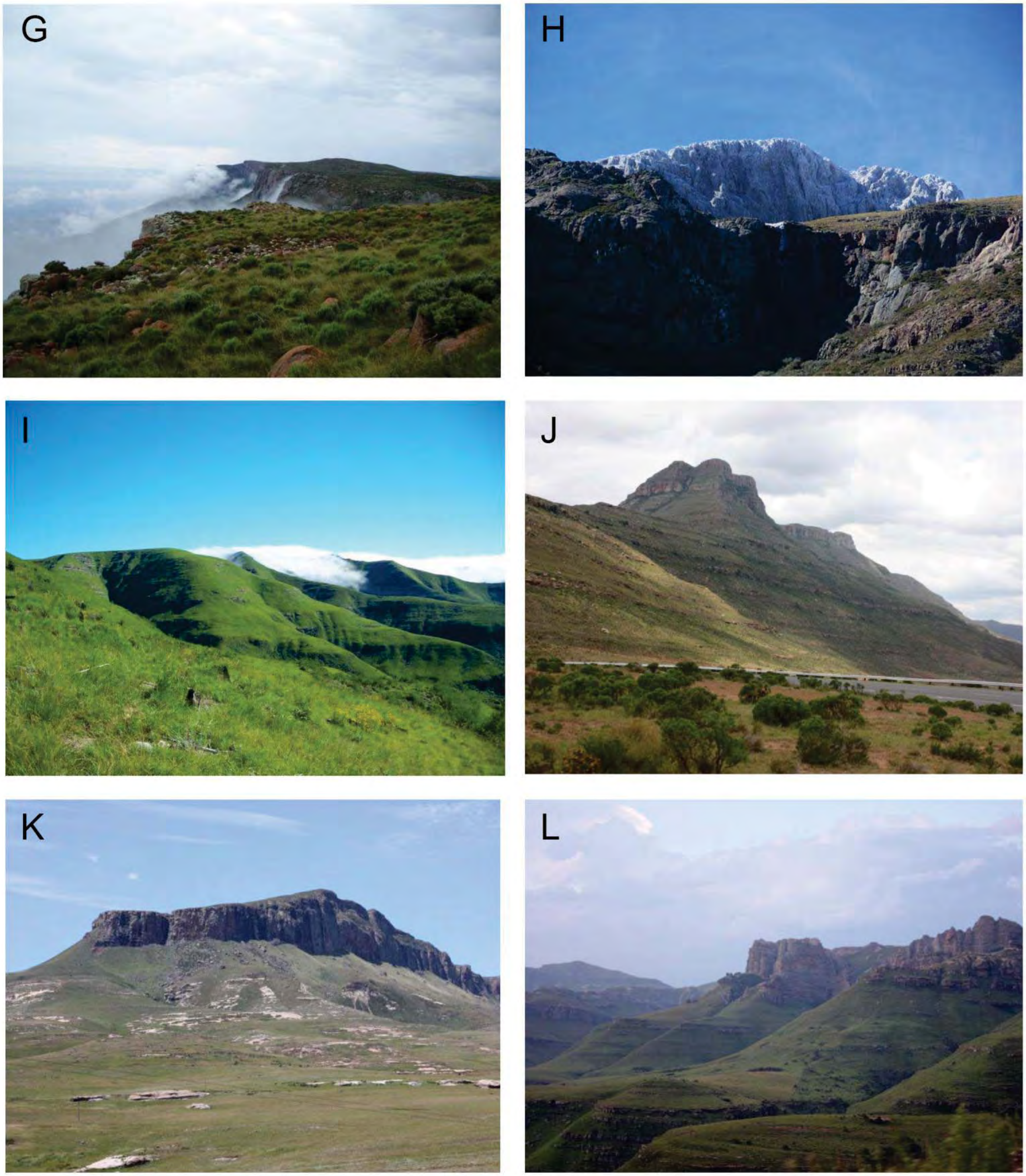


Figure 1.2 (cont.): (G) The Eastern Nuweveldberge on the Hantam–Roggeveld–Nuweveldberg Escarpment, southern South Africa (S.A.); (H) The Nardousberg on the Sneeuberg Escarpment, southern S.A.; (I) The Great Winterberg–Amatola Escarpment near Katberg Pass, southern S.A.; (J) The Stormberg in the Main Drakensberg Escarpment, southern S.A.; (K) The Eastern Cape Drakensberg, part of the Main Drakensberg Escarpment, near Barkley East, southern S.A.; (L) The Eastern Cape Drakensberg, part of the Main Drakensberg Escarpment, from Barkley Pass, southern S.A.. Photos from: (G–I) V.R. Clark; (J–L) Mario Martínez-Azorín.

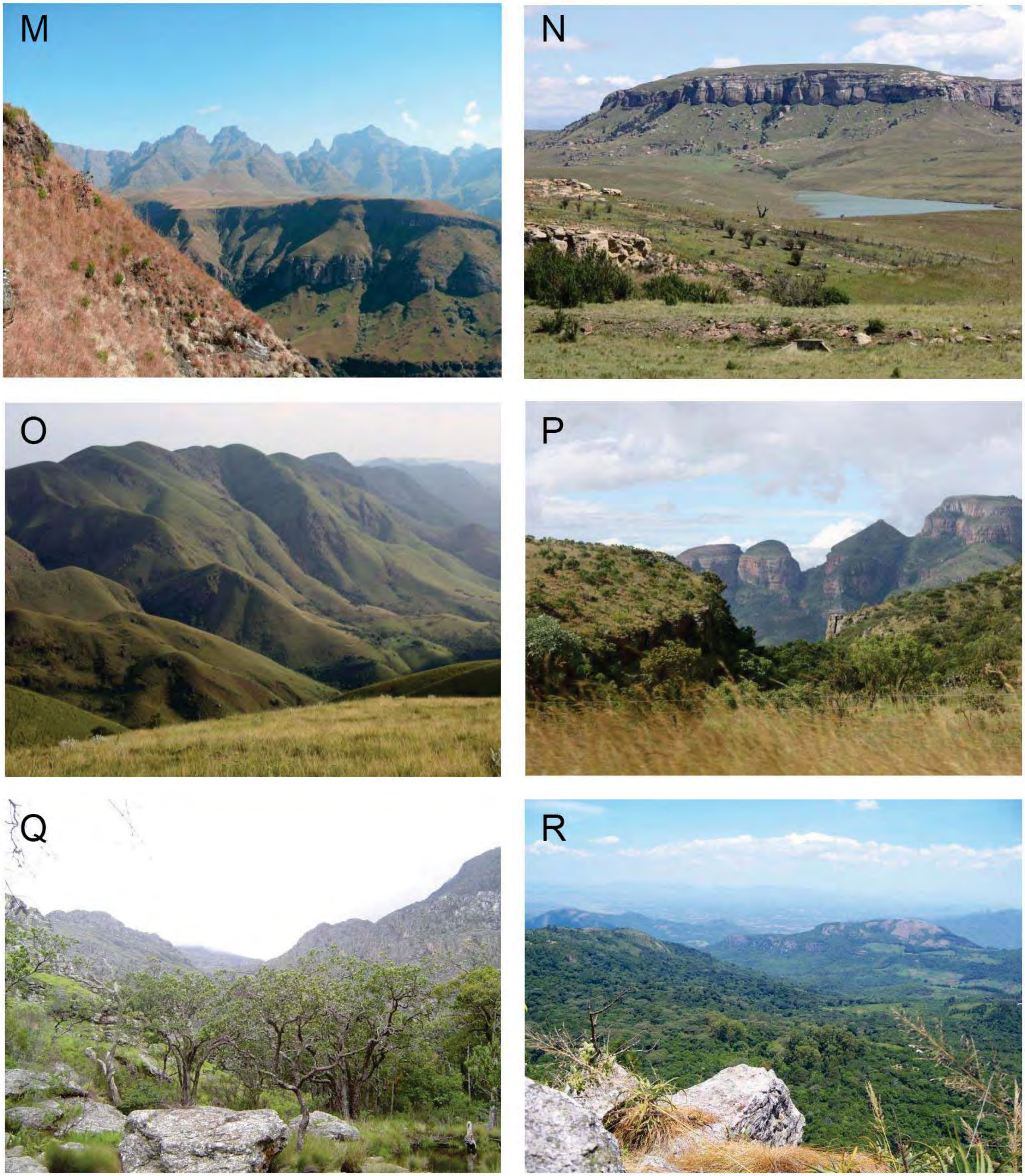


Fig. 1.2 (cont.): (M) The Central Drakensberg on the Main Drakensberg Escarpment, eastern South Africa and Lesotho; (N) Sterkfontein Dam, on the KwaZulu–Natal Drakensberg, eastern South Africa; (O) The Mpumalanga–Limpopo Escarpment, western Swaziland; (P) The Blyde River Canyon area on the Mpumalanga–Limpopo Escarpment, eastern South Africa; (Q) The Chimanimani Mountains on the Chimanimani–Nyanga Escarpment, eastern Zimbabwe; (R) The Bvumba Mountains, on the Chimanimani–Nyanga Escarpment, eastern Zimbabwe. Photos from: (M) Mathew Clark; (N–P) Mario Martínez-Azorín; (Q) Roderick Parsons; (R) V.R. Clark.

1.2. The geology, geomorphology, origin and physical characteristics of the Great Escarpment

1.2.1. Origins

Although the orogenesis of the Great Escarpment is a matter of much debate (Birkenhauer, 1991), it is generally believed to have developed following the break-up of Gondwanaland in the late Jurassic/early Cretaceous (Partridge and Maud, 1987; Gilchrist et al., 1994; McCarthy and Rubidge, 2005; Moore et al., 2009). A key factor in the development of the Great Escarpment was the high absolute elevation of southern Africa at the time of rifting (Partridge and Maud, 1987; Kooi and Beaumont, 1994). The Great Escarpment is considered to represent a passive, erosional remnant of the continental margin that has receded from the original zones of rifting by means of parallel retreat (Artyushkov and Hofmann, 1998; Matmon et al., 2002; Moore and Blenkinsop, 2006), and explains the current primarily parallel orientation of the Great Escarpment relative to the coast 50–200 km distant (Gilchrist et al., 1994; Kooi and Beaumont, 1994). Two continental uplift events (in the Miocene and Pliocene, 18–20 and 2.5–5 Myrs ago respectively) are believed to have accentuated the prominence of the Great Escarpment – particularly in the east in South Africa (Partridge and Maud, 1987; Artyushkov and Hofmann, 1998; Woodford and Chevallier, 2002; McCarthy and Rubidge, 2005; Moore and Blenkinsop, 2006). Consequently the Great Escarpment mountains stand above the landforms produced by the post-uplift Post-African I and II erosion cycles that took place after each of these uplift events (Partridge and Maud, 1987). The highest sections of the Great Escarpment are thus considered (at least in part) to represent the original Gondwana land-surface (Agnew, 1958; Dean, 2001; McCarthy and Rubidge, 2005; Clark et al., 2009), although this has been queried by Fleming et al. (1999).

A matter of debate has been the evolution of the Great Escarpment and the rate of retreat (Matmon et al., 2002; Moore and Blenkinsop, 2006). Current research suggests an initially rapid rate of retreat during seafloor spreading, slowing down following base-level stabilisation relative to the Great Escarpment (Matmon et al., 2002). The shoulder-type nature of the Great Escarpment – where drainage divide and scarp edge co-incide – may also be a later factor given the slower rate of retreat for such escarpments (Kooi and Beaumont, 1994; Matmon et al., 2002). The current position of the Great Escarpment in proximity to gravimetric and magnetic anomalies suggests that deep crustal structure is a controlling element in the current location of the Great Escarpment rather than surficial processes (Matmon et al., 2002). Essentially, the Great Escarpment is believed to have been in its current location since the end of the Cretaceous (McCarthy and Rubidge, 2005), and has been a stable feature of the subcontinent since that time (Gilchrist et al., 1994; Matmon et al., 2002).

1.2.2. Geology

What is fascinating about the Great Escarpment is that despite this common-cause in genesis, the geology of the Great Escarpment is extremely varied (Birkenhauer, 1991). A glance at a geological map of the subcontinent makes it evident that the Great Escarpment includes components of most of southern Africa's principal geological suites. In the west (South Africa, Namibia and Angola) and north-east (South Africa, Swaziland and Zimbabwe/Mozambique), the geology of the Great Escarpment is very complex, being composed of various schists, volcanics, quartzites, gneisses, basement rocks, sedimentary rocks and carbonates (Mouta and O'Donnell, 1933; Van Wyk and Smith, 2001; Schneider, 2004; see Appendix 1.1). In the south and east (South Africa and Lesotho) the geology of the Great Escarpment is much simpler and is composed primarily of horizontal sedimentary sequences intruded by dolerites, and in the Main Drakensberg Escarpment, capped with basalt (Van Wyk and Smith, 2001; Moore and Blenkinsop, 2006). Sections of this southern and eastern Great Escarpment not protected by resistant cap-rock form a gentler, stepped Great Escarpment (Gilchrist et al., 1994), such as parts of the Roggeveld and KZN Escarpments, while sections protected by harder rocks have maintained spectacular drop-offs e.g. the Main Drakensberg Escarpment, the Sneeuberg, and the Nuweveldberge (McCarthy and Rubidge, 2005; Clark et al., 2009). This indicates that lithological control is probably the primary means of Great Escarpment preservation (Gilchrist et al., 1994; Grab et al., 2005; Moore and Blenkinsop, 2006), although Kooi and Beaumont (1994) support climate as being the primary determinant of escarpment form (this is evident when one compares the humid Great Winterberg–Amatolas with the Nuweveldberge). The various components of the Great Escarpment in southern Africa are obviously a complex interaction of lithological control, the influence of climate, vegetation, and interplay between drainage divides and scarp fronts (Birkenhauer, 1991; Gilchrist et al., 1994; Kooi and Beaumont, 1994; Moore and Blenkinsop, 2006).

1.2.3. Relief, Hydrology and Intervals

The highest section of the Great Escarpment is the Main Drakensberg Escarpment (White, 1983; Birkenhauer, 1991; Moore et al., 2009; Fig. 1.1; Appendix 1.1), and incorporates the high-altitude areas of Lesotho and adjacent Eastern Cape, Free State and KZN provinces of South Africa. The highest peak is Thabana Ntlenyana (3 482 m) in Lesotho (White, 1983; McDonald et al., 2002), and much of this section of the Great Escarpment is over 3 000 m (White, 1983), forming the only true alpine zone in southern Africa (McDonald et al., 2002). The next highest points are on the Bié Escarpment (Morro do Môco at 2 620 m) in Angola (White, 1983), followed by the Chimanimani–Nyanga Escarpment (Mount Nyangani at 2 593 m) in Zimbabwe (Van Wyk and Smith, 2001), and the Brandberg (2 573 m) in Namibia (White, 1983, cites an altitude for the Brandberg of 2 695 m). Overall, the sections of Great Escarpment with extensive areas over 2 000 m are the Bié Plateau in Angola, much of the northern and central Namibian Escarpment, the Sneeuberg, Main Drakensberg, and Mpumalanga–Limpopo Escarpments in South Africa, Lesotho and Swaziland and the Nyanga section of the Chimanimani–Nyanga Escarpment in Zimbabwe/Mozambique (Philips' Modern College Atlas for Africa, 1976; White, 1983; Clark et al., 2009; Moore et al., 2009; Fig. 1.1; Appendix 1.1).

Generally speaking the Great Escarpment forms a watershed between seaward-flowing and inland-flowing river systems (White, 1983; Gilchrist et al., 1994; Moore et al., 2009) and reflects the Great Escarpment Axis of epeirogenic flexure (Moore et al., 2009). In the east, all rivers drain to the Indian Ocean, while in west all rivers drain to the Atlantic. Seaward of the Great Escarpment, rivers are usually short and parallel to each other and perpendicular to the ocean, while inland of the Great Escarpment drainage is dendritic (Gilchrist et al., 1994). Local stream-capture has occurred along certain sections of Great Escarpment resulting in catchment-gain for seaward-flowing systems at the expense of inland-flowing catchments, a process inherent in escarpment retreat (Gilchrist et al., 1994; Kooi and Beaumont, 1994). Examples are the Great Fish and Sundays River systems that have incised far back into the Sneeuberg Escarpment, draining most of this area/Great Escarpment to the Indian Ocean (Clark et al., 2009).

Back-cutting by seaward-flowing rivers due to their stronger erosional power has produced a dissected and indented Great Escarpment frontage characterised by ravines, gorges, embayments and isolated sections of mountain. The Great Escarpment is thus a semi-continuous range of mountains that is breached by intervals, these intervals usually being associated with the back-cutting river systems (Birkenhauer, 1991; Matmon et al., 2002). Major intervals (Table 1.1) are here defined as breaches in the Great Escarpment that have resulted in a gap in the Great Escarpment below 1 000 m altitude and occur right through the Great Escarpment. Minor intervals are defined as complete breaches that are above 1 000 m altitude, or below 1 000 m but have not breached the Great Escarpment (Table 1.2). All of the major intervals are or were occupied by major river systems. The widest and most conspicuous of the major intervals are the Limpopo–Save and Loeriesfontein Intervals. The Limpopo–Save Interval separates the Mpumalanga–Limpopo Escarpment from the Chimanimani–Nyanga Escarpment, and the Loeriesfontein Interval is interesting in that it is believed to be the route of the original Orange River prior to river-capture at Prieska (Partridge and Maud, 1987; Moodley and Harley, 2005; Desmet, 2007). The Kunene and Richtersveld Intervals are relatively unimportant biogeographically, despite being occupied by two of the larger river systems on the subcontinent (the Kunene and Orange respectively), and local endemics straddle the Great

Table 1.1: Major intervals along the Great Escarpment. Lettering corresponds with Fig. 1.1. Interval widths measured across the narrowest points at the 1 000 m contour. Sources: Reader's Digest Association of South Africa (sine anno); The Times Atlas of the World (1965); Philips' Modern College Atlas for Africa (1976); Collins World Atlas (2000); Namibia Map (2006); MapStudio (sine anno).

Major Interval	Width	Notes
A. M'Bridge River Interval.	8 km.	Separates the Cuimba Escarpment from the Serra de Mocaba Escarpment, Angola.
B. Lucala River Interval.	17 km.	Separates the Serra de Mocaba Escarpment from the Lombe Escarpment, Angola.
C. Cuanza River Interval.	17 km.	Separates the Lombe Escarpment from the Serra do Bongo (Bié Escarpment), Angola.
D. Curoca River Interval.	Uncertain.	Bié Escarpment, Angola.
E. Kunene River Interval.	25 km.	Kaokoveld Escarpment, Namibia and Angola.
F. Richtersveld (Orange River) Interval.	180 km (the scattered mountain archipelago over 1 000 m is not included).	Separates the Huib–Hoch Mountains and the Hunsberg from the Namaqualand Escarpment. Namibia and South Africa.
G. Loeriesfontein Interval.	125 km.	Separates the Namaqualand and Hantam–Roggeveld–Nuweveld Escarpments, South Africa.
H. Olifants River (Steelpoort) Interval.	ca. 1 km.	Narrow but deep interval on the Mpumalanga–Limpopo Escarpment, South Africa.
I. Limpopo–Save Interval.	300 km (as measured from the Soutpansberg: although not considered part of the Great Escarpment, the Interval between these two orographic entities makes more biogeographic sense than measuring from the Mpumalanga–Limpopo Escarpment itself).	Separates the Mpumalanga–Limpopo Escarpment from the Chimanimani–Nyanga Escarpment, South Africa and Zimbabwe/Mozambique.

Table 1.2: Minor intervals along the Great Escarpment. Lettering corresponds with Fig. 1.1. Sources as for Table 1.1.

Minor Interval	Notes
a. Lodge River Interval.	Serra de Mocaba Escarpment, Angola.
b. Dange River Interval.	Serra de Mocaba Escarpment, Angola.
c. Zenza River Interval.	Serra de Mocaba Escarpment, Angola.
d. Longa River Interval.	Bié Escarpment, Angola.
e. Mutuaćuvo River Interval.	Bié Escarpment, Angola.
f. Cubal (north) River Interval.	Bié Escarpment, Angola.
g. Balombo River Interval.	Bié Escarpment, Angola.
h. Catumbela River Interval.	Bié Escarpment, Angola.
i. Hanja River Interval.	Bié Escarpment, Angola.
j. Cubal (south) River Interval.	Kaokoveld Escarpment, Angola. (Note: Not the same river as the Cubal above).
k. Hoarusib River Interval.	Kaokoveld Escarpment, Namibia.
l. Hoanib River Interval.	Kaokoveld Escarpment, Namibia.
m. Huab River Interval.	Kaokoveld Escarpment, Namibia.
n. Ugab River Interval.	Kaokoveld Escarpment, Namibia.
o. Omaruru River Interval.	Erongo Escarpment, Namibia.
p. Kahn River Interval.	Erongo Escarpment, Namibia.
q. Swakop River Interval.	Separates the Erongo Escarpment from the Windhoek Escarpment (Khomas Hochland), Namibia.
r. Kuiseb River Interval.	Windhoek Escarpment, Namibia.
s. Tsondab River Interval.	Separates the Remhoogteberge from the Naukluftberge, Windhoek Escarpment, Namibia.
t. Tsauchab River Interval.	Separates the Windhoek Escarpment (Naukluft Mountains) from the Tiras Escarpment, Namibia.
u. Awasib Interval.	Tiras Escarpment, Namibia.
v. Koichab River Interval.	Tiras Escarpment, Namibia.
w. Buffelsrivier Interval.	On the Namaqualand Escarpment, South Africa.
x. Nelspoort Interval.	Separates the Hantam–Roggeveld–Nuweveldberg Escarpment from the Sneeuberg Escarpment, South Africa.
y. Sundays River Interval.	Sneeuberg Escarpment, South Africa.
z. Great Fish River Interval.	Separates the Sneeuberg Escarpment from the Great Winterberg–Amatola Escarpment, South Africa.
ai. Mutare Interval.	Chimanimani–Nyanga Escarpment, Zimbabwe/Mozambique.

Escarpment on both sides of these rivers (Branch, 1998; Van Wyk and Smith, 2001; Sinclair and Ryan, 2003; Hockey et al., 2005). There are about four major intervals along the Angolan Escarpment, but it has been difficult to obtain a detailed relief map to consider these in more detail.

The definition of the minor intervals in this thesis is somewhat subjective, and only biogeographical and molecular phylogeographic studies along the Great Escarpment will be able to paint the complex picture of genes relative to disjunctions. Of interest however is the relative continuity of the southern and eastern Great Escarpment (South Africa, Lesotho and Swaziland), where apart from the Olifants River Interval, the intervals are all minor. This is in contrast to the western Great Escarpment, which is much more fragmented in South Africa and has numerous deep incisions in northern Namibia. The Angolan Escarpment appears to have numerous minor intervals, which again are difficult to consider without a proper relief map.

Other means of defining intervals on the Great Escarpment should be explored and may be more appropriate in terms of expressing biogeographical disjunctions rather than a purely geomorphological approach as used here.

1.2.4. Climate

As for geology, climate along the Great Escarpment is extremely varied, but in general is wetter in the east (Lesotho, Swaziland, eastern South Africa and Zimbabwe/Mozambique) and north-west (Angola) and drier in the west (Namibia, western South Africa and southern Angola; Dean, 2001; Moore and Blenkinsop, 2006). Climate is very much dictated by the warm Mozambique/Agulhas Current in the east and the cooler Benguela Current in the west (Huntley and Matos, 1994; Dean, 2001; Eitel et al., 2004; Chase and Meadows, 2007). Mean annual rainfall in the east reaches 4 000 mm in places (Van Wyk and Smith, 2001) while parts of the central and northern Angolan Escarpment receive between 1 400 and 1 800 mm (Huntley and Matos, 1994; Dean, 2001). The dry western South African and the Namibian Escarpments receive between 350 and 600 mm (Van Wyk and Smith, 2001; Eitel et al., 2004). In the east and north-west summer rainfall is dominant, while in the west and south winter rainfall is dominant (Van Wyk and Smith, 2001; Chase and Meadows, 2007; Desmet, 2007). Fog is an important contribution to precipitation in the west (Helme, 2008) while snow is an important contribution in the south and east (Clark et al., 2009; Mills et al., 2009). Throughout the Great Escarpment the moderating effect of altitude is prevalent, with the mountains increasing local effective moisture compared to the lowland plains (Huntley and Matos, 1994; Maggs et al., 1998; Van Wyk and Smith, 2001; Prendini, 2005; Desmet, 2007; Clark et al., 2009). In eastern southern Africa, the Great Escarpment has a major effect on the climate of the interior (McDonald et al., 2002)

1.2.5. Comparisons with other mountain systems in the world

It is worth comparing the Great Escarpment in southern Africa to other mountain systems in the world in order to place it in a physical and biodiversity context. Although it would be ideal to compare the Great Escarpment with all major mountain ranges globally (and also African mountain ranges such as the Atlas and Eastern Arc Mountains, and the Ethiopian and Mount Cameroon–Bamenda Highlands), it has been decided to confine comparisons to the better known major ranges (Alps, Andes, Appalachians, Himalayas and Rocky Mountains) and to other Gondwanan erosional escarpments (Table 1.3). The latter comprise the Madagascan Escarpment, the Serra do Mar (Brazil), the Western Ghats (India) and the Great Dividing Range (Australia); the Great Dividing Range has had to be excluded due to a lack of data however (Weston, pers. comm.).

Floristic and geographical data was obtained from a variety of sources (Table 1.3). Data that is either the most recent or most comprehensive has been preferred, as data varies significantly in the literature. As there is no floristic data available for the total southern African Great Escarpment, a projected flora of the Great Escarpment was obtained as follows:

(1) Totalling the floras of Van Wyk and Smith's (2001) centres of endemism on the western Great Escarpment (Hantam–Roggeveld Centre (HRC), Kamiesberg, Gariep and Kaokoveld Centres), as these are mutually exclusive.

(2) Calculating the mean species diversity for the seven eastern Great Escarpment centres of endemism (the Sneeuberg, DAC, Barberton, Sekhukhuneland, Wolkberg and Chimanimani–Nyanga Highlands; from Clark et al., 2009 and Van Wyk and Smith, 2001) and the Great Winterberg–Amatolas (from Appendix 6.1). This was done by subtracting the number of endemics from each centre/orographic entity, adding the resultant floras, and dividing by seven.

(3) Adding together the total number of endemics per centre/orographic entity in (2) above.

(4) Apportioning an estimated 1 000 species (including an estimated 100 endemics) for the Angolan Escarpment, as there is no floristic data for the Angolan Escarpment itself.

The total Great Escarpment diversity is therefore calculated as the sum of (1) to (4). While this method is a bit crude, it is believed be the best estimate available. The compilation of a complete (and accurate) Great Escarpment flora would be a major step in firmly determining diversity and endemism on the Great Escarpment in the context of the southern African sub-region and globally. The celebrated CFR, as one of the world's "hottest hotspots" (Cowling and Hilton-Taylor, 1994), has been included in the species–area and endemic–area analyses (Fig. 1.3) as a local southern African

Table 1.3: Comparisons between some of the major mountain systems of the world and the Great Escarpment of southern Africa.

Mountain System	Length	Width	Area	Average altitude (Highest point)	Orogenesis	Diversity and Endemism	References
Alps (Europe).	1 200 km	120–250 km	200 000 km^2	ca. 2 000 m (Mont Blanc – 4 807 m).	Folding since the Cenozoic.	A centre of endemism. 33.8% plant endemism (270 out of ca. 800 species).	Stone, 1992; Grabherr et al., 2003; Ozenda and Borel, 2003.
Andes (South America).	7 250 km	200–400 km	8.1 million km^2	4 000 m (Aconcagua – 6 962 m).	Folding and volcanism (since the Jurassic).	Tropical Andes Hotspot. 56% plant endemism (northern Andes), 54% plant endemism (southern Andes): Tropical Andes has 20 000 endemic plants out of ca. 45 000 plant species.	Gentry, 1982; Stone, 1992; Myers et al., 2000; Braun et al., 2002; Conservation International, 2007.
Appalachians (North America).	3 200 km	160–480 km	249 000 km^2	900 m (Mount Mitchell – 2 037 m).	Various orogenies since the Palaeozoic.	1.6% plant endemism (76 out of 4 652 native species). Centre of endemism for snails and salamanders.	Stone, 1992; Pickering et al., 2003.
Great Dividing Range (=East Australian Cordillera) (Australia).	3 500 km	160–300 km	350 000 km^2	1 200 m (Mount Kosciuszko – 2 228 m).	Break-up of Gondwana (Jurassic).	Hotspots: Einasleigh and Desert Uplands; Brigalow North and South; Border Ranges North and South. Eastern Australian Endemic Bird Area. No floristic data available.	BirdLife International, 2003; Department of the Environment, Water, Heritage and the Arts, 2009; Encyclopaedia Britannica, 2010; Weston, pers. comm.
Great Escarpment (southern Africa).	5 025 km	50–120 km	258 945 km^2	ca. 1 800 m (Thabana Ntlenyana – 3 482 m).	Break-up of Gondwana (Jurassic).	Escarpment-associated Centres are Chimanimani–Nyanga, Wolkberg, Sekhukhuneland, Barberton, Drakensberg Alpine, Sneeuberg, Hantam–Roggeveld, Kamiesberg, Gariep and Kaokoveld Centres (see Appendix 1.1). Estimated 17% plant endemism (1 460 endemics out of estimated	Huntley, 1994; Van Wyk and Smith, 2001; Clark et al., 2009.

						Escarpment flora of 8 574). High faunal endemism (see Appendix 1.2).	
Himalayan mountain complex (Asia).	2 500 km	150–400 km	3.4 million km^2	ca. 4 000 m (Mount Everest – 8 848 m).	Folding since the Cenozoic.	Mountains of central Asia Hotspot. No comprehensive tally: ca. 50% plant endemism (Eastern Himalayas have 4 000–5 000 out of 10 000 species; Indian Himalayas 3 200 out of 8 000; Pamir 32 out of 700; Western High Asia 109 out of 1 225).	Jee et al., 1989; Stone, 1992; Mittermeier et al., 1998; Dahr, 2002; Dickoré and Miehe, 2002; Conservation International, 2007; World Wildlife Fund, 2009.
Madagascan Escarpment.	1 500 km	120 km	180 000 km^2	ca. 1 800 m (Maromokotro – 2 876 m)	Break-up of Gondwana (Jurassic).	The Eastern Madagascan floral province, which includes the Escarpment, has 79% plant endemism (4 800 out of 6 100 species).	Takhtajan, 1986; Stone, 1992.
Rocky Mountains (North America).	5 100 km	110–480 km	1504 500 km^2	ca. 2 000 m (Mt Elbert – 4 401m).	Mountains from folding in the Late Cretaceous.	Central Rocky Mountains Centre of Endemism. 53% plant endemism (1 040 out of 1 900 species).	Rydberg, 1919; Bowman and Damm, 2002; Wikipedia, 2010a.
Serra do Mar (Brazilian Escarpment, South America).	2 600 km	ca. 100 km	260 000 km^2	900 m (Pico das Agulhas Negras – 2 791 m).	Break-up of Gondwana (Jurassic).	Mata Atlântica (Atlantic Forest) Hotspot. 50% plant endemism (10 000 out of 20 000 species) but includes lowlands – Serra do Mar considered a distinct centre of endemism. Atlantic Forest Endemic Bird Area.	Myers et al., 2000; BirdLife International, 2003; Lucas et al., 2008; Murray-Smith et al., 2009; Encyclopaedia Britannica, 2010.
Western Ghats (India).	1 600 km	100 km	60 000 km^2	1 200 m (Anamudi – 2 695 m).	Break-up of Gondwana (Jurassic).	Western Ghats and Sri Lanka Hotspot. 61% plant endemism (2 182–3 049 out of ca. 5 000 species). 16 endemic birds.	Myers et al., 2000; Wikipedia, 2010b.

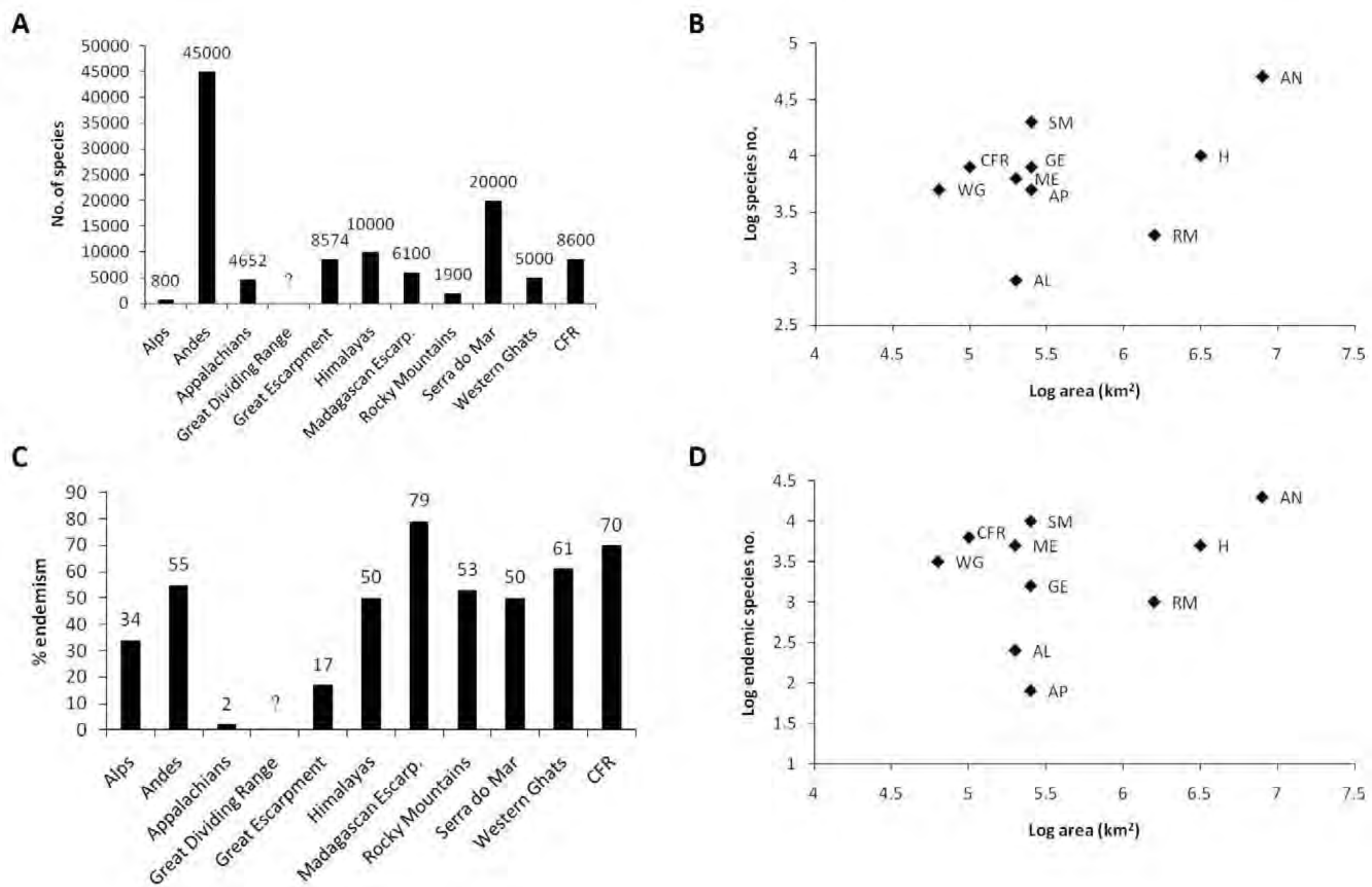


Figure 1.3: Floristic comparison of the southern African Great Escarpment with other major mountain systems globally: (A) Species diversity; (B) Species–area relationships; (C) Endemism; (D) Endemism–area relationships. For B and D: AL = Alps, AN = Andes, AP = Appalachians, CFR = Cape Floristic Region, GE = Great Escarpment, H = Himalayas, ME = Madagascan Escarpment, RM = Rocky Mountains, SM = Serra do Mar, WG = Western Ghats. Data sources detailed in Table 1.3.

comparison (data was obtained from Van Wyk and Smith, 2001, and Cowling and Hilton-Taylor, 1994).

The results are tabulated in Table 1.3 and Figure 1.3A–D. The Great Escarpment is the third-longest mountain range in the world, following the Andes and the Rocky Mountains, and is by far the longest of the four Gondwanan erosional escarpments (Table 1.3). In terms of surface area – a more realistic measurement of montane extent – the Great Escarpment is more comparable to the Alps, the Serra do Mar, the Great Dividing Range, and the Appalachians. Although these latter mountain ranges are much shorter than the Great Escarpment, the Great Escarpment is generally a much narrower mountain zone with only the Main Drakensberg Escarpment (incorporating the Lesotho Highlands) being wider than 100 km. The Great Escarpment is not nearly as floristically diverse as the Andes or the Serra do Mar, and has a floristic diversity similar to the Himalayas and the CFR (Fig. 1.3A). Apart from the Serra do Mar, it has a higher floristic diversity than the other Gondwanan escarpments considered here (i.e. the Western Ghats and the Madagascan Escarpment), and it has a much higher floristic diversity than the Alps, Appalachians and Rocky Mountains. What is noteworthy is that the Great Escarpment has a floristic diversity similar to that of the CFR, although the surface area of the CFR is much less and thus more species-rich and with a higher percentage endemism. Plant species-richness on the Great Escarpment, as indicated by the species–area analysis in Fig. 1.3B, is moderate, and is most comparable to the Appalachians and Madagascan Escarpment. The Great Escarpment has one of the lowest percentages of floral endemism, exceeding only the Appalachians, while the general trend for the other ranges is over 50% endemism (Fig. 1.3C). This is particularly noteworthy in terms of the other Gondwanan erosional escarpments, all of which have a much higher percentage endemism than the Great Escarpment – the Madagascan Escarpment in fact exhibiting the highest endemism in these analyses. Percent endemism on the Great Escarpment may increase with more intensive floristic surveys of the Great Escarpment, particularly in Angola and Namibia. In terms of area-endemism, the Great Escarpment again occupies an intermediate position (Fig. 1.3D). The Andes exhibits the greatest diversity and species-richness in these analyses.

1.3. The Biodiversity of the Great Escarpment

The Great Escarpment is known to host a unique array of flora and fauna. The combinations of biodiversity assemblages along the Great Escarpment form nodes of high local endemism that have contributed towards the concept of "centres of endemism" in southern Africa (Morrone, 1994; Maggs et al., 1998; Van Wyk and Smith, 2001). The concept of a "centre of endemism" as used in this thesis is as per Van Wyk and Smith (2001, p. 11) – "*a convenient neutral term to designate a focal point of high endemism*" – as opposed to a floristically hierarchical definition or the term "hotspot". Of the 18 plant centres described by Van Wyk and Smith (2001), nine are associated with the Great Escarpment. If the recently described Sneeuberg Centre is included (Clark et al., 2009; see Chapter 2), this means that over half of southern Africa's centres of floral endemism are associated with the Great Escarpment. Apart from the overview by Van Wyk and Smith (2001), some of these Great Escarpment centres have been studied in some detail with accompanying checklists or floras e.g. the Kaokoveld Centre by *inter alia* De Matos (1970), Nordenstam (1974, 1982) and Viljoen (1980), the Barberton Centre by Balkwill and Balkwill (1999), the Sekhukhuneland Centre by Siebert (2001) and Siebert et al. (2001), the Wolkberg Centre by Matthews et al. (1991, 1992a, b, 1993, 1994), the DAC by *inter alia* Galpin (1908), Jacot Guillarmot (1971), Hilliard and Burtt (1987), Pooley (2003) and Carbutt and Edwards (2004, 2006), and the Sneeuberg Centre by Clark et al. (2009) (see Appendix 1.1, and Chapter 2). As many of these Centres have been delineated to include adjacent lowland areas it would take some effort to disentangle Great Escarpment endemism from the overall endemism in each Centre. As seen in Table 1.3, total plant endemism along the Great Escarpment can be expected to be significant however, and based on levels of endemism within the Centres mentioned above, could account for 7% of the flora of southern Africa. Not only is floral endemism high along the Great Escarpment, but so is faunal endemism. Appendix 1.2 contains a list of known avifaunal, reptile, amphibian and mammal endemics, and even higher invertebrate endemism can probably be expected (see for example Prendini, 2005, for scorpions; Woodhall, 2005, and Krüger, 2007, for Lepidoptera; Kirk-Spriggs and McGregor, 2009, for Diptera; and Herbert, 2006, for Mollusca such as *Prestonella*).

Prendini (2005, pp. 49–50) states that "*Mountain ranges exert a significant influence on rainfall, temperature and vegetation and may thus have indirectly promoted speciation in taxa with restricted climatic tolerances during periods of palaeoclimatic change".* Great Escarpment endemics are often palaeo-endemics, i.e. relicts from previous climatic eras now restricted to the more climatically moderate Great Escarpment mountains (Hall, 1960; Simmons et al., 1998; Desmet, 2007). Fragmentation of formerly more widespread species by these contractions has no doubt resulted in new (sister) species emerging (Barraclough et al., 1998), while new habitats provide opportunity for colonisation from elsewhere. Thus the Great Escarpment is probably a habitat for both neo- and palaeo-endemics, and relative landscape (see above) and climatic stability (as has been postulated for the CFR mountains; Tolley et al., 2009) compared to the adjacent lowlands and interior plateau may be the key contributing factors to Great Escarpment endemism (Grant and Samways, 2007; Clark et al., 2009). The combination of the Great Escarpment being a corridor for some species while the intervals along the Great Escarpment form barriers to others, together with high topographic, geological, edaphic and environmental heterogeneity – and long-term climate fluctuation – has probably also promoted speciation (Robinson and Gibbs Russell, 1982; Poynton, 1983; Maggs et al., 1994; Nekola, 1999; Prendini, 2005; Grant and Samways, 2007).

1.3.1. Angola

The Angolan Escarpment is equivalent in length to the eastern Great Escarpment of South Africa, Lesotho and Swaziland. However very little is known on the biodiversity of Angola, including the rugged, steep Angolan Escarpment (Huntley and Matos, 1994; Dombo et al., 2002), and only recently has a national list of plant species become available (Figueiredo et al., 2009). Plant and animal endemism on the Angolan Escarpment is high (IUCN, 1990). This is due to the abrupt change from the arid coastlands to the moist Angolan Escarpment frontage, the Angolan Escarpment variability (stepped in the north to sheer cliffs and inselbergs in the centre and south), the numerous vegetation/habitat types represented along the Angolan Escarpment, and the biogeographic buffer effect of the Angolan Escarpment between the lowlands and the plateau (Hall, 1960; Dean, 2001; Sekercioglu and Riley, 2005).

Vegetation types along the Angolan Escarpment vary from tropical evergreen and semi-deciduous rainforest in the north, through Afromontane forest–grassland mosaics and miombo woodland in the central Angolan Escarpment, to Kalahari-Highveld shrublands and Nama-Karoo semi-desert in the south (Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002; World Wildlife Fund and McGinley, 2008a, b). Of particular interest is the narrow band of what Airy Shaw (1947) calls “cloud forest” and Olson and Dinerstein (1998) “Angolan Escarpment Woodlands”, confined to the Angolan Escarpment between 350 and 1 000 m above sea level, and the associated “montane brushwood”. These vegetation types are listed as critically endangered and are among the most biodiversity-rich areas on earth (Olson and Dinerstein, 1998). Very localised stands of *Podocarpus* Labill. forest occur in the higher areas around Morro do Môco and southwards (Airy Shaw, 1947; Huntley and Matos, 1994; Shi et al., 1998). This central Angolan Escarpment and associated highlands form one of the most isolated sections of the Afromontane archipelago in Africa (Van Zinderen Bakker, 1962; White, 1983; Meadows and Linder, 1993; Dupont and Behling, 2003), and still requires detailed botanical investigation (Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002; World Wildlife Fund and McGinley, 2008a).

Angolan Escarpment avifaunal endemism – both specific and sub-specific – is significant, forming the Western Angola Endemic Bird Area (Hall, 1960; Huntley and Matos, 1994; Dean, 2001; Cohen et al., 2004; Sekercioglu and Riley, 2005; Figueiredo and Smith, 2008; World Wildlife Fund and McGinley, 2008a, b; BirdLife International, 2009; see Appendix 1.2). The Gabela region is particularly rich, with most of the Angolan Escarpment bird endemics found in this area (Cohen et al., 2004; Sekercioglu and Riley, 2005). Several other bird species that are restricted to the Angolan Escarpment and only one other African highland area also occur, such as *Malaconotus monteiri* (Monteiro's Bush-shrike, shared with the Cameroon Highlands) and *Cinnyris ludovicensis* (Ludwig's Double-collared Sunbird, shared with the Nyika Plateau, Malawi) (Sinclair and Ryan, 2003). Frog and reptile endemism is also pronounced (Appendix 1.2), and detailed exploration will shed light on the poorly known endemics and probably add new species to the tally.

Overall, the Angolan Escarpment almost certainly qualifies as a Great Escarpment Centre of Endemism or – most likely – as a suite of local centres equivalent to those on the eastern Great Escarpment in South Africa, Lesotho and Swaziland. It also provides a corridor for equatorial species from the north and arid species from the south (Dean, 2001). There appears to be – at least avifaunally – a strong relationship between the Angolan Escarpment and the Cameroon Highlands, as well as with the distant Afromontane regions in East Africa (Hall, 1960). Both botanically and faunally much fieldwork and inventory compilation is required on the Angolan Escarpment before patterns of endemism and richness can be suitably ascertained.

1.3.2. Namibia

The Namibian Escarpment is a focal area for faunal and botanical endemism in Namibia, with a strong correlation between the country's endemics and the Namibian Escarpment being evident (Barnard et al., 1998; Griffin, 1998; Robertson et al., 1998; Simmons et al., 1998; Van Wyk and Smith, 2001). The Kaokoveld mountainous region in the north-west and the Brandberg (together forming the Kaokoveld Centre; Maggs et al., 1994; Van Wyk and Smith, 2001), and the Sperrgebiet (associated with the Gariep Centre; Van Wyk and Smith, 2001) in the south are the principal areas of endemism, but the entire Namibian Escarpment is of importance in this regard (Simmons et al., 1998) and most of the Tiras Escarpment still requires botanical exploration (Burke and Strohbach, 2000). Currently the Namibian Escarpment is the stronghold of *Equus zebra hartmannae* (Hartmann's Mountain Zebra), now extinct on the Namaqualand Escarpment in South Africa (Moodley and Harley, 2005). Similarly as for the links between the eastern Great Escarpment and the Highveld in South Africa, Swaziland and Lesotho (see below), several Namibian Escarpment-centred avifaunal species are shared with the adjacent Otavi–Waterberg Highlands (Hockey et al., 2005). Apart from research on avifauna and *Equus zebra hartmannae*, there does not appear to have been much research on Namibian Escarpment fauna.

1.3.3. South Africa, Lesotho and Swaziland

The arid western and southern Great Escarpment in southern Africa has localised faunal endemism, but very high plant endemism, particularly on the Richtersveld (part of the Gariep Centre), Namaqualand (the Kamiesberg Centre) and Hantam–Roggeveld Escarpments (part of the HRC) (Van Wyk and Smith, 2001; Helme and Desmet, 2006; Helme, 2008). These are the most arid components of the Great Escarpment in South Africa, but receive reliable winter rainfall and form part of the very species-rich Succulent Karoo and Fynbos Biomes (Low and Rebelo, 1998; Van Wyk and Smith, 2001; Mucina and Rutherford, 2006; Desmet, 2007).

As for the central Angolan Escarpment, the eastern sections of the Great Escarpment (White's, 1978, Drakensberg Regional Mountain System) form part of the Afromontane region, as well as provide a floristic and faunal link between the CFR and the remainder of the Afromontane archipelago (Stuckenberg, 1962; Goldblatt, 1978; Oliver et al., 1983; Linder, 1990; Carbutt and Edwards, 2001; Galley et al., 2007 etc.). Not only do these eastern sections of the Great Escarpment host the most centres of plant endemism on the Great Escarpment (i.e. the Sneeuberg, Drakensberg Alpine, Barberton, Sekhukhuneland and Wolkberg Centres; Van Wyk and Smith, 2001; Clark et al., 2009) – although further research in Angola may challenge this – and many faunal endemics (Skinner and Chimimba, 2005), but also harbour important populations of faunal species that are not Great Escarpment endemics but are confined solely to the Great Escarpment and the CFR (e.g. *Buteo trizonatus* Forest Buzzard and *Georychus capensis* Cape Mole-rat), or to the Great Escarpment and the adjacent Highveld plateau and/or KZN Midlands (e.g. *Eupodotis caerulescens* Blue Korhaan, *Oenanthe bifasciata* Buff-streaked Chat, *Myosorex cafer* Dark-footed Forest Shrew, *Breviceps verrucosus* Plaintive Rain Frog, *Leptopelis xenodactylus* Long-toed Tree Frog etc.; Channing, 2001; Minter et al., 2004; Hockey et al., 2005; Skinner and Chimimba, 2005). Other species occurring more widely in the Afromontane region in Africa are restricted in southern Africa to the moist eastern Great Escarpment (e.g. *Telephorus nigrifrons* Black-fronted Bush-shrike, *Zoothera gurneyi* Orange Ground-Thrush, and the critically endangered *Hirundo atrocaerulea* Blue Swallow; Sinclair and Ryan, 2003; Hockey at al., 2005). For other, historically less-restricted species, the Great Escarpment hosts important remnant populations of these species as it provides suitable habitat, food resources and comparatively lower persecution than in their previous ranges (e.g. *Gypaetus barbatus* Bearded Vulture; Sinclair and Ryan, 2003; Hockey at al., 2005). Despite being relatively close to major population centres such as Gauteng, Bloemfontein and Durban, the eastern Great Escarpment remains botanically poorly explored, with new species still being discovered even in relatively well-collected areas (Van Wyk and Smith, 2001).

1.3.4. Zimbabwe–Mozambique

The Chimanimani–Nyanga Highlands are the most isolated component of the Great Escarpment, separated from the rest of the Great Escarpment by the Limpopo–Save Interval, and straddle the border between Zimbabwe and Mozambique. The entire Nyanga component is in Zimbabwe, while much of the Chimanimani component is in Mozambique. As for the Angolan and eastern Great Escarpments, the Chimanimani–Nyanga Highlands form part of the Afromontane region, and are a floristic and faunal link between the eastern Great Escarpment to the south and the East African mountains to the north (White, 1983; Van Wyk and Smith, 2001). It is a floristic centre in its own right (the Chimanimani–Nyanga Centre) with two sub-centres (the Nyanga and Chimanimani sub-centres) and a floristic endemism of 6.7% (Van Wyk and Smith, 2001). It shares one avifaunal endemic with the eastern Great Escarpment (*Promerops gurneyi* Gurney's Sugarbird), and has one of its own avifaunal endemics (*Oreophilias robertsii* Roberts's Warbler). There are seven reptile, two mammal and seven frog endemics (see Appendix 1.2).

The isolated, free-standing Mount Gorongosa (130 km to the east) is clearly biogeographically related to the Chimanimani–Nyanga Escarpment and presents a similar problem as that of other Great Escarpment-associated but free-standing peaks e.g. Ngeli Mountain in KwaZulu–Natal, the Brandberg in Namibia, and the numerous isolated inselbergs adjacent to the Angolan Escarpment. Geologically, Mount Gorongosa is also part of the same geological formation as the Chimanimanis (the Umkondo Group; Van Wyk and Smith, 2001; pers. obs.) and is not a typical crystalline inselberg as characteristic of many other free-standing mountains in southern Africa. Almost certainly Mount Gorongosa should be included in the Chimanimani–Nyanga Centre (e.g. World Wildlife Fund and McGinley, 2008c) as it shares numerous floral and faunal endemics with that Centre (e.g. several avifaunal species are restricted to the Chimanimani–Nyanga Escarpment and Mount Gorongosa). Although it does not constitute part of the Great Escarpment geomorphologically, biogeographic and phylogeographic studies of taxa on the Chimanimani–Nyanga Escarpment should take cognisance of Mount Gorongosa.

1.4. Research opportunities and initiatives on the Great Escarpment

Despite the prominence of the Great Escarpment in southern African topography and biodiversity, there has been no dedicated initiative in studying the natural history of the Great Escarpment. Research efforts have been fragmented and sporadic, resulting in a patchy distribution of studies. Needless to say, most of the Great Escarpment has yet to be adequately explored in terms of biodiversity (Krüger, 2007). Even the impressive Main Drakensberg Escarpment has no comprehensive published flora, and only recently has a list of endemics and near-endemics been published (Carbutt and Edwards, 2006). The same is true for much of the Great Escarpment. For instance only recently have botanical assessments of the Kamiesberg (Helme and Desmet, 2006; Helme, 2008) and Sneeuberg been completed (Clark et al., 2009). Reasons for limited exploration and study are no doubt due mainly to limited accessibility, rugged terrain, adverse climatic conditions, (often) the distance from main urban centres (Simmons et al., 1998; Krüger, 2007), and no doubt also limited numbers of researchers in particular research field. In Angola, three decades of civil unrest has obviously been an obstacle to research in that country (Huntley and Matos, 1994), and most of the Angolan Escarpment is virtually untouched by researchers (Hawkins, 1993). A similar situation regarding that portion of the Chimanimanis in Mozambique exists, and the current farm invasions and economic meltdown in Zimbabwe have all but put a halt to biodiversity work on the Chimanimani–Nyanga Escarpment. Even in South Africa there are numerous sections of Great Escarpment that are situated adjacent to long- and well-established towns and cities yet have slipped under the research-radar (Maggs et al., 1998; Clark et al., 2009). In this regard Rhodes University has recently commenced with a Great Escarpment Biodiversity Programme to address this research vacuum.

Field-collecting probably remains the principal need regarding biodiversity studies on the Great Escarpment, and great opportunity (and need) exists for extensive fieldwork and the compilation of biodiversity inventories (Huntley and Matos, 1994; Maggs et al., 1994). Such research is, while perhaps unfashionable, fundamental to accurate biogeographical analysis, systematic studies, and the generation of robust phylogenies, taxonomy, and conservation planning (Huntley and Matos, 1994; Kahindo et al., 2007). The latter is important especially considering the high local endemism on the Great Escarpment, and the threats to this endemism from various land-uses (see below).

Systematic studies including Great Escarpment taxa will contribute to the current thinking of the Great Escarpment as a refugium from previous climatic periods (Simmons et al., 1998), as a migration corridor for species (Clark et al., 2009), as a barrier for others (Griffin, 1998; Prendini, 2005), and as a region of speciation (such as Verboom et al., 2009, for the CFR). In this vein, palaeoclimate studies are very limited along the Great Escarpment, and an increase in these will compliment systematic studies. Modern climate change and its effect on Great Escarpment endemics and species assemblages is also of critical concern, as over the next 50 years many localised endemics may be forced into small refugia or suffer wholesale extinction (Simmons et al., 2004). Modelling and predicting the impact of climate change will be an important element in Great Escarpment research and conservation planning (Eggermont and Verschuren, 2007; Tolley et al., 2009).

Finally, much work is also required on cryptograms, especially as they may mirror the diversity of higher plants (and thus centres of endemism on the Great Escarpment) (Maggs et al., 1998). Moister montane areas along the Great Escarpment may also harbour new and localised species of these cryptograms.

1.5. Conservation considerations

Despite its length, the Great Escarpment is a narrow entity with very steep environmental gradients. This has resulted in narrow stretches of any particular habitat, with these habitats more vulnerable to interference than the larger habitats on the adjacent lowlands and inland plateau. Threats to the Great Escarpment and its biodiversity vary according to each component of the Great Escarpment, but include overgrazing, deforestation, charcoal-burning, civil unrest, illegal plant collecting, over-harvesting of plants for traditional uses, mining (both formal and informal), commercial forestry, irresponsible forms of tourism, water over-extraction, dam-building, erosion, overgrazing, peat collecting, acid rain, over-population and "rural urbanisation", population displacement, land-grabs, intensive commercial and subsistence agriculture, subsistence hunting, invasive alien species, rogue fires, logging of natural timber, and global warming (Hawkins, 1993; Cowling and Hilton-Taylor, 1994; Huntley and Matos, 1994; Talukdar, 1994; Burke et al., 1998; Maggs et al., 1998; Dean, 2001; Dombo et al., 2002; Simmons et al., 2004; BirdLife International, 2009).

The Great Escarpment is generally not well represented in southern Africa's protected area network. Except for one small reserve on the central Angolan Escarpment and marginally in the south as part of the Parque Nacional do Iona, the Angolan Escarpment does not fall into any protected areas (Huntley and Matos, 1994; Dean, 2001), and key areas of biological diversity such as the Kumbira Forest near Gabela and the *Podocarpus* forests of central and southern Angolan Escarpment need urgent formal protection (Huntley and Matos, 1994; Cohen et al., 2004; Sekercioglu and Riley, 2005). In Namibia, virtually none of the Great Escarpment falls into a protected area (Maggs et al., 1994), with only small areas occurring in the Ai-Ais–Huntsberg Reserve Complex in the south, some of the Naukluft Mountains into the Namib–Naukluft Park, some of the Khomas Hochland into Daan Viljoen Nature Reserve near Windhoek, and a portion of the Kaokoveld Escarpment into Etosha National Park (Griffin, 1998; Robertson et al., 1998). (The remainder of the Kaokoveld Escarpment previously fell into the since deproclaimed Game Reserve No. 2, one of the then largest conservation areas in the world; Barnard et al., 1998). Fifty-nine percent of the Namibian Escarpment is owned by rural communities with the remainder falling into commercially-owned farm- and rangeland (Robertson et al., 1998). Lesotho, Swaziland and eastern and southern South Africa have numerous protected areas which were intentionally established to protect sections of Great Escarpment (Cowling and Hilton-Taylor, 1994), but human pressure on the Great Escarpment in these areas is much higher, particularly in the east where conservation concerns compete with mining, agriculture, large-scale commercial forestry and dense rural settlements. In western South Africa the Great Escarpment has virtually no formal protection (Huntley and Matos, 1994). Formal conservation of the Chimanimani–Nyanga Escarpment is represented by two substantial national parks and numerous forest reserves in Zimbabwe, but the intentional and selective dissolution of law and order since 2000 in Zimbabwe has resulted in a major threat to biodiversity from land-grabs, gold-mining, alien plant invaders and deforestation (pers. obs.). Conservation authorities have little financial resources or legal clout to combat these issues. There is no formal protection of that portion of the Chimanimanis occurring in Mozambique despite the Chimanimani Transfrontier Conservation agreement.

International collaboration in terms of Great Escarpment protection has been achieved with the Ai-Ais/Richtersveld Transfrontier National Park between Namibia and South Africa (it includes some of the Richtersveld Escarpment), and the Maloti–Drakensberg Transfrontier Park between South Africa and Lesotho and the Chimanimani Transfrontier Conservation Area between Zimbabwe and Mozambique (Peace Parks Foundation, 2010). The Iona–Skeleton Coast Transfrontier Conservation Area (Peace Parks Foundation, 2010) may conserve some of the Kaokoveld Escarpment in Angola and Namibia (Barnard et al., 1998). Currently, private game reserves and conservancies are the most effective means of environmental protection for much of the Great Escarpment in Namibia and South Africa (Barnard et al., 1998; Griffiths, 1998), and co-operation with local landowners and rural communities is probably the only way in which the high local biodiversity of the Great Escarpment will be protected in the long run (Barnard et al., 1998).

1.6. Conclusion

The Great Escarpment is a 5 000 km-long mountain system in southern Africa that harbours a rich assemblage of biodiversity and endemism. This review is the first attempt to provide a holistic overview of the Great Escarpment by piecing together disparate sources of data and literature and provides a context for endemism, biodiversity, and foci for future research.

The unique biodiversity of the Great Escarpment as defined here is a consequence of a number of factors. These are the physical stability of the Great Escarpment since the Cretaceous, a wide variety of geological suites and resultant edaphic substrates, the presence of different rainfall regimes and moisture gradients along the Great Escarpment, and the functioning of the Great Escarpment as both a corridor and refugium for taxa (perhaps since the Pliocene). The Great Escarpment is thus a repository for both palaeo- and neo-endemics. However, despite the recognition of ten centres of plant endemism associated with the Great Escarpment, there are still many sections of Great Escarpment which are poorly or almost completely unknown and unstudied.

This thesis contributes towards filling one of these gaps. Here I report on an in-depth study of the floristics of the southern Great Escarpment (the Sneeuberg, Nuweveldberge and Roggeveldberge). This data is then used to assess the role of the southern Great Escarpment as both a corridor and a series of refugia, and its connectivity to the CFR.

Appendix 1.1: The sections of Great Escarpment in southern Africa (from north-west to north-east), with notes on principal mountain ranges, geology, highest points, biodiversity, representation in protected areas and key references. General sources not cited in the Key References are: AA Road Maps (sine anno); Reader's Digest Association of South Africa (sine anno); Mouta and O'Donnell (1933); Brink (1979, 1981); Levy (1987); Huntley and Matos (1994); Schneider (2004); World Wildlife Fund and McGinley (2008a, b).

Great Escarpment Section	Principal Mountain Ranges	Geology	Highest Points	Biodiversity Notes	Protected Areas	Key References
1. Cuimba Escarpment (northern Angola).	–	Bembe Group (“schisto-calcaire”).	–	More data required.	None.	Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002.
2. Serra de Mocaba Escarpment (northern Angola).	Serra de Mocaba, Serra do Cusso.	Bembe Group (“schisto-calcaire”).	1 478 m.	More data required.	None.	Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002.
3. Lombe Escarpment (central Angola).	–	Bembe Group (“schisto-calcaire”).	1 000 m+.	Probably a distinct Centre of Endemism, or linked with the Bié Escarpment as a Centre.	None.	Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002.
4. Bié Escarpment (central and southern Angola).	Serra do Humbe, Serra do Bongo, Serra da Chela.	Oedolongo System (metamorphics).	Morro do Môco (2 620 m), peak near Mepo (2 582 m), peak near Lubango (2 554 m).	Probably a distinct Centre of Endemism, or linked with the Lombe Escarpment as a Centre. It may be worth defining the Lubango Escarpment as a separate section.	Namba Strict Nature Reserve.	Mendes, 1961; Huntley and Matos, 1994; Dean, 2001; Dombo et al., 2002.
5. Kaokoveld Escarpment (southern Angola and northern Namibia).	Cerra Cafema, Serra da Chela (Angola); Baynes Mountains, Zebra Mountains, Steilrandberge, Joubertberge, Fransfonteinberge (Namibia).	Epupa and Huab Complexes (basement granite), Damara Group (schists and gneisses), Kunene Basic Complex (anorthosite), Nosib Group (quartzites), Otavi Group (dolomite and limestone).	Omavandaberge (2 065 m), Baynes Mountains, (2 039 m), Otjihipa (2 016 m). Some peaks apparently up to 2 300 m.	Kaokoveld Centre of Endemism. (Note: The Brandberg massif – 2 573 m and comprising basement granite – could be considered part of this Escarpment although it is a free-standing entity).	Parque Nacional do Iona (Angola), Etosha National Park (Namibia).	Volk, 1964, 1966; De Matos, 1970; Nordenstam, 1974, 1982; Viljoen, 1980; Hilton-Taylor, 1994; Maggs et al., 1998; Craven and Craven, 2000; Van Wyk and Smith, 2001; Van Jaarsveld et al., 2004; Burke, 2002, 2005.
6. Erongo Escarpment (north-central Namibia).	Erongo, Etjo, Huosberge, Otjipateraberge, Chuosberge.	Damara Sequence (schists), granite.	Hohenstein (2 319 m), Erongo (2 216 m).	Numerous local endemics.	Erongo Mountain Nature Conservancy.	Maggs et al., 1998; Burke, 2002, 2005.
7. Windhoek	Otjihaveraberge,	Damara Sequence (schists,	Auasberge (2 479 m),	Khomas Hochland has 68	Daan Viljoen Nature	Volk and Lieppert, 1971;

Great Escarpment Section	Principal Mountain Ranges	Geology	Highest Points	Biodiversity Notes	Protected Areas	Key References
Escarpment (central Namibia).	Khomas Hochland, Remhoogteberge, Naukluftberge.	quartzites), basement granites; Nosib, Hakos and Swakop Groups.	unnamed (2 417 m, 2 336 m, 2 252 m), Gamsberg (2 347 m), Rantberge (2 219 m).	endemic plant species.	Reserve, Namib-Naukluft Park.	Joubert, 1979, 1997; Geiss, 1983; Kellner, 1986; Burke, 1997, 2001.
8. Tiras Escarpment (southern Namibia).	Tsarisberge, Schwarzrand, Tirasberge, Huib-Hochplato, Hunsberg.	Sinclair Sequence, Namaqualand Complex, Nama Group etc.	Chowagasberg (2 063 m), Losberg (1 976 m), Tirasberge (1 973 m).	Partly in the Gariep Centre of Endemism. The Escarpment itself has mostly not been surveyed (Burke and Strohbach, 2000).	–	Volk, 1966; Jürgens, 1991; Van Wyk and Smith, 2001.
9. Richtersveld Escarpment (southern Namibia, north-western South Africa).	Stinkfonteinberge, Cornellsberg, Ploegberg, Vandersterrberg.	Gariep Supergroup (congomerate, sandstone, quartzite, shale, limestone, dolomite, dolerite, schist,lava, volcanic breccia and tuff).	Cornellsberg (1 377 m).	Gariep Centre of Endemism.	Ai-Ais/Richtersveld Transfrontier National Park.	Jürgens, 1991; Williamson, 2000a, b; Van Wyk and Smith, 2001.
10. Namaqualand Escarpment (western South Africa)	Kamiesberge, Swartklaasriet-se-Berg.	Granite and granite gneisses.	Rooiberg (1 706 m).	Kamiesberg Sub-centre of Endemism (part of the CFR).	Goegab Nature Reserve.	Adamson, 1938; Van Wyk and Smith, 2001; Helme and Desmet, 2006; Desmet, 2007; Helme, 2008.
11. Hantam–Roggeveld–Nuweveld Escarpment (south-western South Africa).	Hantamberge, Roggeveldberge, Komsberg, Besemgoedberg, Beesberg, Langberg, Steenkampsberg, Hartbeesvleiberg.	Beaufort Group (sandstones and shales), dolerites.	Swaarweerberg (1 844 m), Besemgoedberge (1 742 m), Salpeterkop (1 766 m), Sneeukrans (1 739 m), Tafelberg (Beaufort West; 1 956 m), Teepunt (1 946 m), Bontberg (1 922 m), Tafelberg (Teekloof Pass; 1 913 m).	Hantam–Roggeveld Centre of Endemism.	Tanqua Karoo National Park, Nieuwoudtville Wild Flower Reserve, Akkerdam Nature Reserve, Karoo National Park. Several private nature and game reserves.	Rubin and Palmer, 1996; Rubin et al., 2001; Van Wyk and Smith, 2001. See also Chapters 4 and 5.
12. Sneeuberg Escarpment (southern South Africa).	Onder-Sneeuberg, Kamdebooberge, Koudeveldberge, Compassberg, Lootsberg, Wapadsberg, Renosterberg,	Beaufort Group (sandstones and shales), dolerites.	Compassberg (2 504 m), Nardousberg (2 429 m), Unnamed ("Harry's Peak", Renosterberg, 2 298 m), Toorberg (2 278 m).	Sneeuberg Centre of Endemism.	Camdeboo and Mountain Zebra National Parks, Boschberg Nature Reserve, Glen Avon Falls Natural Heritage Site. Numerous private nature and game reserves.	Van der Walt, 1972; Palmer, 1988, 1990, 1991; Clark et al., 2009. See also Chapters 2 and 3.

Great Escarpment Section	Principal Mountain Ranges	Geology	Highest Points	Biodiversity Notes	Protected Areas	Key References
	Kikvorsberge, Coetzeesberge, Bankberg, Groot-Bruintjieshoogde, Boschberg.					
13. Great Winterberg–Amatola Escarpment.	Baviaanskloofberge, Great Winterberg, Katberg, Amatolas, Khologa Mountains.	Beaufort Group (sandstones and shales), dolerites.	Great Winterberg (2 369 m), Klein-Winterberg (2 117 m), Elandsberg (2 017 m), Bakenkop (2 011 m), Tafelberg (1 965 m), Gaika's Kop (1 956 m).	Considered by Nordenstam (1969) to be part of a broader Centre of Endemism that includes the Sneeuberg and Stormberg; considered by Mucina and Rutherford (2006) to be part of the DAC. Endemism of 1.5%, possibly 2%. May warrant separate status as a Centre.	Mpofu and Tsolwana Game Reserves, Fort Fordyce Nature Reserve. Various State Forests.	Story, 1952a, b; Phillipson, 1987.
14. Main Drakensberg Escarpment (Lesotho and central-eastern South Africa).	Suurberg, Bamboesberge, Stormberg, Witteberg, Thaba Putsoa, Central Range, Malutis, Drakensberg.	Drakensberg Group (basalt), Stormberg Group (sandstones and shales), dolerites.	Thabana Ntlenyana (3 484 m), Champagne Castle (3 377 m), Giant's Castle (3 314 m), Mont-aux-Sources (3 282 m), Thaba Putsoa (3 096 m).	Drakensberg Alpine Centre of Endemism (DAC).	Maloti–Drakensberg Transfrontier Park, incorporating Qua-Qua–Golden Gate Highlands, Royal Natal and uKhahlamba–Drakensberg (South Africa), Tsehlanyane and Sehlabathele National Parks (Lesotho). Bakong (Lesotho), Malekgonyane/ Ongeluksnek, Black Eagle, Lawrence De Lange, Koos Ras Nature Reserves (South Africa).	Galpin, 1908; Phillips, 1917; Killick, 1963, 1990, 1994, 1997; Roberts, 1969; Jacot Guillarmod, 1971; Hilliard and Burtt, 1987; Bester, 1998; Hoare and Bredenkamp, 2001; Pooley, 2003; Moffett et al., 2001; Van Wyk and Smith, 2001; Carbutt and Edwards, 2004, 2006.
15. KwaZulu–Natal Escarpment (eastern South Africa).	Drakensberg.	Beaufort and Ecca Groups (shales and sandstones), dolerite.	Platberg (2 395 m), De Berg (2 331 m).	Higher parts are outliers of or allied to the DAC.	Ncandu, Pongola Bush, Sterkfontein Dam, Zeekoeivlei Nature Reserves. Drakensberg Wildflower Gardens. Various state	Van Zinderen Bakker, 1973; Smit et al., 1992, 1995; Eckhardt et al., 1993, 1995; Hill, 1996; Brand et al., 2008.

Great Escarpment Section	Principal Mountain Ranges	Geology	Highest Points	Biodiversity Notes	Protected Areas	Key References
					forests.	
16. Mpumalanga–Limpopo Escarpment (Swaziland and north-eastern South Africa).	Drakensberg, Leolo, Strydpoortberge, Wolkberg, Krokodilpoortberge, Steenkampberge, Thabakgolo, Bosbokrand.	Barberton Supergroup (volcanics, greenstones, granites and sedimentary); Transvaal Supergroup (quartzites, shales, mudstones, dolomite).	Mount Anderson (2 284 m), Kliprots (2 238 m), Iron Crown (2 126 m), Black Hill (2 097 m), Serala (2 050 m), Marangrang (2 040 m), Mount Sheba (1 958 m).	Barberton, Sekhukhune and Wolkberg Centres.	Songimvelo, Buffelskloof, Ohrigstad Dam, Blyde River Canyon, Verloren Vlei, Lekgalameeste, Modjadji, Malete, Mount Sheba, Gustav Klingbiel, Sterkspruit, Nelshoogte, Barberton, Bewaarkloof (South Africa), Malolotja, Phophonyane Nature Reserves (Swaziland). Wolkberg Wilderness Area (South Africa), Mlilwane Wildlife Sanctuary (Swaziland). 16 Natural Heritage Sites. Various state forests. Numerous private conservation areas.	Van der Schijff and Schoonraad, 1971; Matthews et al., 1991, 1992a, b, 1993, 1994; Balkwill and Balkwill, 1999; Stalmans et al., 1999; Siebert, 2001; Siebert et al., 2001; Van Wyk and Smith, 2001.
17. Chimanimani–Nyanga Escarpment (eastern Zimbabwe and western Mozambique).	Chimanimani, Bvumba and Nyanga Mountains.	Umkondo Group (Mozambique and Rhodesia Facies – deformed and metamorphosed quartzites, quartz schists, shales, siltstones), basement granites.	Mount Nyangani (2 593 m), Mount Binga (2 440 m).	Chimanimani–Nyanga Centre.	Nyanga, Mtarazi Falls and Chimanimani National Parks; York, Stapleford, Banti, Nyambewa, Tandai, Ngungunyana Forest Lands; Bvumba Botanical Gardens and Reserve; Bunga and Chirinda Forest Botanical Reserves; Chipinge Safari Area.	Crook, 1956; Goodier and Phipps, 1961, 1962; Phipps and Goodier, 1962; Basset, 1963; Wild, 1964; Tomlinson, 1975; Clarke, 1991; Timberlake and Müller, 1994; Müller, 1999; Van Wyk and Smith, 2001.

Appendix 1.2: Fauna endemic to the Great Escarpment in southern Africa. The eastern Great Escarpment incorporates the Main Drakensberg, KZN and Mpumalanga–Limpopo Escarpments. Names in brackets are suggested common names. Sources: Birds – Sinclair and Ryan, 2003; Hockey et al., 2005; BirdLife International, 2003, 2009. Reptiles – Barboza du Bocage, 1895; Marx, 1956; Mertens, 1958; Branch, 1998; Herpetologia Angola, sine anno. Mammals – Minter et al., 2004; Skinner and Chimimba, 2005. Amphibians – Channing, 2001; Du Preez and Carruthers, 2009. Fish – Skelton, 2001.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
BIRDS (20 endemics)		
Swierstra's Spurfowl *Pternistes swierstrai*	Angolan Escarpment.	Angolan endemic. Vulnerable.
Red-crested Turaco *Tuaraco erythrolophus*	Angolan Escarpment.	Angolan endemic. Least concern.
Violet Woodhoopoe *Phoeniculus damarensis*	Northern Namibian and southern Angolan Escarpment.	Namibian and Angolan endemic. No conservation status but of considerable conservation concern.
Rudd's Lark *Mirafra ruddi*	Eastern Great Escarpment.	South African endemic. Critically endangered.
Bush Blackcap *Lioptilus nigricapillus*	Sneeuberg, Great Winterberg–Amatola and eastern Great Escarpments.	South African, Lesotho and Swaziland endemic.
Gabela Akalat *Sheppardia gabela*	Angolan Escarpment.	Angolan endemic. Endangered.
Orange-breasted Rockjumper *Chaetops aurantius*	Sneeuberg, Great Winterberg–Amatola and eastern Great Escarpments.	South African and Lesotho endemic. Not threatened.
Gurney’s Sugarbird *Promerops gurneyi*	Eastern Great and Chimanimani–Nyanga Escarpments.	South African, Lesotho, Swaziland, Zimbabwean and Mozambican endemic.
Roberts’s Warbler *Oreophilias robertsii*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Pulitzer's Longbill *Macrosphenus pulitzeri*	Angolan Escarpment.	Angolan endemic. Endangered.
Angola Slaty Flycatcher *Dioptrornis brunneus*	Angolan Escarpment.	Angolan endemic.
Herero Chat *Namibornis herero*	Northern Namibian and southern Angolan Escarpment.	Namibian and Angolan endemic. Not threatened.
Angolan Cave Chat *Xenocopsychus ansorgei*	Angolan Escarpment.	Angolan endemic.
Yellow-breasted Pipit *Anthus chloris*	Eastern Great Escarpment.	South African and Lesotho endemic. Vulnerable.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
Mountain Pipit *Anthus hoeschi*	Main Drakensberg Escarpment.	Breeding South African and Lesotho endemic, winters south-central Africa. Not threatened.
Braun's Bush-Shrike *Laniarius brauni*	Northern Angolan Escarpment.	Angolan endemic. Endangered.
Gabela Bush-Shrike *Laniarius amboimensis*	Angolan Escarpment.	Angolan endemic. Endangered.
White-tailed Shrike *Lanioturdus torquatus*	Northern Namibian and southern Angolan Escarpment.	Namibian and Angolan endemic. Not threatened.
Gabela Helmet-shrike *Prionops gabela*	Central Angolan Escarpment.	Angolan endemic. Endangered.
Drakensberg Sisken *Crithagra symonsi*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
REPTILES (64 endemics)		
Swazi Rock Snake *Lamprophis swazicus*	Eastern Great Escarpment.	South African and Swaziland endemic.
Namibian Wolf Snake *Lycophidion namibianum*	Northern Namibian Escarpment.	Namibian endemic.
Angola File Snake *Mehelya vernayi*	Northern Namibian Escarpment and western Angola.	Namibian and Angolan endemic.
Cream-spotted Mountain Snake *Montaspis gilvomaculata*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Viperine Bark Snake *Hemirhagerrhis viperinus*	Northern Namibian Escarpment and southern Angola.	Namibian and Angolan endemic.
Angolan Adder *Bitis heraldica*	Bié Escarpment.	Angolan endemic.
Plain Mountain Adder *Bitis inornata*	Sneeuberg Escarpment.	South African endemic.
Short-headed Legless Skink *Acontias breviceps*	Sneeuberg, Great Winterberg–Amatola and Mpumalanga–Limpopo Escarpments.	South African endemic.
Woodbush Legless Skink *Acontophiops lineatus*	Mpumalanga–Limpopo Escarpment.	South African endemic.
Arnold's Skink *Proscelotes arnoldi*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Western Dwarf Burrowing Skink *Scelotes capensis*	Southern and central Namibian Escarpment.	Namibian endemic.
Montane Dwarf Burrowing Skink *Scelotes mirus*	Mpumalanga–Limpopo Escarpment and northern KZN Midlands.	South African endemic.
Albert's Burrowing Skink *Sepsina alberti*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
Wedge-snouted Skink *Mabuya acutilabris*	Possibly Namibian and Angolan Escarpments to the	Namibian, Angolan and Democratic Republic of

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
	Democratic Republic of Congo (DRC).	the Congo (DRC) endemic.
Chimba Skink *Mabuya chimbana*	Kaokoveld - on Great Escarpment?	Namibian and Angolan endemic.
Hoesch's Skink *Mabuya hoeschi*	Central and northern Namibian Escarpment and southern Angola.	Namibian and Angolan endemic.
Cregoi's Blind Legless Skink *Typhlosaurus cregoi bicolor*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Marx's Rough-scaled Lizard *Ichnotropis microlepidota*	Bié Escarpment.	Angolan endemic.
Angolan Blue-tailed Skink *Mabuya laevis*	Kaokoveld – on Great Escarpment?	Namibian and Angolan endemic.
Essex's Mountain Lizard *Tropidosaura essexi*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Cottrell's Mountain Lizard *Tropidosaura cottrelli*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Ferocious Round-headed Worm Lizard *Zygaspis ferox*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
(Kaokoveld) Giant Plated Lizard *Gerrhosaurus validus maltzahni*	Central and northern Namibian Escarpment and southern Angola.	Namibian and Angolan endemic.
Breyer's Long-tailed Seps *Tetradactylus breyeri*	Main Drakensberg and Mpumalanga–Limpopo Escarpments – also KZN Midlands?	South African and Lesotho endemic. Rare.
Eastwood's Long-tailed Seps *Tetradactylus eastwoodae*	Mpumalanga–Limpopo Escarpment.	South African endemic. Extinct.
Transvaal Grass Lizard *Chamaesaura aenea*	Eastern Great Escarpment.	South African and Lesotho endemic.
Campbell's Girdled Lizard *Cordylus campbelli*	Tiras Escarpment.	Namibian endemic.
Lawrence's Girdled Lizard *Cordylus lawrenci*	Richtersveld Escarpment.	South African endemic.
Cloete's Girdled Lizard *Cordylus cloetei*	Hantam–Roggeveld –Nuweveld Escarpment (Nuweveld only).	South African endemic.
Rooiberg Girdled Lizard *Cordylus imkeae*	Rooiberg – Namaqualand Escarpment.	South African endemic.
Regal Girdled Lizard *Cordylus regius*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Zimbabwean Girdled Lizard *Cordylus rhodesianus*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Herero Girdled Lizard *Cordylus pustulatus*	Khomas Hochland Escarpment?	Namibian endemic.
Sekhukhune Flat Lizard *Platysaurus orientalis*	Mpumalanga–Limpopo Escarpment.	South African endemic.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
Lang's Crag Lizard *Pseudocordylus langi*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Drakensberg Crag Lizard *Pseudocordylus melanotus*	Eastern Great Escarpment.	South African and Lesotho endemic.
Spiny Crag Lizard *Pseudocordylus spinosus*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Cape Crag Lizard *Pseudocordylus microlepidotus*	*P. m. fasciatus* – Sneeuberg and Great Winterberg–Amatolas Escarpments. *P .m. namaquensis* – Hantam–Roggeveld –Nuweveld Escarpment (Nuweveld only).	South African endemic.
Marshall's African Leaf Chameleon *Rhampholeon marshalli*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Drakensberg Dwarf Chameleon *Bradypodium dracomontanum*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Transvaal Dwarf Chameleon *Bradypodium transvaalense*	Mpumalanga–Limpopo Escarpment.	South African and Swaziland endemic.
African Flat Gecko *Afroedura africana*	*A. a. namaquensis* – Namaqualand Escarpment (South Africa)? *A. a. tirasensis* – Tiras Escarpment (Namibia). *A. a. africana* – Khomas Hochland Escarpment? (Namibia).	South African and Namibian endemic.
Amatola Flat Gecko *Afroedura amatolica*	Sneeuberg and Great Winterberg–Amatolas Escarpments.	South African endemic.
Kaokoveld Flat Gecko *Afroedura* cf. *bogerti*	Kaokoveld Escarpment.	Namibian endemic.
Karoo Flat Gecko *Afroedura karroica*	Sneeuberg and Great Winterberg–Amatolas Escarpment.	South African endemic.
Hall's Flat Gecko *Afroedura halli*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Mountain Flat Gecko *Afroedura nivaria*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Giant Swazi Flat Gecko *Afroedura major*	Mpumalanga–Limpopo Escarpment.	Swaziland endemic.
Woodbush Flat Gecko *Afroedura multiporus*	Mpumalanga–Limpopo Escarpment.	South African endemic.
Tembo Flat Gecko *Afroedura tembulica*	Main Drakensberg Escarpment (Stormberg only).	South African endemic.
Braack's Dwarf Leaf-toed Gecko *Goggia braacki*	Hantam–Roggeveld–Nuweveld Escarpment (Nuweveld only).	South African endemic.
Richtersveld Dwarf Leaf-toed Gecko *Goggia gemmula*	Richtersveld Escarpment.	South African and Namibian endemic.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
Namaqualand Dwarf Leaf-toed Gecko *Goggia rupicola*	Namaqualand Escarpment.	South African endemic.
(Angolan Leaf-toed Gecko) *Hemidactylus benguellensis*	Bié Escarpment.	Angolan endemic.
Lawrence's Dwarf Gecko *Lygodactylus lawrencei*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
Methuen's Dwarf Gecko *Lygodactylus methueni*	Mpumalanga–Limpopo Escarpment.	South African endemic.
Bernard’s Dwarf Gecko *Lygodactylus bernardi*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
(Laura’s Dwarf Gecko) *Lygodactylus laurae*	Bié Escarpment.	Angolan endemic.
Golden Spotted Thick-toed Gecko *Pachydactylus oculatus*	Hantam–Roggeveld –Nuweveld (Nuweveld only), Sneeuberg and Great Winterberg–Amatolas Escarpments. Also southern Free State (South Africa).	South African endemic.
Namaqua Thick-toed Gecko *Pachydactylus namaquensis*	Namaqualand, Richtersveld and Huib-Hoch Escarpments.	South African and Namibian endemic.
Kaokoveld Thick-toed Gecko *Pachydactylus oreophilus*	Brandberg Massif and Kaokoveld Escarpment.	Namibian and Angolan endemic.
Brandberg Thick-toed Gecko *Pachydactylus gaiasensis*	Brandberg Massif.	Namibian endemic.
Barnard's Namib Day Gecko *Rhoptropus barnardi*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
Kaokoveld Namib Day Gecko *Rhoptropus biporosus*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
Boulton's Namib Day Gecko *Rhoptropus boultoni*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
MAMMALS (9 endemics)		
Hartmann's Mountain Zebra *Equus zebra hartmannae*	Namibian Escarpment.	Namibian endemic (historically southern Angola south to the Kamiesberg).
Sclater's Golden Mole *Chlorotalpa sclateri*	Hantam–Roggeveld –Nuweveld (Nuweveld only) to KZN Escarpment.	South African and Lesotho endemic.
Gunning's Golden Mole *Neamblysomus gunningi*	Mpumalanga–Limpopo Escarpment.	South African and Swaziland endemic.
Arend’s Golden Mole *Carpitalpa arendsi*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Robust Golden Mole *Amblysomus robustus*	Mpumalanga–Limpopo Escarpment.	South African and Swaziland endemic.
Damara Ground-squirrel *Xerus princeps*	Namibian and southern Angolan Escarpments.	Namibian and Angolan endemic.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
Sloggett's Vlei Rat *Otomys sloggettii*	Eastern Great Escarpment.	South African, Lesotho and Swaziland endemic.
Selinda Rock Rat *Aethomys silindensis*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Kaokoland Slender Mongoose *Galarella flavescens*	Kaokoveld Escarpment.	Namibian and Angolan endemic.
AMPHIBIANS (25 endemics)		
Amatola Toad *Vandijkophrynus amatolicus*	Great Winterberg–Amatola Escarpment.	South African endemic. Endangered.
Inyanga Toad *Vandijkophrynus inyangae*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Northern Forest Rain Frog *Breviceps sylvestris sylvestris*	Mpumalanga–Limpopo Escarpment.	South African endemic. Vulnerable.
Highland Primitive Rain Frog *Probreviceps rhodesianus*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Drakensberg River Frog *Amietia dracomontana*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Inyanga River Frog *Amietia inyangae*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Large-mouthed (Maluti River) Frog *Amietia umbraculata*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Phofung River Frog *Amietia vertebralis*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Rattray's (Hogsback Chirping) Frog *Anhydrophryne rattrayi*	Great Winterberg–Amatola Escarpment.	South African endemic. Endangered.
Drakensberg Stream Frog *Strongylopus hymenopus*	Main Drakensberg Escarpment.	South African and Lesotho endemic.
Chimanimani Stream Frog *Strongylopus rhodesianus*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Namaqua Stream Frog *Strongylopus springbokensis*	Richtersveld and Namaqualand Escarpments.	South African and Nambian endemic. Vulnerable.
Mountain Caco *Cacosternum parvum*	Eastern Great Escarpment.	South African, Lesotho and Swaziland endemic.
Namaqua Caco *Cacosternum namaquense*	Richtersveld and Namaqualand Escarpments.	South African and Nambian endemic.
Long-toed Tree Frog *Leptopelis xenodactylus*	Main Drakensberg Escarpment.	South African and Lesotho endemic. Endangered.
Hoesch's Pygmy Toad *Poyntonophrynus hoeschi*	Central Namibian Escarpment.	Namibian endemic.
Damaraland Sand Frog *Tomopterna damarensis*	Kaokoveld Escarpment.	Namibian endemic.

Taxon	Great Escarpment Region	Endemicity and Conservation Status (where available)
Cave Squeaker *Arthroleptis troglodytes*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Chirinda Toad *Mertensophryne anotis*	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Swynnerton's Reed Frog *Hyperolius swynnertoni* "Swynnerton's Form"	Chimanimani–Nyanga Escarpment.	Zimbabwean and Mozambican endemic.
Hyperolius cinereus	Bié Escarpment.	Angolan endemic.
Hyperolius erythromelanus	Bié Escarpment.	Angolan endemic.
Hyperolius fasciatus	Serra de Mocaba Escarpment.	Angolan endemic.
Hyperolius tristis	Bié Escarpment.	Angolan endemic.
Hyperolius vermiculatus	Lombe Escarpment.	Angolan endemic.
FISH (6 endemics)		
Maloti Minnow *Pseudobarbus quathlambae*	Main Drakensberg Escarpment.	South African and Lesotho endemic. Critically Endangered.
Amatola Barb *Barbus amatolicus*	Great Winterberg–Amatola Escarpment.	South African endemic.
Treur River Barb *Barbus treurensis*	Mpumalanga–Limpopo Escarpment.	South African endemic. Vulnerable.
Top-stripe Barb *Barbus dorsolineatus*	Angolan Escarpment.	Angolan Endemic.
Incomati Chiselmouth *Varicorhinus nelspruitensis*	KZN and Mpumalanga–Limpopo Escarpments.	South African and Swaziland endemic. Vulnerable.
Southern Kneria *Kneria auriculata*	Mpumalanga–Limpopo and Chimanimani–Nyanga Escarpments.	South African, Zimbabwean and Mozambican endemic.

Chapter 2: The Sneeuberg mountain complex.

2.1. Introduction

The possibility that the Sneeuberg could be considered as a centre or sub-centre of endemism in its own right was first raised by Weimarck (1941) in his discussion on the Karoo Interval. Weimarck (1941) considered the Sneeuberg as a possible sub-centre within the CFR, based on the presence of several disjunct CFR species. He suggested that the Sneeuberg may parallel his concept of the HRC, which was considered a sub-centre of his NW Centre. However, he eventually excluded the Sneeuberg as a sub-centre of endemism owing to the paucity of CFR elements (Weimarck, 1941).

Despite this, the concept of the Sneeuberg as a centre of endemism was perpetuated by Nordenstam (1969), who recognised the region as a centre of diversity and endemism for the genus *Euryops* Cass.. His concept of the Sneeuberg Centre (or "Sneeuwbergen Centre" as published) included the Stormberg and Great Winterberg–Amatolas. It is thus a montane region centred on the Great Escarpment between Nordenstam's (1969) Drakensberg Centre and Weimarck's (1941) Cape Centre. Nordenstam (1969) indicates that this Sneeuberg Centre could possibly be sub-divided further, although he does not suggest how, and further noted that the region was poorly known and its importance needed further investigation. At the family level, Koekemoer (1996) identified eight putative centres of Asteraceae diversity in southern Africa, the Sneeuberg region being one, but termed by her the "Middelburg Centre".

Hilton-Taylor (1987), following the work of Weimarck (1941) and Nordenstam (1969), also recognised the existence of the Sneeuberg Centre within the Western Cape Domain (*sensu* Werger, 1978) and adjacent areas. In contrast to these workers, who considered the Sneeuberg unusual if not discrete, Van Wyk and Smith (2001) included the Sneeuberg in their broadly defined Albany Centre of Endemism. However, the delimitation of the Albany Centre is by no means clear. The concept of an Albany Centre was first introduced by Weimarck (1941) as the Zuurberg Subcentre, a sub-centre within the CFR based on Cape elements and the endemic Cape genus *Oldenburgia* Less.. Croizat (1965) later described an Albany Centre based on *Euphorbia* L. and which comprised the Great Fish River drainage basin (Van Wyk and Smith, 2001). Thicket is now considered the most obvious and typical aspect of the Albany Centre (Hamilton, 1994; Van Wyk and Smith, 2001). Hamilton (1994) also considers the Albany Centre to be a transitional centre of endemism for genera centred in the Cape, Nama-Karoo and Maputo–Pondoland regions. Based on the current broad delimitation, the Albany Centre is believed to have approximately 4 000 species/infra-specific taxa, of which more than 600 are endemic or near-endemic, and many of which are succulents (Hamilton, 1994; Van Wyk and Smith, 2001).

White (1978) included the Sneeuberg in his Afromontane archipelago, in Africa south of the Limpopo stretching from Knysna to the Soutpansberg (Bester, 1998). Various centres of endemism have been defined within this region i.e. the Wolkberg, Sekhukhune, Barberton, Soutpansberg and DAC of Van Wyk and Smith (2001). The definition of such centres is perhaps challenging given the phytogeographical commonality between them (Hilliard and Burtt, 1987; Van Wyk and Smith, 2001; Carbutt and Edwards, 2006; Mucina and Rutherford, 2006). Mucina and Rutherford (2006) have accordingly proposed a "Northern Sourveld Endemics" concept for the total eastern (Afromontane) Great Escarpment in southern Africa, comparable to Stuckenberg's (1962) Eastern Highlands Centre for palaeogenic invertebrate fauna. The largest and perhaps most important of these Afromontane centres is the DAC, considered to be a possible hub between the CFR, the eastern Great Escarpment (as far north as the Chimanimani–Nyanga mountains in Zimbabwe/Mozambique), and the midlands of KZN, Transkei and Pondoland (Van Wyk and Smith, 2001; Carbutt and Edwards, 2004; Mucina and Rutherford, 2006). Van Wyk and Smith's (2001) DAC is defined as "alpine" (based on climate and not floristics) and occurs above 1 800 m in the Eastern Cape and high altitude KZN Drakensberg, Witteberg, Lesotho Highlands and Malutis. The grasslands and Afromontane forests below 1 800 m are excluded from this definition of the DAC (vanWyk and Smith, 2001). Van Wyk and Smith's (2001) DAC is a smaller version of Phillips's (1917) Eastern Mountain Region, which includes the DAC as well as the surrounding highlands above 1 525 m as far south as Queenstown and the mountains in the Transkei (Hilliard and Burtt, 1987; Bester, 1998; Carbutt and Edwards, 2006). Carbutt and Edwards (2004) in their definition of the DAC also use the 1 800 m-contour, but include outliers above 1 800 m such as the Kamberg (2 095 m) and Ngele Range (2 698 m), following on from Hilliard and Burtt (1987) in this regard. The DAC as defined by these authors is estimated to have between 2 200 and 2 618 species, of which between 334 (13%) and 400 (18.2%) are endemic (Van Wyk and Smith, 2001; Carbutt and Edwards, 2006). Carbutt and Edwards (2006) indicate that some 595 species (24%) are considered to be DAC near-endemics. Other notable proposals of a DAC include Weimarck's (1941) Drakensberg Centre, which includes the Stormberg thus overlapping with Nordenstam's (1969) "Sneeuwbergen Centre", and Nordenstam's (1969) Drakensberg Centre.

Mucina and Rutherford (2006) have proposed a revision of the southern African Afromontane centres, and propose six centres in the Grassland Biome, namely the Soutpansberg, Wolkberg, Sekhukhune, Barberton, (KZN) Midlands and DAC. Their DAC is the widest of all the DAC concepts, and includes the Stormberg, Great Winterberg–Amatolas and the Bankberg or Boschberg (part of the Sneeuberg), effectively extending the DAC well to the south-west to include these fragmented but high sections of the south-eastern Great Escarpment.

Here the floristic diversity of the Sneeuberg is documented and analysed, with special emphasis on levels of endemism and floristic relationships with the various centres mentioned above. In this chapter, the Sneeuberg Centre is firstly delimited, secondly the history of botanical exploration and land-use is discussed, thirdly a synopsis of the abiotic and biotic environments is presented, and finally the methods and results of the floristic surveys and phytogeographic analyses are detailed. Based on these results and analyses, the formal recognition of the Sneeuberg Centre of Endemism is motivated.

2.1.1. Defining and delimiting the Sneeuberg Centre

The name ‘Sneeuberg’ (historically “Sneeuwbergen”, meaning ‘snow mountains’; Henning, 1975; Smith, 1976) has been applied in various ways to a significant portion of the southern African Great Escarpment in the Cradock, Murraysburg, Richmond, Graaff-Reinet, Nieu-Bethesda and Middelburg Districts of the Great Karoo, mostly in the Eastern Cape Province, South Africa (Fig. 2.1). Given the complexity of historical names and associated confusion (Palmer, 1966; Archer, 2000), the Sneeuberg is here defined explicitly as the discrete orographic entity forming a mountain arc some 200 km in length and which incorporates (from west to east) the Onder-Sneeuberg, Kamdebooberge, Meelberg, Koudeveldberge, Toorberg, Winterhoekberge, Compassberg, Lootsberg, Renosterberg, Agter-Renosterberg, Wapadsberg, Nardousberg, Tandjiesberg, Coetzeesberg, Bankberg, Aasvoëlkrans, Groot-Bruintjieshoogde and Boschberg. Although the Boschberg is climatically different from the rest of the Sneeuberg, it has been included as it forms part of the same discrete entity of Great Escarpment (see also Chapter 3). The Sneeuberg is separated from the Nuweveldberge by Nordenstam's (1969) “Nelspoort Interval” formed by the Gouritz–Kariega drainage basin, and from the Great Winterberg–Amatolas by the Great Fish River valley (Phillipson, 1987; here termed the “Great Fish River Interval”). A montane bridge around the north of the Great Fish River basin (the Kikvorsberg and the Suurberg in the Noupoort and Steynsburg Districts) links the Sneeuberg to the Stormberg. The Plains of Camdeboo, made famous by Palmer's (1966) book and part of Weimarck's (1941) “Karroo Interval”, separates the Sneeuberg from the Cape Fold Belt to the south.

The high-altitude floras of southern and central Africa are incompletely documented, including that of the Sneeuberg (Carbutt and Edwards, 2001; Küper et al., 2006). In general, the Sneeuberg is a very poorly collected mountain range (Nordenstam, 1969; Hilliard, 1994), despite being one of the most

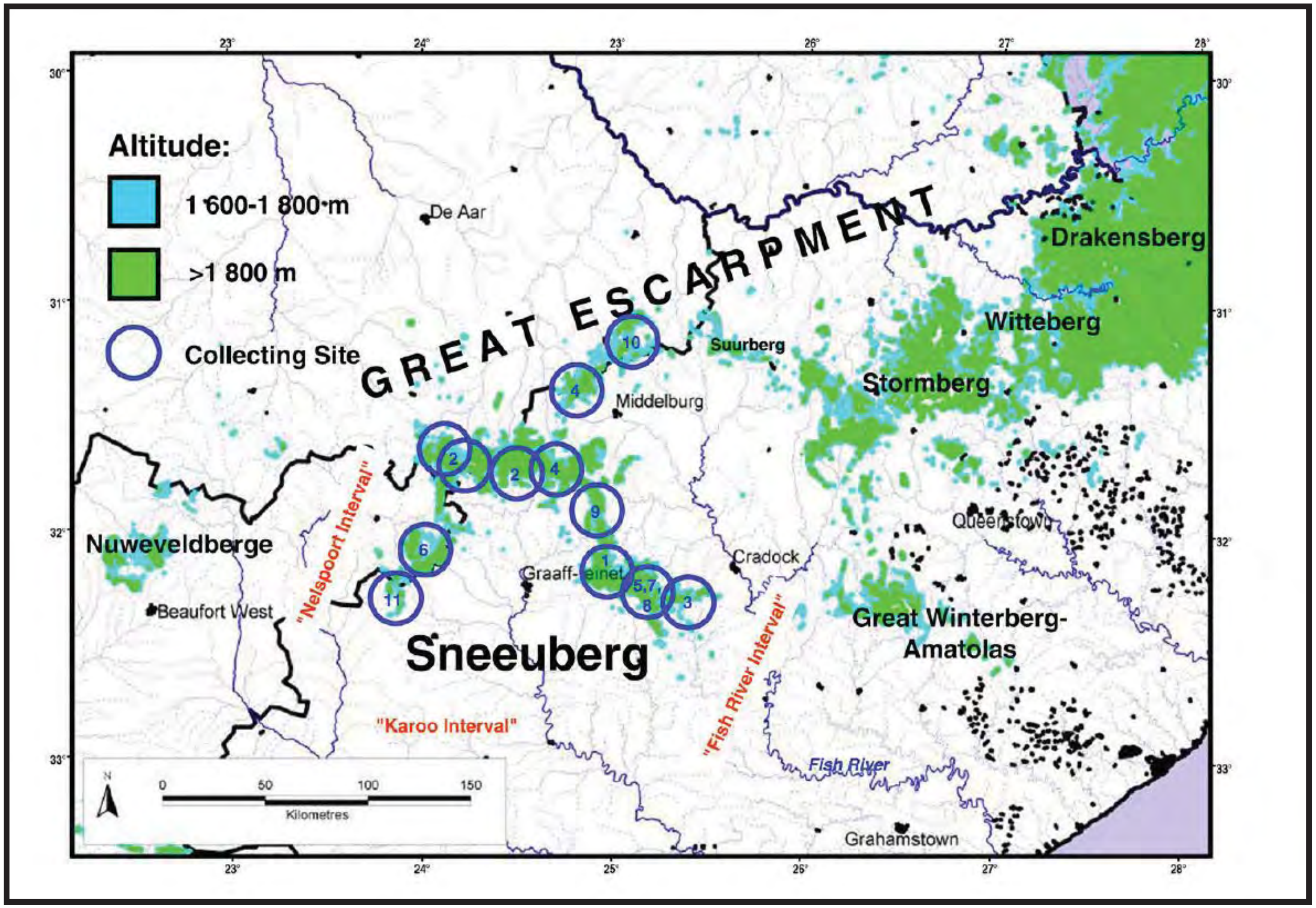


Figure 2.1: Map showing the location of the Sneeuberg on the southern Great Escarpment, South Africa. Circles indicate areas investigated during this survey; numbers correspond with Table 2.1. Map generated by G. McGregor (Department of Geography, Rhodes University).

prominent mountain ranges in the Great Escarpment (Boardman et al., 2003; Holmes et al., 2003). Botanical efforts to date have been mostly confined to specific taxonomic studies (e.g. Nordenstam, 1969; Whitehouse, 2002; Oliver, pers. comm.), and there is no indication of the Sneeuberg ever having been comprehensively treated in terms of its flora, or in a detailed biogeographic comparison with other portions of the Great Escarpment in southern Africa. The closests works in this regard are Weimarck's (1941) work on the endemic centres of the CFR, Nordenstam's (1969) treatment of *Euryops*, and Carbutt and Edwards's (2001) consideration of high-altitude Cape elements in Africa. In addition, several species from the Sneeuberg, such as *Apodolirion bolusii*, are only known by their type material (Golding, 2002).

2.1.2. Pioneer botanical work

Carl Thunberg and Francis Masson would have been the earliest collectors in the Sneeuberg as they intended to visit the area in 1773 to 1774, but they were thwarted by difficulties and had to abandon the idea (Gunn and Codd, 1981). William Burchell passed through the area in 1812 and 1813 (McKay, 1943), and the brothers C. and J. Drège collected on the Compassberg and Renosterberg in 1829 (Gunn and Codd, 1981). The vast majority of pioneer botanical was however done by Harry Bolus between 1865 and 1875 while he lived in Graaff-Reinet (Gunn and Codd, 1981). He particularly collected on the Oudeberg to the north of Graaff-Reinet and on the mountains around Graaff-Reinet, but also made trips to the Boschberg (1866, 1867), Compassberg (1868), Nardousberg (1873) and the Koudeveldberge (1872, 1873) (Bolus, unpublished collecting book, No. 1, housed in BOL). Numerous species from the region were discovered by Harry Bolus and have been named after him (e.g. *Pteronia bolusii* E.Phillips). Several species collected by him have not since been encountered again until recently when several were rediscovered during fieldwork for this research (see later). Two contemporaries of Harry Bolus were Peter MacOwan, who collected extensively on the Boschberg and Groot-Bruintjieshoogde (Phillipson, 1987), and William Tyson, who collected in the Koudeveldberge (Gunn and Codd, 1981).

More recent work has been done on the Mountain Zebra National Park (MZNP) area of the Sneeuberg by A.M. Barnard (1952–1955), L.C.C. Liebenberg (1960s; Penzhorn, 1970), and by Pond et al. (2002). Other more recent collectors in the Sneeuberg region have been H.P. Linder (1980s), B. Nordenstam (*Euryops*, 1950s), J.P.H. Acocks (Middelburg District), A.R. Palmer (Cape Midlands, 1980s), N.A. Helme (Nardousberg), C. Hobson (Aberdeen), E.G.H. Oliver (Ericaceae) and C. McMaster (Boschberg). It is not known how many specimens these collectors acquired. Key collections of Sneeuberg specimens are kept at PRE, BOL, GRA, and the reference herbaria at MZNP and the Camdeboo National Park.

2.1.3. Historical land-use and vegetation

Since the establishment of European farmlands in the area from the 1770's (Boardman et al., 2003), the vegetation of the Sneeuberg can be expected to have been modified to some degree. The primary land-use has been stock grazing, with the higher altitude grasslands being used for cattle and the lower shrublands for sheep and goats (Boardman et al., 2003). Very high stock densities in the Sneeuberg for the duration of a century, peaking between the 1940s and 1960s, may have converted marginal grasslands to shrublands, this being exacerbated by periodic drought (Boardman et al., 2003). Such overgrazing of the higher altitude grasslands has possibly resulted in a dominance of the unpalatable *Merxmuellera disticha* grass at the expense of more palatable grasses such as *Themeda triandra* and *Tetrachne dregei* (Meadows and Watkeys, 1999). Farms managed according to a strict rotational fire and grazing regime are dominated by *T. triandra* at medium altitudes and by greater grass diversity than the otherwise dominant *M. disticha* at higher altitudes. These may be suggestive of ‘normal’ grass biodiversity and abundance. Historical over-stocking in thicket areas has also left a legacy of *Portulacaria afra* extinction on some farms (Acocks, 1988; Palmer, 1990; Mucina and Rutherford, 2006).

Gully erosion is associated with historical overgrazing in high and low altitude water-courses, and there is a prevalence of sheet erosion in lower altitude areas (Keay-Bright and Boardman, 2007). The Seekoeirivier (arising at the north-western base of the Compassberg), was historically described as a system of vleis with intermittent pools used by hippopotamus (Boardman et al., 2003). It is currently a series of deep dongas, the erosion believed to have been initiated by the high wagon traffic and associated grazing and trampling by oxen and livestock after the opening of the Kimberley diamond fields in the 1870s (Boardman et al., 2003). The presence of such dongas is common throughout the Sneeuberg however, and a combination of concentrated grazing and watering of livestock along such wetland systems on local farms is the likely reason for their tragic demise. It would appear that most low-altitude wetland systems in the Sneeuberg have been severely degraded in this manner. In general, wetlands in the Sneeuberg have not fared well historically, and those that are not eroded out are often locally threatened by current live-stock grazing and trampling. Most previously extensive wetlands at lower altitudes have been eroded out (e.g. Holmes, 1998) and no longer function as such.

There has been a recent shift towards game farming and associated eco-tourism in the region, and it is likely that most of the original game species except *Diceros bicornis* (Black Rhinoceros) and *Panthera leo* (Lion) are now represented in the numerous game farms in the region. Rangeland management will remain an important concern for the management/restoration of natural vegetation cover on these farms.

2.2. Physical and biotic aspects

2.2.1. Geology

The geology of the Sneeuberg is dominated by Jurassic dolerite sills, dykes, basins, belljar intrusions, laccoliths and inclined sheets that have intruded into the older Beaufort Group sandstones and mudstones of the Karoo Supergroup (Du Toit, 1920; Van der Walt, 1980; Palmer, 1988, 1991; Hill, 1993; De Klerk et al., 2002; Van Zijl, 2006). These dolerites are considered to be (at least in part) the feeder veins of the lava outpourings which terminated the Karoo depositional sequence at the breakup of Gondwana (Du Toit, 1920; Brink, 1983; Van Zijl, 2006), but as many as seven individual dolerite injections are believed to have taken place over time (Kent, 1980). The Beaufort sediments belong to the Late Permian Adelaide Subgroup (Hill, 1993). Metamorphic or "baked" sediments comprising hornfels and quartzites occur along the contact zones between the sedimentary strata and the dolerite intrusions (Hill, 1993).

2.2.2. Geomorphology

The Great Escarpment, in the form of mountain ranges with dramatic scarp slopes, is considered to be the oldest geomorphological feature of the Great Karoo (Watkeys, 1999) representing a passive relict of the Gondwana continental margin (Hill, 1993; Matmon et al., 2002). The structurally resistant nature of the Karoo dolerites has contributed to its continuing presence (Du Toit, 1920; Pond et al., 2002), and it is easily recognisable by its massive, prow-shaped ramparts.

In the Sneeuberg the Great Escarpment forms a wide dissected region rather than a single scarp (Hill, 1993;Watkeys, 1999), being the result of head-ward erosion by south-flowing rivers such as the Sundays, Great Fish and Little Fish Rivers as well as a host of smaller streams (Hill, 1993). This has resulted in the continental watershed being pushed back by some 60 km from the main southern scarps of the Sneeuberg. The continental watershed now runs from the Winterhoekberge (in the Richmond District – not to be confused with the ranges of similar names in the Uitenhage District) through to the Compassberg, north-east along the Agter-Renosterberg, then east along the Kikvorsberg and Suurberg, and south-east along the Bamboesberge (part of the Stormberg). On the Compassberg there is 800 m between the headwaters that drain to the Atlantic and Indian Oceans (as evidenced on the 1:50 000 topographic sheets 3124DA and DC), indicating that the Compassberg is "close" to be being isolated south of the continental watershed by a process of stream-piracy.

Partridge and Maud (1987) in their landmark paper on southern African erosion surfaces simply place the Sneeuberg, together with all high lying areas of the Great Escarpment, into "*mountainous areas above the African surface*" (Partridge and Maud, 1987: their Fig. 12). These represent landscapes older than the African cycle of erosion, and the higher peaks are considered to be remnants of the Jurassic/Gondwanan surface (Agnew, 1958). The intervening sections of the Great Escarpment are described as "*other dissected areas*" with "*major structural control commonly present*" (Partridge and Maud, 1987: their Fig. 12). The Plains of Camdeboo to the south represent the Post-African I surface, while the interior plateau north of the Great Escarpment represents the African surface (Partridge and Maud, 1987). The Sundays, Great Fish and Little Fish Rivers valleys represent the beginnings of the Post-African II erosion surface. Although the Sneeuberg is considered to simply predate the African surface, it comprises a fairly consistent double-plateau system, at ca. 1 800 and at ca. 2 100 m throughout the range (the two levels are for example clearly evident on the Sneeuberg north-west of Compassberg). The four major peaks (see below) in the Sneeuberg all stand as pyramids above the 2 100 m plateau. These plateaux may represent structural control from horizontal sills, but may also suggest planing prior to the African surface (Partridge, pers. comm.), and are interpreted as such for the Great Winterberg–Amatolas, with the highest peaks representing remnants of the Gondwanan surface (Agnew, 1958).

The Sneeuberg contains the highest peaks in the Great Escarpment in South Africa west of the Eastern Cape Drakensberg. The Compassberg, at 2 504 m, is one of the highest free-standing southern African peaks outside of the Drakensberg Massif and Lesotho Highlands (Readers Digest Atlas of Southern Africa, sine anno; see Fig. 2.2E). It is formed from an inclined dolerite sheet, such sheets being considered typical of the higher points in the Karoo (this is in contrast to the usual "tafelkop" nature of the Karoo mesas, more typical inland of the Great Escarpment and that result from horizontal sills; Du Toit, 1920). The next highest peak in the Sneeuberg, the Nardousberg (2 429 m), follows the same structural pattern as that of the Compassberg, and this is repeated for the third peak (unnamed – here proposed has "Harry's Peak" after Harry Bolus), 2 298 m near the Renosterberg and fourth highest peak (Toorberg, 2 278 m) in the Sneeuberg. These peaks are all typically capped with a mass of irregular, angular boulders, probably the legacy of the severe climate in which mechanical weathering from frost action and shattering is dominant (Watkeys, 1999).

Other landforms in the Sneeuberg include bell-shaped dolerite intrusions which are present in the Blinkberg and Bankberg, and the resultant convex cliffs, summit rainwater rock pools and wetlands

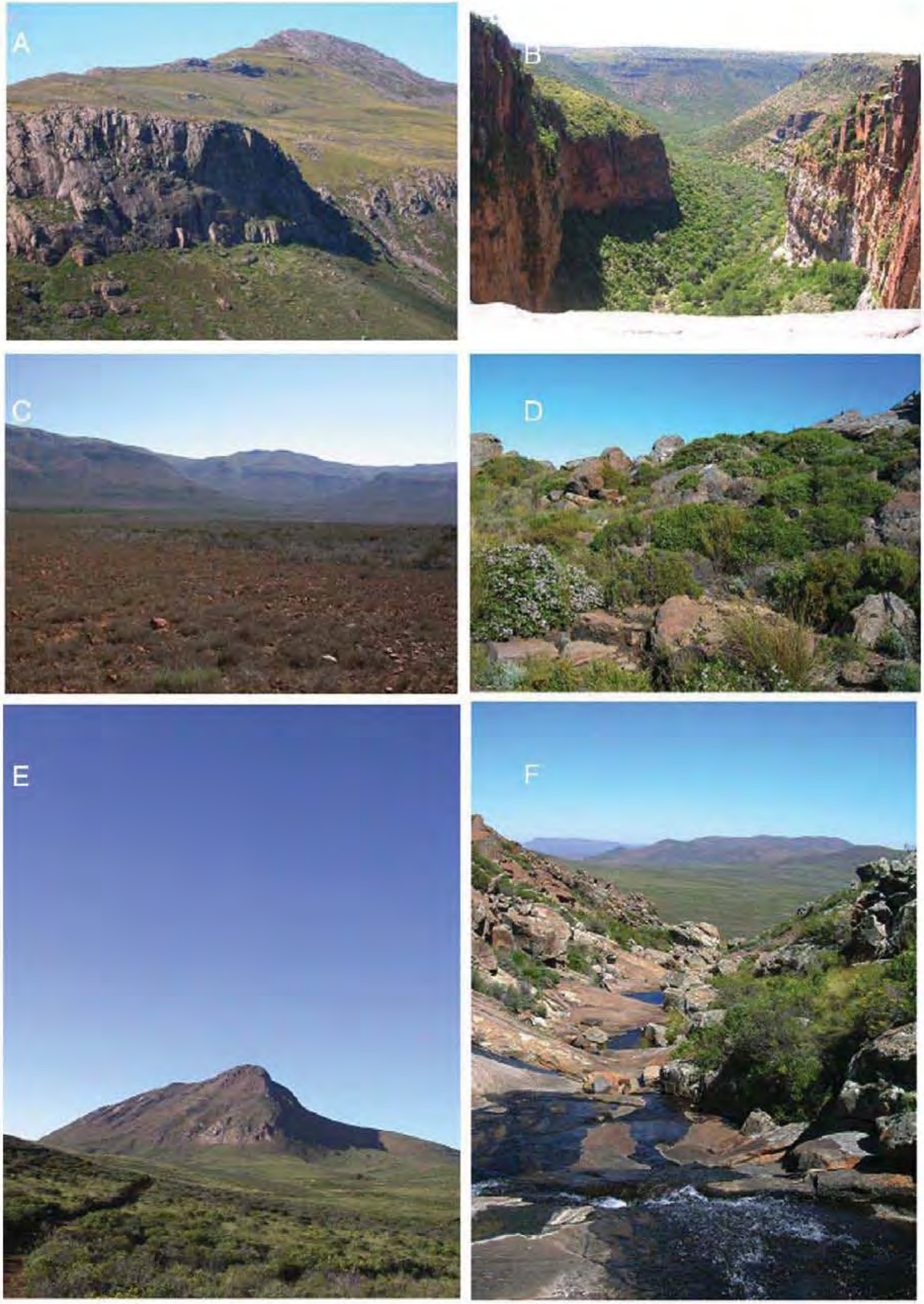


Figure 2.2: A selection of photographs of the Sneeuberg: (A) Karoo Escarpment Grassland, Toorberg (1 900–2 200 m); (B) Camdebo Escarpment Thicket, Farm Kleinfontein (1 100 m); (C) Eastern Lower Karoo, Asante Sana Private Game Reserve (900 m); (D) Fynbos elements, Toorberg (2 100 m); (E) Compassberg (summit 2 503 m), as viewed from the north-west; (F) Perennial stream on the Koudeveldberge (1 900 m).

with high sinuosity are unusual for the Sneeuberg. Columnar dolerite (Du Toit, 1920) is common at medium altitudes (ca. 1 600–1 800 m) and free standing columns occasionally occur (such as in the famous Valley of Desolation in the Camdeboo National Park).

The abundant vertical to near-vertical rock scarps throughout the Sneeuberg vary from minor (<5 m in height) to major (>50 m in height). Such south-facing scarps provide almost all-day shade, and consequently provide a cool, often moist environment for annual and herbaceous species ill-equipped for the arid Karoo environment. Numerous Afromontane and Cape elements are found in these locations, and scarps in general in the Sneeuberg provide an important mesic micro-habitat (Van der Walt, 1980; see Chapter 6). Many of these scarps are also associated with seeps. The higher scarps are often characterised by scree slopes at their bases. Dissected, rocky kloofs (valleys) – often flanked by tors comprising exposed, balancing dolerite corestones (Boardman et al., 2003) – are common throughout the Sneeuberg foothills (1 200–1 500 m).

2.2.3. Soils

Soils of the Sneeuberg are very broadly described as “undifferentiated soils” of the Great Escarpment by Watkeys (1999), with duplex soils occurring in the eastern area of higher rainfall, or locally in areas of higher precipitation (Watkeys, 1999). From observation, soils in the Sneeuberg are nutrient-poor, shallow soils on sedimentary strata; moderately deep, richer loamy-clay vertisols occur on upper, gentler, dolerite slopes; and black, deep (>1 m), heavy turf clays in the often extensive (>1 ha) upland *Merxmuellera macowanii* wetlands on the summit plateau (above 1 800 m). Steep, rocky slopes are characterised by shallow Mispah and Glenrosa soils forms (Hartmann, 1988; Holmes, 1998), and Quaternary alluvial soils of limited extent but often significant depth (>2m) occur on floodplains and along drainage lines at the base of the mountains (Palmer, 1988; Mucina and Rutherford, 2006).

2.2.4. Climate

The Sneeuberg is located in the climatic tension zone between the arid west and moist east (Van der Walt, 1980). Kopke (1988) places the Sneeuberg region as transitional to autumn and summer maximum rainfall in the Eastern Cape, e.g. Graaff-Reinet has its mean annual precipitation (MAP) evenly distributed between spring, summer and autumn (Cannon, 1924). The region receives the edge of all major weather systems in southern Africa (Desmet and Cowling, 1999). There is evidence of wet and dry oscillations every 10 to 12 years in the region (Palmer, 1988; Boardman et al., 2003);

Palmer (1966) notes the historical occurrence of severe droughts in the region, as well as years of high rainfall and deep snowfalls.

The surrounding plains have a lower MAP than the mountains themselves (Van der Walt, 1980; Pond et al., 2002; Mucina and Rutherford, 2006). For example Graaff-Reinet at 750 m receives 353 mm (Palmer, 1991) and Cradock at 900 m receives 316 mm (Desmet and Cowling, 1999), while the Farm Toorberg at 1 300 m receives about 500 mm (Kritzinger, pers. comm.) and on the Farm Compassberg at 1 720 m MAP is 517 mm (Boardman et al., 2003). Holmes (1998) indicates that most of the higher-lying areas of the Sneeuberg receive between 400 and 500 mm per annum, with the eastern section (from the Nardousberg to the Bankberg) receiving between 500 and 600 mm. Rain is typically in the form of thunderstorms with heavy showers (De Klerk et al., 2001) and has a reliability of 65–70% (Palmer, 1988). The rainfall peaks in late summer (March; Van der Walt, 1980; Boardman et al., 2003) as a result of tropical disturbances (Desmet and Cowling, 1999) while equinoctial rains from cut-off lows, winter rains, and snowfalls are important forms of precipitation (Desmet and Cowling, 1999; Watkeys, 1999; De Klerk et al., 2001; Pond et al., 2002). The Boschberg receives the highest rainfall in the Sneeuberg, between 900 and 1 000 mm (B. Brown, pers. comm.), as evidenced by its Afromontane forest and moister grassland (Palmer, 1991; Mucina and Rutherford, 2006; see Chapter 3). Other forms of precipitation in the Sneeuberg are infrequent hail (Van der Walt, 1980), dew (Desmet and Cowling, 1999), and mist (Pond et al., 2002). The region has 52 frost days recorded (Mucina and Rutherford, 2006), these mostly occurring between May and October (Van der Walt, 1980).

The low-altitude plains are warmer than the mountains, with average maximum temperatures in summer varying from 23–28 °C, and in winter from 16–23°C (De Klerk et al., 2001). The average minimum temperatures in summer vary from 6–14°C and in winter from 0–8°C (De Klerk et al., 2001). Temperatures in the mountains are cooler as a result of altitude (Van der Walt, 1980; Kopke, 1988) and minimum temperatures can drop to as low as −10°C in the higher areas (Boardman et al., 2003). Local names such as “Koudeveldberge”, “Sneeuberg”, and “Winterhoekberge” attest to these cool montane conditions. Humidity varies from 59% to 85% with no readily discernible pattern (Van der Walt, 1980).

There is a summer dominance of south-easterly winds of 1.1–7.9 m/s (Van der Walt, 1980; Palmer, 1991), although winds from the north-western quadrant are stronger (8.0–13.8 m/s) if not as dominant (Palmer, 1991). Calm days account for 21.1% of wind data (Palmer, 1991). Winter data indicates a strong dominance of winds from the north-western quadrant (Van der Walt, 1980; Palmer, 1991), reaching strengths of between 8.0 and 13.8 m/s (Palmer, 1991). Winds are mostly local in nature

(Desmet and Cowling, 1999) and Kopke (1988) notes that local winds from the south-east along the Sneeuberg Escarpment each afternoon moderate the average daily temperatures, especially in summer. Palmer (1966) noted that farmers in the Sneeuberg foothills appreciate the affect this moist wind has on the vegetation. Hot dry north winds dominate in January and February causing mid-summer drought (Kopke, 1988).

Micro-climates in the Sneeuberg are created by aspect. South and south-east facing scarps are noticeably moister and cooler compared to north- and north-west scarps and slopes as they receive a higher incidence of mist, rain and shade (Pond et al., 2002). The higher peaks have their own micro-climate characterised by persistent wind and extremely low temperatures in winter and during cold fronts.

The available moisture to vegetation in the Sneeuberg is sufficient to maintain Afromontane grassland at higher altitudes (above 1 800 m), and to support mesic fynbos and Afromontane forest on the Kamdebooberge and the Boschberg (see Chapter 3).

2.2.5. Vegetation

The Eastern Cape is well known to be a meeting place of several biomes (Cowling, 1983; Palmer, 1990, 1991), this being the result of the major climatic, topographic and geological transitions that occur in that Province (Cowling, 1983; Vlok et al., 2003). This meeting of biomes is no less apparent in the Sneeuberg region, resulting in complex vegetation gradients (Palmer, 1991).

a) Grassland biome

The dominant grassland vegetation unit in the Sneeuberg is Karoo Escarpment Grassland (Mucina and Rutherford, 2006; Fig. 2.2A) which generally occurs above 1 600 m. Typical grass species include *Ehrharta calycina*, *Melica decumbens*, *Merxmuellera macowanii*, *M. disticha*, *Tetrachne dregei*, *Karroochloa purpurea*, *Helictotrichon* spp., and specialist grasses such as *Festuca* spp. and *Brachypodium bolusii* at the base of scarps and *Pentaschistis airoides* subsp. *jugorum* in moist crevices and on high peaks. The grassland is replaced above ca. 2 100 m on rocky peaks and stony plateaux by an “Arid Fynbos” (White, 1978; Low and Rebelo, 1998). Forbs and geophytes are well represented throughout this grassland unit. Minor grassland types in the region are Amathole Montane Grassland (Mucina and Rutherford’s, 2006, spelling) on the Boschberg, and Bedford Dry Grassland occurs along the southern foot of the Great Escarpment below the Groot-Bruintjieshoogde and Boschberg (Mucina and Rutherford, 2006; see Chapter 3).

b) Forest biome

Southern Mistbelt Forest occurs on the southern slopes of the Boschberg (Mucina and Rutherford, 2006; see Chapter 3), and moist thicket/scarp forest approaching Afromontane forest occurs on the Kamdebooberge, on the Buffelshoek section of the Sneeuberg Escarpment behind Pearston, and on the Groot-Bruintjieshoogde.Temperate forest elements are present in mesic niches in the remainder of the Sneeuberg but do not come near Afromontane in character or composition. Typical such species found throughout the Sneeuberg are *Celtis africana*, *Kiggeleria africana*, *Maytenus acuminata* var. *acuminata* and *Searsia krebsiana*.

c) Albany thicket biome

Camdeboo Escarpment Thicket is the dominant vegetation on the Sneeuberg foothills between Aberdeen and Pearston at altitudes of ca. 1 000–1 400 m (Mucina and Rutherford, 2006; Fig. 2.2B). *Portulacaria afra* is the historically dominant species (Mucina and Rutherford, 2006). The vegetation structure is comprised of dense, often thorny, woody shrubs such as *Acacia karroo*, *Carissa bispinosa* (=*C. haematocarpa* (Eckl.) A.DC.), *Euclea crispa* subsp. *crispa*, *Pappea capensis*, *Grewia robusta*, *Ehretia rigida* subsp. *rigida*, *Searsia* spp., *Gymnosporia linearis* subsp. *linearis*, *G. buxifolia* and *Boscia oleoides* up to 3 m tall in dense clumps, with a matrix of *P. afra* up to 3 m tall and scattered *Aloe ferox* up to 4 m tall (Palmer, 1990).

Eastern Cape Escarpment Thicket occurs on the northern and southern slopes of the Bankberg and Boschberg (Mucina and Rutherford, 2006). Great Fish Thicket occurs along the Great Fish River and Little Fish Rivers, the former to Cradock and the latter into the Swaershoek area (Mucina and Rutherford, 2006).

d) Nama-Karoo biome

Eastern Lower Karoo dominates the Plains of Camdeboo (Mucina and Rutherford, 2006; Fig. 2.2C). This vegetation unit forms the lower altitude context for the base of the Sneeuberg Escarpment and adjacent plains and is distinguished from other Nama-Karoo types by its higher proportion of succulent dwarf and larger woody shrubs (Mucina and Rutherford, 2006). The vegetation is typically sparse, consisting of low bushes and succulents up to 50 cm and comprising species such as *Sarcocaulon camdeboense*, *Eriocephalus ericoides* subsp. *ericoides*, *Pentzia incana*, *P. globosa*, *Delosperma* spp. and *Ruschia* spp. (Low and Rebelo, 1998).

Mucina and Rutherford's (2006) Upper Karoo Hardeveld is an ambiguous vegetation type in the Sneeuberg, and is reputed to include most of the crest and steep south-facing slopes of the Great Escarpment between Teekloofpas and Graaff-Reinet (Mucina and Rutherford, 2006). This is considered to be one of the richer floras of the Nama-Karoo Biome, but in the Sneeuberg area is often difficult to distinguish from adjacent thicket and other vegetation units (Mucina and Rutherford, 2006). Eastern Upper Karoo occurs on the plains to the north of the Sneeuberg and is transitional between the Grassland Biome and the Nama-Karoo Biome (Mucina and Rutherford, 2006).

e) Fynbos elements

True fynbos as defined for the Fynbos Biome or the CFR (i.e. having Ericaceae, Proteaceae and Restionaceae as the dominant components; Low and Rebelo, 1998; Mucina and Rutherford, 2006) occurs in the study area only on the Goewermentsberg in the Kamdebooberge. This "CFR outlier" is a ca. 50 ha, dense patch dominated by *Erica leucopelta*, *Faurea* sp. nov. (Proteaceae), several restio species including the conspicuous *Rhodocoma capensis*, and the Rutaceae species *Agathosma venusta* and *A*. cf. *capensis* (Trinder-Smith, pers. comm.). The CFR-endemic genus *Acmadenia* Bartl.& H.L.Wendl. is represented by one new species (Trinder-Smith, pers. comm.). The nearest similar fynbos is on the south-east escarpment slopes of the Toorberg (ca. 20 km north–north-east), where *A. venusta* and *E. leucopelta* are dominant (1 700–1 900 m).

Although no other true CFR patches are known to occur in the Sneeuberg, "Cape elements" as defined by Carbutt and Edwards (2001) are present throughout the Sneeuberg (Carbutt and Edwards, 2001, 2004), and are referred to by Van der Walt (1980) as "arid fynbos" and by Nordenstam (1969) as "false macchia". Such elements are typically located along cliff-lines, on rocky plateaux at higher altitudes (ca. 2 100 m), and on the higher peaks (Fig. 2.2D). Species include *A. venusta* (Toorberg area), *Euryops exsudans* (Nardousberg and Wapadsberg), *Passerina montana*, *Ischyrolepis distracta*, *Erica woodii* var. *woodii*, *E. caespitosa*, *E. passerinoides* (Toorberg), *E. leucopelta*, *Erica* sp. aff. *reenensis* (Nardousberg), *Cliffortia eriocephalina*, *C. ramosissima*, *C. bolusii* (Nardousberg), *C. montana* (Toorberg), *Muraltia alticola* and *M. alopecuroides*. Lower altitude (1 300–1 600 m) Cape elements include *Otholobium macradenium*, *Lotononis caerulescens*, *Psoralea glabra* and *Aspalathus acicularis* subsp. *acicularis*. *Dicerothamnus rhinocerotis*, considered an arid Cape element (Mucina and Rutherford, 2006) is common throughout the Sneeuberg from ca. 1 500–1 800 m, and an undescribed Renosterveld unit may be present. Carbutt and Edwards (2001) note the Sneeuberg to have only a third of the Cape elements compared to the DAC, perhaps due to the Sneeuberg's drier climate (Linder et al., 1993; Carbutt and Edwards, 2004), and probably also from under-collecting.

f) Azonal vegetation

Azonal vegetation types in the study area include montane wetlands above 1 800 m, consisting of headwater sponges, rainwater pools, seeps, streams and floodplains and may be analogous to Mucina and Rutherford's (2006) Drakensberg Wetlands. Many of these high-altitude perennial and seasonal marshlands are dominated by *Merxmuellera macowanii*. The soil profile consists of black humus-rich clays to a depth of at least 2 m and comprises perennially moist headwater systems fed by summer rains and winter snows. Lower altitude wetlands and floodplains (1 600–1 800m) in broad upland valleys are dominated by *Pseudoschoenis inanis*, often in extensive stands (>0.5 ha). Rocky watercourses above 1 800 m (Fig. 2.2F) are often dominated by species such as *Buddleja salviifolia*, *Leucosidea sericea*, *Miscanthus capensis*, *Geranium* spp. and *Phygelius capensis*.

The middle reaches (1 200–1 600 m) of the deeper valleys are densely wooded and are composed of a composite of "bushveld" (e.g. *Olea europaea* subsp. *africana*), thicket (e.g. *Searsia pallens*) and Afromontane (e.g. *S. krebsiana* and *L. sericea*) elements, and may best bedescribed as "temperate thicket" (Cowling et al., 2005) or "incipient forest" (Van der Walt, 1980). At lower altitudes (ca. 1 000 m) the riparian vegetation becomes Mucina and Rutherford's (2006) typical Southern Karoo Riviere vegetation type dominated by *A. karroo*.

2.3. Materials and methods

The floristic data for the Sneeuberg have been collated from numerous sources, notably historical specimens of Harry Bolus, Peter MacOwan and William Tyson in GRA; taxonomic revisions and treatments; and specimens collected since 2005 (see below). Species listed in local checklists (Palmer, 1988, for the Karoo Nature Reserve, now Camdeboo National Park; Penzhorn, 1970, and Pond et al., 2002, for the MZNP; and Van der Walt, 1972; and Westfall, pers. comm., for the Boschberg) have only been used where specimens could be verified. The resultant Sneeuberg flora represents altitudes from 800–2 500 m, covering most of the vegetation units in the Sneeuberg mountain complex.

As published botanical information is limited or outdated, the vast majority of the floristic data is a result of fieldwork undertaken between 2005 and 2008. Twenty individual fieldtrips have been undertaken (Table 2.1), with collecting being focussed above 1 300 m (and especially above 1 500 m). The highest peaks, adjacent scarps and surrounding plateaux above 2 000 m received special emphasis, but collecting was also undertaken at lower altitudes (1 100–1 800 m) in kloofs and in Camdeboo Escarpment Thicket. Some 5 000 specimens have been collected during this fieldwork. The Boschberg and Groot-Bruintjieshoogde have received special emphasis in Chapter 3 given their higher rainfall and unique set of vegetation units compared to the rest of the Sneeuberg.

The identification of specimens was undertaken in the Selmar Schönland Herbarium (GRA), Albany Museum. Numerous taxonomists assisted with more difficult groups and with groups that were being revised at the time (see Acknowledgements). Specimens have been lodged in GRA, with duplicates of various groups sent primarily to BOL, S, NBG, PRE, K, MO, NU, JRAU and WITS. Specimens collected by N.P. Barker from the Nardousberg region in 1997 were included in the project and treated in the same manner. Nomenclature of the resultant flora (Appendix 2) was updated from available revisions.

Table 2.1: Collecting localities in the Sneeuberg mountain complex during the study period (2005–2008).

Localities	Dates	Collectors	Grids
1. Asante Sana Private Game Reserve (Petersburg) and Nardousberg (Graaff-Reinet District).	October, December 2005; January, March, November 2006; April, October 2008.	Clark VR, Barker NP, Devos N; Clark VR, Coombs G; McKenzie RJ, Weston P, Clark VR; Clark VR, Ramdhani S; Clark VR, Crause I.	3224BB, BD, 3225AC
2. Compassberg and adjacent NW mountains (Richmond, Middelburg and Graaff-Reinet Districts).	February 2006, 2007.	Clark VR, Devos N, McKenzie RJ; Clark VR, McKenzie RJ.	3124CB, CD, DA, DC
3. Swaershoek Pass and Schurfteberg (Bankberg) (Cradock District).	March 2006; November, December 2007.	McKenzie RJ, Weston P, Clark VR; Clark VR, Rose M.	3225BC
4. Lootsberg Pass, Renosterberg and adjacent mountains (Middelburg District).	April 2006.	Clark VR, Ngcobo L, Pienaar C.	3124DB, DD
5. Aasvoëlkrans/Buffelshoek-se-pas (behind Pearston, Graaff-Reinet District).	October 2006, November 2007.	Clark VR, Ramdhani S; Clark VR, Rose M.	3225AC, AD
6. Meelberg, Koudeveldberge and Toorberg (Murraysburg and Graaff-Reinet Districts).	November 2006, December 2007.	Clark VR, Te Water Naudé T; Clark VR, Pienaar C.	3223BB, 3224AA
7. Tandjiesberg–Coetzeesberg (behind Pearston, Graaff-Reinet District).	December 2006.	Clark VR, Coombs G.	3225AC
8. Blinkberg (Cradock District).	March 2007, December 2007.	Clark VR, McKenzie RJ; Clark VR, Rose M.	3225AC
9. Wapadsberg (Cradock and Graaff-Reinet Districts).	December 2007.	Clark VR, Pienaar C.	3124DD
10. Kikvorsberge (Noupoort and Colesburg Districts).	January, February 2008.	Clark VR, Pienaar C, Lochner EJ.	3125AA
11. Kamdebooberge (behind Aberdeen, Graaff-Reinet District).	April, June 2008.	Clark VR, Crause I; Clark VR, Pienaar C.	3223BD
12. Kamdebooberge (behind Aberdeen, Graaff-Reinet District).	September 2008.	Clark VR, O'Connor R.	3223BD

2.4. Results and discussion

2.4.1. Flora

As of the end of August 2008 the Sneeuberg has a flora of 1 195 species (Appendix 2). The flora is composed of 29 pteridophytes (2.4% of the total flora), four gymnosperms (0.3%), 278 monocotyledons (23.2%) and 884 dicotyledons (74%). One-hundred-and-seven (9%) species are alien, most of these being innocuous and confined to disturbed areas around homesteads, along roads, and in degraded sites. Several species present problems due to their invasive nature, most notably *Populus* x *canescens* along water courses, *Nassella trichotoma* in grassland and *Rosa rubiginosa* in moist grassland and valleys. Management strategies are urgently needed throughout the Sneeuberg to control these species, especially for *Nassella* on the Boschberg and Groot-Bruintjieshoogde (see Chapter 3). A potentially problematic species is *Sambucus nigra* – widespread and occasional at the base of moist cliffs – whilst *Schinus molle*, *Robinia pseudoacacia* and *Salix babylonica* var. *babylonica* are potential problem plants in riparian zones.

2.4.2. A Sneeuberg Centre of Endemism

Twenty-eight (2.3%) endemic species occur on the Sneeuberg (Table 2.2). The Sneeuberg can be considered a southern component of Mucina and Rutherford's (2006) “Northern Sourveld Endemics” concept, similar to the Soutpansberg in terms of being at the end of the eastern Great Escarpment centre-continuum but with almost double the percentage levels of endemism (2.3% versus 1.5% in the Soutpansberg; Van Wyk and Smith, 2001). The Sneeuberg endemics cover a variety of families in both the monocots and dicots, and comprise plant groups typical of the Albany Centre, the Afromontane regions (especially the DAC), and the CFR (see below). Such a diverse array of endemic species supports the recognition of the Sneeuberg as a centre of endemism.

Table 2.2: Endemic plant species of the Sneeuberg mountain complex, together with collection and habitat notes (* denotes type or other specimens viewed on the Aluka Foundation: African Plants Initiative website: http://www.aluka.org/).

Species	Family	Collections	Notes	References
Acmadenia sp. nov. 1 aff. *sheilae* I. Williams	Rutaceae	Clark VR, Crause I 130, Kamdebooberge, 1 606 m, April 2008.	Endemic to the Kamdebooberge behind Aberdeen. This is a range extension of ca. 150 km for the genus from the CFR onto the Great Escarpment. *A. sheilae* occurs on the Roodeberg, Swartberg and Touwsberg (Ladismith District).	Williams, 1982; Trinder-Smith, pers. comm.
Adromischus fallax Tölken	Crassulaceae	Bolus H 758*, Tandjiesberg, 1 390 m, 1870.	Occurs in Camdeboo Escarpment Thicket. Re-collected more recently by E. van Jaarsveld.	Tölken, 1978; Van Jaarsveld, pers. comm.
Apodolirion bolusii Baker	Amaryllidaceae	Bolus H 717*, Cave Mountain, 1 390 m, 1868.	Only known from the type. Occurs in Camdeboo Escarpment Thicket.	Golding, 2002; Dold, pers. comm.
Cliffortia bolusii Diels ex C.Whitehouse	Rosaceae	Bolus H 260, Nardousberg, 1 770 m, 1873.	Only known from the type. Occurs in Karoo Escarpment Grassland.	Whitehouse, 2002; Whitehouse and Fellingham, 2007; Whitehouse, pers. comm.
Conium sp. no. 4 (Hilliard & Burtt, 1985b)	Apiaceae	Bolus H 189, Graaff-Reinet, sine anno. Hilliard OM, Burtt BL 10650, Renosterberg, 1 800 m, 1977. Clark VR, McKenzie RJ 177, Compassberg, 2 260 m, February 2007. Clark VR, McKenzie RJ 429, Blinkberg, 2 009 m, March 2007. Clark VR, Rose M 313, Bankberg, 1 874 m, December 2007. Clark VR, Rose M 524, Blinkberg, 1 877 m, December 2007. Clark VR, Crause I 25, Asante Sana Private Game Reserve, 1 843 m, April 2008.	Only two previous collections known. Recollected throughout the N and E Sneeuberg: common above 1 700 m along moist cliff-bases and other upland rocky areas in Karoo Escarpment Grassland. Taxonomy being considered by P. Winter and J. Stratton, as possibly part of *Conium fontanum* Hilliard and B.L.Burtt complex.	Hilliard and Burtt, 1985b; Stratton, pers. comm.; Winter, pers. comm.
Delosperma sp. nov. 1 aff. *D. dyeri* L.Bolus	Mesembryanthe-maceae	Only known from a specimen collected by E.G.H. Oliver in 2004 (Nardousberg, 2 400 m) and a photograph by N. Helme in 2004.	Considered to be an undescribed species with affinities to *D. dyeri*. Occurs in Karoo Escarpment Grassland.	Burgoyne, pers. comm.

Diascia ramosa Scott-Elliot	Scrophulariaceae	Scott Elliot GF 488*, Boschberg, 1 200 m, ca. 1888. MacOwan P 1968*, Boschberg, 1 360 m, sine anno.	Only known from two specimens. Habitat recorded as “in bush”. Not rediscovered despite extensive searches in 2008.	Hilliard and Burtt, 1984.
Dierama grandiflorum G.J.Lewis	Iridaceae	Clark VR, Daniels R, Le Roux J, Frabricius M 287, Boschberg, 1 575 m, December 2009.	Occurs on the Boschberg from 1 300–1 400 m in Amathole Montane Grassland, and on the Oudeberg in Karoo Escarpment Grassland. Locally common on the Boschberg.	Hilliard and Burtt, 1991; McMaster, 2007a.
Erica passerinoides (Bolus) E.G.H.Oliv.	Ericaceae	Bolus H 2582*, Koudeveldberge–Toorberg, 1872.	Recollected by E.G.H. Oliver in 2004 at the same locality. Endemic to the Toorberg plateau, Karoo Escarpment Grassland.	Oliver, pers. comm.
Euryops dentatus B.Nord.	Asteraceae	Tyson W 295*, Koudeveldberge, 1879. Tyson W 5761*, Murraysburg District, 1881. Clark VR, Pienaar C 381, Koudeveldberge, 1 600–1 800 m, December 2007. Clark VR, Crause I 127, Kamdebooberge, 1 421 m, April 2008. Clark VR, Pienaar C 618, Kamdebooberge, 1 403 m, June 2008.	Recollected on the southern and eastern slopes of the Koudeveldberge and Toorberg in December 2007 and on the Kamdebooberge in April and June 2008. Locally abundant in Karoo Escarpment Grassland and fynbos.	Nordenstam, 1969; Nordenstam, pers. comm.
Euryops exsudans B.Nord. & V.R.Clark	Asteraceae	Palmer AR 2938, MZNP, November 1980. Clark VR, Coombs G 110, E of Nardousberg (Asante Sana Private Game Reserve), 1 900 m, December 2005. McKenzie RJ, Weston P, Clark VR 175, as above, 1 877 m, March 2006. Clark VR, Ramdhani S 453, as above, 1 600 m, November 2006. Clark VR, Pienaar C 118, Wapadsberg, 2 109 m, December 2007. Clark VR, Crause I 54, Nardousberg ridge (Asante Sana Private Game Reserve), 1 919 m, April 2008.	First known record is from the Bankberg in MZNP. Occurs on the Sneeuberg E of Nardousberg, 1 800–2 100 m, and on the Wapadsberg at 2 000 m in Karoo Escarpment Grassland. Locally abundant.	Nordenstam et al., 2009; Nordenstam, pers. comm.

Euryops proteoides B.Nord. & V.R.Clark	Asteraceae	Clark VR, Coombs G 105, E of Nardousberg (Asante Sana Private Game Reserve), 2 014 m, December 2005. Clark VR, Ramdhani S 452, as above, November 2006. Clark VR, Coombs G 553, Sneeuberg behind Pearston, 1 300–2 000 m. Clark VR, Crause I 40, 55, E of Nardousberg (Asante Sana Private Game Reserve), 1 650–1 919 m, April 2008.	Occurs on the Sneeuberg–Tandjiesberg–Coetzeesberg behind Pearston, from 1 300–2 100 m along streams and in moist Karoo Escarpment Grassland. Locally abundant.	Nordenstam et al., 2009; Nordenstam, pers. comm.
Faurea sp. nov. 1	Proteaceae	Clark VR, Crause I 106, Kamdebooberge, 1 396 m, April 2008. Clark VR, Pienaar C 609, Kamdebooberge, 1 403 m, June 2008.	Only known from one population in the Kamdebooberge, behind Aberdeen, at 1 400 m in dense fynbos. Locally abundant.	Rourke, pers. comm.
Gazania caespitosa Bolus	Asteraceae	Bolus H 2578*, Koudeveldberge, 1872. Clark VR, Ramdhani S 448, Sneeuberg E of Nardousberg, 2 115 m, November 2006. Clark VR, Te Water Naudé T 235, 307, Toorberg–Koudeveldberg–Meelberg, 2 000–2 100 m, November 2006. Clark VR, Crause I 46, Nardousberg ridge, 2 171 m, April 2008. Clark VR, Crause I 182, Kamdebooberge, 1 614 m, April 2008.	Locally abundant on the Toorberg–Koudeveldberg–Meelberg above 1 800 m. Range extension to the E of the Nardousberg where locally abundant. Also common on the Kamdebooberge.	Howis, pers. comm.
Haworthia marumiana var. *batesiana* (Uitewaal) M.B.Bayer	Asphodelaceae	Clark VR, Crause I 275, Kamdebooberge, 1 614m, April 2008. Clark VR, O'Connor R, Kamdebooberge, 1 200 m, September 2008.	Valley of Desolation and Tandjiesberg (Graaff-Reinet); now also collected from the Kamdebooberge behind Aberdeen where abundant. Occurs in Camdeboo Escarpment Thicket. (Note: listed by Rubin et al., 2001 as occurring in the Nuweveldberge but the taxonomy of this species is difficult; distribution here as per Bayer, pers. comm.).	Bayer, pers. comm.; Dold pers. comm.

Hermannia sneeubergensis MS D.Gwynne-Evans & V.R.Clark	Sterculiaceae	Clark VR, Barker NP, Devos N 7, E of Nardousberg (Asante Sana Private Game Reserve), 1 600 m, October 2005. Clark VR, Coombs G 141, 212, 336, as above, above 1 800 m, December–January 2005–2006. Clark VR, McKenzie RJ 196, 442, Blinkberg, 2 090 m, March 2007. Clark VR, Ramdhani S 371, Sneeuberg behind Pearston, 1 350m, October 2006. Clark VR, Ramdhani S 431, E of Nardousberg (Asante Sana Private Game Reserve), 1 900 m, November 2006.	Abundant from the Nardousberg to Aasvoëlkrans (Pearston), above 1 800 m.	Gwynne-Evans, pers. comm.
Hermannia crassifolia MS D.Gwynne-Evans	Sterculiaceae	Collected by D. Gwynne-Evans, 2006. Clark VR, Andrews A 200, Waainek Road, Boschberg, 1 185 m, November 2008.	Boschberg.	Gwynne-Evans, pers. comm.
Hesperantha helmei Goldblatt & J.C.Manning	Iridaceae	Helme NA 1134, Nardousberg, 2 300 m, 2004. Clark VR, TeWater Naudé T 266, Toorberg, 2 017 m, November 2006.	Known from the Nardousberg and from the Toorberg.	Goldblatt and Manning, 2007; Goldblatt, pers. comm.
Huernia kennedyana Lavranos	Apocynaceae	Collected by H.W. James in 1930, H.C. Kennedy in 1964 and P.V. Bruyns in 1977.	Only known from the Farm Welgemoed, north of the Bankberg on a "flat mountain top".	Brodie, 1998; Bruyns, 2005.
Indigofera sp. nov. 1	Fabaceae	Clark VR, Te Water Naudé T 335, Toorberg–Koudeveldberge–Meelberg, 2 100 m, November 2006. Clark VR, Pienaar C 511, Toorberg, 1 780 m, December 2007.	Summit plateau of the Toorberg–Koudeveldberge–Meelberg. Locally common on summit turf soils.	Schrire, pers. comm.
Indigofera sp. nov. 2	Fabaceae	Clark VR, Coombs G 208, E of Nardousberg (Asante Sana Private Game Reserve), 1 853 m, December 2005. Clark VR, Coombs G 635, Sneeuberg behind Pearston, 1 950 m, December 2006.	Mountain slopes and summit plateau above 1 700 m, Sneeuberg E of Nardousberg. Locally abundant.	Schrire, pers. comm.
Kniphofia acraea Codd	Asphodelaceae	McKenzie RJ, Weston P, Clark VR 1, Swaershoek Pass, 1 590 m, 2006.	Occurs on the Bankberg and Boschberg, in Karoo Escarpment Grassland and Amathole Montane Grassland. Locally abundant.	Dold and McMaster, 2005; Ramdhani, pers. comm.

Ornithogalum sp. nov. 1 aff. *flexuosum* (Thunb.) U. & D.Müll.-Doblies	Hyacinthaceae	Clark VR, Rose M 498, Blinkberg, 2 125 m, December 2007. Clark VR, Pienaar C 414, mid-plateau SE of Koudeveldberge, 1 495 m, December 2007.	Locally common on rocky plateau areas near Koudeveldberge and E of the Nardousberg. Possibly throughout the Sneeuberg.	Manning, pers. comm.
Selago bolusii Rolfe	Scrophulariaceae	Bolus H 695*, Graaff-Reinet, sine anno.	Occurs on the mountains around Graaff-Reinet. Numerous specimens which fit Hilliard's (1999) description have been collected since 2005, but verification of their status would be preferable; in the interim these specimens have been named *S.* cf. *bolusii*.	Hilliard, 1999.
Selago crassifolia (Rolfe) Hilliard	Scrophulariaceae	Tyson W 177*, Sneeuberg, Murraysburg District, 1879.	Only know from the type (possibly from the Koudeveldberge).	Hilliard, 1999.
Selago retropilosa Hilliard	Scrophulariaceae	Hilliard OM, Burtt BL 10651*, Lootsberg, 1977. Clark VR, Te Water Naudé T 100, Koudeveldberge, 1 900 m, November 2006. Clark VR, McKenzie RJ 144, NW of Compassberg, 2 080 m, February 2007. Clark VR, McKenzie RJ 367, Blinkberg, 1 850 m, March 2007.	Previously only known from the type. Recollected throughout the Sneeuberg. Common at higher altitudes.	Hilliard, 1999.
Syringodea pulchella Hook.f.	Iridaceae		Occurs between Middelburg and Graaff-Reinet, and on the Boschberg and Renosterberg.	De Vos, 1983.
Trichodiadema olivaceum L.Bolus	Mesembryanthe-maceae		Somerset East (Camdeboo Escarpment Thicket and grassland). Poorly known.	Dold, pers. comm.; Burgoyne, pers. comm.

2.4.3. Links with the Sneeuberg Centre of Endemism

a) Sneeuberg–Albany Centre links

The thicket vegetation units of the Sneeuberg can comfortably be assigned to the Albany Centre given that they are geographically continuous with thicket in the core of the Albany Centre, and that several endemics such as *Adromischus fallax* and *Haworthia marumiana* var. *batesiana* are confined to these vegetation units in the Sneeuberg.

b) Sneeuberg–southern Great Escarpment links

Twenty-one (1.8%) Sneeuberg near-endemic species (Table 2.3) are shared with adjacent sections of the southern Great Escarpment, i.e. the Nuweveldberge, Stormberg and the Great Winterberg–Amatolas. However, as the floras of these adjacent mountain ranges are poorly known the values given here may well change following further botanical exploration.

c) Sneeuberg–DAC links

Five species considered by Carbutt and Edwards (2006) to be DAC endemics have now been recorded from the Sneeuberg (Table 2.4). These are *Pentzia tortuosa* (previously collected in the Sneeuberg by Harry Bolus), *Senecio dissimulans*, *Ehrharta longigluma*, *Asclepias humilis* and *Isolepis angelica* (Fish, pers. comm.; Bester, pers. comm.; Muasya, pers. comm.). Along with *Albuca* cf. *rupestris* (Manning, pers. comm.) this places DAC endemics at 0.5% of the Sneeuberg flora.

Links between the Sneeuberg and the DAC are further supported by the presence of *Euryops proteoides*, which is morphologically very similar to the DAC endemic *E. evansii* (Nordenstam et al., 2009), and *Erica* sp. aff. *reenensis*, *E. reenensis* being endemic to the north-western face of the Drakensberg Massif (Oliver, pers. comm.). In addition, 105 of Carbutt and Edwards's (2006) DAC near-endemics (17.6% of the DAC near-endemics and 8.8% of the Sneeuberg flora) have been recorded from the Sneeuberg (Table 2.5). Only 16 of these have the Boschberg as their western limit, the rest being found throughout most of the Sneeuberg and a few across the Nelspoort Interval to the Nuweveldberge. Several other Afromontane range extensions (not specifically DAC) into the Sneeuberg have been recorded e.g. *Moraea spathulata* (Manning, pers. comm.; Table 2.4).

The floristic composition indicates that the Sneeuberg is definitely part of the Afromontane belt in southern Africa. There is an indication that the Sneeuberg above 1 800 m may be a drier, western

Table 2.3: Species endemic to the Sneeuberg mountain complex and to one or more of the adjacent sections of the Great Escarpment i.e. the Stormberg, Great Winterberg–Amatolas and/or Nuweveldberge.

Species	**Family**	**Details**	**References**
Alepidea macowani Dummer	Apiaceae	Sneeuberg, Great Winterberg–Amatolas.	Mucina and Rutherford, 2006; Winter, pers. comm.
Bergeranthus nanus A.P.Dold & S.A.Hammer	Mesembryanthe-maceae	Sneeuberg, Great Winterberg–Amatolas.	Dold et al., 2005; Dold, pers. comm.
Cineraria vagans Hilliard	Asteraceae	Sneeuberg, Great Winterberg–Amatolas.	Hilliard and Burtt, 1988.
Clutia impedita Prain	Euphorbiaceae	Appears to be an endemic from the Stormberg, Great Winterberg–Amatolas and Sneeuberg.	
Crassula exilis subsp. *cooperi* (Regal) Tölken.	Crassulaceae	Sneeuberg, Stormberg.	Tölken, 1977.
Delosperma concavum L.Bolus	Mesembryanthemaceae	Sneeuberg, Nuweveldberge.	Hartmann, 2001a.
Erica brownleeae Bolus	Ericaceae	Boschberg, Great Winterberg–Amatolas.	Baker and Oliver, 1967.
Euryops galpinii Bolus	Asteraceae	Sneeuberg, Stormberg, Great Winterberg–Amatolas.	Nordenstam, 1969.
Euryops trilobus Harv.	Asteraceae	Sneeuberg, Stormberg.	Nordenstam, 1969.
Ficinia compasbergensis Drège	Cyperaceae	Sneeuberg, Nuweveldberge.	Muasya, pers. comm.; Sonnenberg, pers. comm.. See also Chapter 4.
Garuleum tanacetifolium (MacOwan) Norl.	Asteraceae	Sneeuberg, Boschberg, Great Winterberg–Amatolas.	Norlindh, 1943.
Helichrysum tysonii Hilliard	Asteraceae	Sneeuberg, Nuweveldberge and possibly Roggeveldberge.	Hilliard, 1983. See also Chapters 4 and 5.
Hermannia violacea (Burch. ex DC.) K.Schum.	Sterculiaceae	Boschberg, Great Winterberg–Amatolas.	Gwynne-Evans, pers. comm.
Huernia piersii N.E.Br.	Apocynaceae	Sneeuberg, Great Winterberg–Amatolas, Stormberg.	Bruyns, 2005.
Jamesbrittenia crassicaulis (Benth.) Hilliard	Scrophulariaceae	Sneeuberg, Bamboesberge, Wildeschutsberg, Andriesberg (Stormberg).	Hilliard, 1994.

Species	**Family**	**Details**	**References**
Lessertia sneeuwbergensis Germish.	Fabaceae	Sneeuberg, Nuweveldberge.	Germishuizen, 1992. See also Chapter 4.
Lotononis caerulescens (E.Mey.) B.-E.van Wyk	Fabaceae	Stormberg, Great Winterberg–Amatolas, Sneeuberg, Nuweveldberge.	Van Wyk, 1988, 1991. See also Chapter 4.
Polemannia grossulariifolia Eckl. & Zeyh.	Apiaceae	Sneeuberg, Great Winterberg–Amatolas.	Winter, pers. comm.
Ruschia complanata L.Bolus	Mesembryanthemaceae	Sneeuberg, Nuweveldberge.	Burgoyne, pers. comm.. See also Chapter 4.
Wahlenbergia laxiflora (Sond.) Lammers	Campanulaceae	Boschberg, Katberg (Great Winterberg).	Adamson, 1955b.

Table 2.4: Additional significant rediscoveries and range extensions recorded in the Sneeuberg mountain complex during the study period (2005–2009).

Species	Family	Collection records	Notes	References
Agathosma cf. *capensis* (L.) Dummer	Rutaceae	Clark VR, Crause I 229, Kamdebooberge, 1 606 m, April 2008.	*A. capensis* is one of the most widely distributed species in the CFR. Range extension of ca. 150 km from the CFR onto the Kamdebooberge where locally common. Possibly a new species.	Pillans, 1950; Trinder-Smith, pers. comm.
Agathosma venusta (Eckl. & Zeyh.) Pillans	Rutaceae	Clark VR, Te Water Naudé T 280, Toorberg–Meelberg–Koudeveldberge, 2 050–2 200 m, November 2006. Clark VR, Pienaar C, Toorberg, 1 600–1 850 m, December 2007. Clark VR, Crause I 201, Kamdebooberge, 1 300–1 600 m, April 2008.	This is a CFR species with an outlying population in the western Sneeuberg. The species was previously collected on the Koudeveldberge in 1872 by H. Bolus and also by W. Tyson in the same area. Locally abundant on the moist Escarpment slopes of the Toorberg and Kamdebooberge, and on the summit of the Toorberg, Meelberg and Koudeveldberge.	Pillans, 1950; Trinder-Smith, pers. comm.
Asclepias humilis (E.Mey.) Schltr.	Apocynaceae	Clark VR, Coombs G 205, E of Nardousberg (Asante Sana Private Game Reserve), 1 850 m, December 2005. Clark VR, Coombs G 604, 609, Sneeuberg behind Pearston, 2 029 m, December 2006. Clark VR, McKenzie RJ 267, Blinkberg, 2 000 m, March 2007.	A DAC endemic (98% of records for this species are in the DAC). Common above 2 000 m in the eastern sections of the Sneeuberg. Locally common. A range extension of ca. 300 km.	Carbutt and Edwards, 2006; Bester, pers. comm.
Conium sp. no. 3 (Hilliard & Burtt, 1985b)	Apiaceae	Clark VR, Crause I 69, E of Nardousberg (Asante Sana Private Game Reserve), 1 919 m, April 2008.	Known from Underberg (KZN), the Eastern Cape Drakensberg and the Amatolas. According to Stratton (pers. comm.) possibly part of *Conium fontanum* Hilliard & B.L.Burtt complex. A range extension of ca. 200 km onto the Sneeuberg E of the Nardousberg.	Hilliard and Burtt, 1985b; Stratton, pers. comm.; Winter, pers. comm.

Species	Family	Collection records	Notes	References
Corycium flanaganii (Bolus) Kurzweil & H.P.Linder	Orchidaceae	Clark VR, Ramdhani S 206, Sneeuberg behind Pearston, 1 800 m, October 2006. Clark VR, Rose M 464, Blinkberg, 2 075 m, December 2007. Clark VR, Pienaar C 44, Wapadsberg, 2 148 m, December 2007.	A DAC near-endemic. A range extension of ca. 200 km from the Stormberg to the Sneeuberg. Common in high altitude turf marshlands above 1 700 m on Sneeuberg E of Nardousberg and on the Wapadsberg.	Linder and Kurzweil, 1999; Carbutt and Edwards, 2006; Bellstedt, pers. comm.
Disa harveiana Lindl. subsp. *harveiana*	Orchidaceae	Clark VR, Te Water Naudé T 305, Meelberg, 2 100 m, November 2006.	Endemic to the mountains of the CFR. A range extension of ca. 150 km from the Swartberg and Outeniquas across the Karoo Interval to the Meelberg.	Linder and Kurzweil, 1999; Bellstedt, pers. comm.
Ehrharta longigluma C.E.Hubb.	Poaceae	Clark VR, Coombs G 189, E of Nardousberg (Asante Sana Private Game Reserve), 2 000 m, December 2005.	A DAC endemic. This is a range extension of ca. 400 km. Common above 2 000 m on the Sneeuberg E of Nardousberg.	Carbutt and Edwards, 2006; Fish, pers. comm.
Garuleum tanacetifolium (MacOwan) Norl.	Asteraceae	Clark VR, Coombs G 703, E of Nardousberg (Asante Sana Private Game Reserve), 1 830 m, October 2008. Clark VR, Coombs G 1057, Boschberg, 1 330 m, November 2008.	Endemic to the Great Winterberg–Amatolas and Boschberg. Now also known as far W as the Nardousberg.	Norlindh, 1943.
Geranium cf. *brycei* N.E.Br.	Geraniaceae	Weston P, McKenzie RJ, Clark VR 144, E of Nardousberg (Asante Sana Private Game Reserve), 1 887 m, March 2006. Clark VR, Ramdhani S 35, Sneeuberg behind Pearston, 1 813 m, October 2006. Clark VR, Te Water Naudé T 192, Koudeveldberge, 1 800 m, November 2006. Clark VR, Coombs G 647, Sneeuberg behind Pearston, 1 950 m, December 2006. Clark VR, McKenzie RJ 212, Blinkberg, 2 050 m, March 2007. Clark VR, Pienaar C 480, Toorberg, 1 860 m, December 2007.	*G. brycei* is a DAC near-endemic from the KZN and E. Cape Drakensbergs, Witteberg and Lesotho Highlands, and one record from near Cathcart. The Sneeuberg species occurs throughout the Sneeuberg above 1 800 m and is common. Sneeuberg specimens match well with specimens of *G. brycei*. A range extension of ca. 100–200 km.	Hilliard and Burtt, 1985a; Carbutt and Edwards, 2006; Dreyer, pers. comm.

Species	Family	Collection records	Notes	References
Haplocarpha nervosa (Thunb.) Beauverd	Asteraceae	Clark VR, Te Water Naudé T 232, Toorberg, 2 000 m, November 2006. Clark VR, McKenzie RJ 236, Blinkberg, 2 064 m, March 2007. Clark VR, Pienaar C 468, Toorberg, 1 834 m, December 2007.	Found from the Cape Peninsular along the moister eastern mountains to Zimbabwe. Not previously recorded in the Sneeuberg. Locally common in upland seeps and wetlands.	Hilliard, 1977; McKenzie, pers. comm.
Haplocarpha scaposa Harv.	Asteraceae	Clark VR, Coombs G 365, E of Nardousberg (Asante Sana Private Game Reserve), 2 000 m, January 2006. Clark VR, Ramdhani S 272, Sneeuberg behind Pearston, ca. 1 600 m, October 2006. Clark VR, McKenzie RJ 395, Blinkberg, 1 870 m, March 2007.	Known from Uitenhage and Somerset East to the moister central and eastern provinces of South Africa (and northwards). This is a range extension onto the Sneeuberg-proper as far W as the Nardousberg. It is common in montane grassland above 1 800 m.	Hilliard, 1977; McKenzie, pers. comm.
Isolepis angelica B.L.Burtt	Cyperaceae	Clark VR, Te Water Naudé T 296, Toorberg, 1 879 m, November 2006.	A DAC endemic. Recorded in seeps on the Toorberg, a range extension of ca. 400 km.	Sonnenberg, 1993; Carbutt and Edwards, 2006; Muasya, pers. comm.
Kniphofia baurii Baker	Asphodelaceae	Clark VR, McKenzie RJ 47, NW of Compassberg, 1 650 m, February 2007.	A range extension of ca. 300 km from the former Transkei to near the Compassberg: one colony recorded in a wetland at the base of the Muishoekberge.	Codd, 1968; Ramdhani, pers. comm.
Kniphifia caulescens Baker	Asphodelaceae	Clark VR, Te Water Naudé T135, Koudeveldberge, 1 900 m, November 2006. Clark VR, Crause I 269, Kamdebooberge, 1 710 m, April 2008.	A range extension of ca. 200 km from the Great Winterberg onto the Toorberg and Kamdebooberge. Locally abundant on the Kamdebooberge.	Codd, 1968; Ramdhani, pers. comm.

Species	Family	Collection records	Notes	References
Moraea spathulata (L.f.) Klatt	Iridaceae	Clark VR, Coombs G 155, E of Nardsousberg (Asante Sana Private Game Reserve), 1 800 m, December 2005. Clark VR, Ramdhani S 113, Sneeuburg behind Pearston, 1 723 m, October 2006. Clark VR, Te Water Naudé T 25, Koudeveldberge, 1 879 m, November 2006. Clark VR, McKenzie RJ 480, Blinkberg, 2 009 m, March 2007.	A range extension of 100–200 km from the Great Winterberg–Amatolas to throughout the Sneeuberg. Locally abundant above 1 800 m.	Goldblatt, pers. comm.; Manning, pers. comm.
Nemesia umbonata (Hiern) Hilliard & B.L.Burtt	Scrophulariaceae	Clark VR, Coombs G 196, 198, 207, Sneeuberg E of Nardousberg, 1 800–2 000 m, December 2005. Clark VR, Devos N, McKenzie RJ 34, Compassberg, 2 200 m, February 2006. Clark VR, Ramdhani S 217, Sneeuberg behind Pearston, 1 700 m, October 2006. Clark VR, Ramdhani S 441, Sneeuberg E of Nardousberg, 1 900 m, November 2006. Clark VR, McKenzie RJ 311, 335, Blinkberg, 1 883 m, March 2007.	A range extension of 100–200 km from the Great Winterberg–Amatolas to throughout the Sneeuberg. Common above 1 800 m. Identifications confirmed by E. Brink	Brink, pers. comm.
Otholobium macradenium (Harv.) C.H.Stirt.	Fabaceae	Clark VR, Barker NP, Devos N 30, E of Nardsousberg (Asante Sana Private Game Reserve), 1 400 m, October 2005. Clark VR, Te Water Naudé T 82, Koudeveldberge, 1 600 m, November 2006. Clark VR, Coombs G 645, Sneeuberg behind Pearston, 1 350 m, December 2006. Clark VR, Rose M 60, Sneeuberg behind Pearston, 1 472 m, November 2007. Clark VR, Pienaar C 617, Kamdebooberge, 1 283 m, June 2008.	This is a range extension of 150–250 km across the Karoo Interval from the CFR (Swartberg and Kouga/Baviaanskloofberge). The species is abundant on the southern scarps both E and W of Graaff-Reinet from 1 300–1 600 m. The species was previously last collected in the CFR in 1986.	Stirton, pers. comm.

Species	Family	Collection records	Notes	References
Passerina montana Thoday	Thymelaceae	Clark VR, Ramdhani S 205, Sneeuberg behind Pearston, 1 805 m, October 2006. Clark VR, Ramdhani S 443, E of Nardousberg, 2 120 m, November 2006.	In South Africa throughout the eastern sections of the Great Escarpment. A range extension of ca. 100–200 km onto the Sneeuberg.	Bredenkamp and Van Wyk, 2003.
Perlargonium laevigatum (L.f.) Willd.	Geraniaceae	Clark VR, Crause I 194, Kamdebooberge, 1 614 m, April 2008.	Essentially a CFR species but also known from the Boschberg. Now recorded from the Kamdebooberge, where common.	Van der Walt et al., 1981.
Pimpinella caffra (Eckl. & Zeyh.) D.Dietr.	Apiaceae	Clark VR, Crause I 12, E of Nardousberg (Asante Sana Private Game Reserve), 2 012 m, April 2008. Clark VR, Crause I 62, Nardousberg ridge (Asante Sana Private Game Reserve), 2 220 m, April 2008.	Occurs from the KZN Drakensberg and Lesotho Highlands to the Amatolas. Range extension of ca. 120 km onto the Sneeuberg as far W as the Nardousberg.	Winter, pers. comm.
Rhodocoma capensis Steud.	Restionaceae	Clark VR, Crause I 268, Kamdebooberge, 1 606 m, April 2008. Clark VR, Pienaar C 614, Kamdebooberge 1 403 m, June 2008.	Occurs along the more arid inland edges of the CFR mountains. A range extension of ca. 150 km from the CFR onto the Kamdebooberge. Locally abundant.	Linder, 1985.
Schoenoxiphium sp. aff. *basutorum* Turrill	Cyperaceae	Clark VR, Te Water Naudé T 234, Toorberg, 2 200 m, November 2006. Clark VR, Te Water Naudé 340, Koudeveldberge, 1 780 m, November 2006.	*S. basutorum* is a DAC near-endemic (ca. Free State and Lesotho). The Sneeuberg specimens would be a range extension of ca. 400–500 km, or a new species.	Carbutt and Edwards, 2006; Muasya, pers. comm.

Species	Family	Collection records	Notes	References
Senecio arenarius Thunb.	Asteraceae	Clark VR, Coombs G 414, Groot Suurkop (Asante Sana Private Game Reserve), 1 900 m, January 2006. Clark VR, Ramdhani S 446, Sneeuberg E of Nardousberg (Asante Sana Private Game Reserve), 1 900 m. Clark VR, Coombs G 524, Sneeuberg behind Pearston, 1 300 m, December 2007. Clark VR, Rose M 453, Blinkberg, 2 014 m, December 2007. Clark VR, Crause I 159, Kamdebooberge, 1 421 m, April 2008.	A West Coast/western CFR species, but Sneeuberg specimens are virtually indistinguishable except for both rays and discs being purple. Found on the Kamdebooberge and E of the Nardousberg where locally abundant. Possibly a new variety or subspecies. A range extension of ca. 300 km.	Manning, 2007; Brink, pers. comm.
Senecio dissimulans Hilliard	Asteraceae	Clark VR, Rose M 481, Blinkberg, 2 005 m, December 2007.	A DAC endemic. Locally common on the southern, wet slopes of the Blinkberg (E of Nardousberg). A range extension of ca. 400 km.	Pooley, 2003; Carbutt and Edwards, 2006.

Table 2.5: Drakensberg Alpine Centre near-endemics recorded in the Sneeuberg mountain complex. Near-endemic status as per Carbutt and Edwards (2006). "Boschberg" indicates species confined within the Sneeuberg mountain complex to the Boschberg and the Groot-Bruintjieshoogde. Appendix 2 should be referred to for collection details/references.

Species	**Location**
Aloe aristata Haw.	Sneeuberg (also west along the Great Escarpment).
Aloe striatula Haw. var. *striatula*	Sneeuberg.
Anthospermum monticola Puff	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Asparagus microraphis (Kunth) Baker	Sneeuberg.
Athrixia angustissima DC.	Sneeuberg.
Brachypodium bolusii Stapf	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Brunsvigia grandiflora Lindl.	Sneeuberg.
Cineraria aspera Thunb.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Cineraria geraniifolia DC.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Cineraria mollis E.Mey. ex DC.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Corycium flanaganii (Bolus) Kurzweil & H.P.Linder	Sneeuberg (also west along the Great Escarpment).
Cotula hispida (DC.) Harv.	Sneeuberg.
Craterocapsa montana (A.DC.) Hilliard & B.L.Burtt	Sneeuberg.
Cysticapnos pruinosa (Bernh.) Lidén	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Dierama robustum N.E.Br.	Sneeuberg.
Empodium elongatum (Nel) B.L.Burtt	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Erica alopecurus Harv. var. *alopecurus*	Boschberg.
Erica caespitosa Hilliard & B.L.Burtt	Sneeuberg.
Erica caffrorum Bolus var. *caffrorum*	Sneeuberg.
Euclea coriacea A.DC.	Sneeuberg.
Euryops annae E.Phillips	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Euryops candollei Harv.	Sneeuberg.

Species	**Location**
Euryops oligoglossus DC. subsp. *oligoglossus*	Sneeuberg.
Felicia rosulata Yeo	Sneeuberg.
Festuca longipes Stapf	Boschberg.
Geranium cf. *brycei* N.E.Br.	Sneeuberg.
Geranium magniflorum R.Knuth	Boschberg.
Geranium multisectum N.E.Br.	Sneeuberg.
Geum capense Thunb.	Sneeuberg.
Gladiolus mortonius Herb.	Boschberg.
Glekia krebsiana (Benth.) Hilliard	Sneeuberg.
Gnidia polyantha Gilg.	Sneeuberg.
Guthriea capensis H.Bolus	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Gymnopentzia bifurcata Benth.	Sneeuberg.
Helichrysum albo-brunneum S.Moore	Sneeuberg.
Helichrysum anomalum Less.	Sneeuberg.
Helichrysum cooperi Harv.	Sneeuberg.
Helichrysum grandibracteatum M.D.Hend.	Boschberg.
Helichrysum melanacme DC.	Sneeuberg.
Helichrysum montanum DC.	Sneeuberg.
Helichrysum nanum Klatt	Boschberg.
Helichrysum psilolepis Harv.	Sneeuberg.
Helichrysum scitulum Hilliard & B.L.Burtt	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Helichrysum sessile DC.	Sneeuberg.
Helichrysum trilineatum DC.	Sneeuberg (also west along the Great Escarpment).
Helictotrichon longifolium (Nees) Schweick.	Sneeuberg.

Species	**Location**
Hyobanche rubra N.E.Br.	Sneeuberg.
Indigofera cuneifolia Eckl. & Zeyh. var. *cuneifolia*	Sneeuberg.
Inulanthera dregeana (DC.) Källersjö	Boschberg.
Jamesbrittenia filicaulis (Benth.) Hilliard	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Kniphofia caulescens Baker	Sneeuberg.
Kniphofia stricta Codd	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Kniphofia triangularis Kunth subsp. *triangularis*	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Lobelia preslii A.DC.	Sneeuberg.
Lotononis divaricata (Eckl. & Zeyh.) Benth.	Boschberg.
Lotononis pulchella (E.Mey.) B.-E.van Wyk	Boschberg.
Lotononis sericophylla Benth.	Sneeuberg.
Manulea crassifolia Benth. subsp. *crassifolia*	Sneeuberg.
Massonia echinata L.f.	Sneeuberg.
Melolobium obcordatum Harv.	Sneeuberg.
Merxmuellera macowanii (Stapf) Conert	Sneeuberg.
Moraea huttonii (Baker) Oberm.	Boschberg.
Muraltia saxicola Chodat	Sneeuberg.
Nemesia albiflora N.E.Br.	Sneeuberg.
Nemesia umbonata (Hiern) Hilliard & B.L.Burtt	Sneeuberg.
Nerine angustifolia (Baker) Baker	Boschberg.
Nidorella agria Hilliard	Sneeuberg.
Ornithogalum paludosum Baker	Boschberg.
Pachycarpus vexillaris E.Mey.	Sneeuberg.
Pelargonium aridum R.A.Dyer	Sneeuberg (Kikvorsberg).

Species	**Location**
Pelargonium griseum R.Knuth	Sneeuberg.
Pelargonium leucophyllum Turcz.	Boschberg.
Pelargonium ranunculophyllum (Eckl. & Zeyh.) Baker	Sneeuberg.
Pentaschistis airoides subsp. *jugorum* (Stapf) H.P.Linder	Sneeuberg.
Pentaschistis setifolia (Thunb.) McClean	Sneeuberg.
Pentzia cooperi Harv.	Sneeuberg.
Phygelius capensis E.Mey. ex Benth.	Sneeuberg.
Rhus bolusii Sond. ex Engl.	Sneeuberg.
Rhus divaricata Eckl. & Zeyh.	Sneeuberg.
Rhus dregeana Sond.	Sneeuberg.
Rhus erosa Thunb.	Sneeuberg.
Rhus krebsiana C.Presl ex Engl.	Sneeuberg.
Romulea macowanii Baker var. *macowanii*	Sneeuberg.
Rumex woodii N.E.Br.	Boschberg.
Ruschia putterillii (L.Bolus) L.Bolus	Sneeuberg (also the Roggeveld; see Chapter 5).
Schizoglossum bidens E.Mey. subsp. *bidens*	Sneeuberg.
Schoenoxiphium schweickerdtii Merxm. & Podlech	Sneeuberg.
Sebaea thomasii (S.Moore) Schinz	Sneeuberg.
Selago saxatilis E.Mey.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Senecio gramineus Harv.	Sneeuberg.
Senecio harveianus MacOwan	Sneeuberg.
Senecio hieracioides DC.	Sneeuberg.
Senecio hypochoerideus DC.	Boschberg.
Senecio napifolius MacOwan	Boschberg.

Species	**Location**
Senecio polyodon var. *subglaber* (O.Hoffm. ex Kuntze) Hilliard & B.L.Burtt	Sneeuberg.
Senecio tanacetopsis Hilliard	Sneeuberg.
Stachys cymbalaria Briq.	Sneeuberg.
Stachys dregeana Benth.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Stachys linearis Burch. ex Benth.	Sneeuberg (also west along the Great Escarpment to the Nuweveldberge).
Troglophyton capillaceum subsp. *diffusum* (DC.) Hilliard	Sneeuberg.
Wahlenbergia krebsii Cham. subsp. *krebsii*	Sneeuberg.
Wurmbea cf. *elatior* B.Nord.	Sneeuberg.
Zaluzianskya glareosa Hilliard & B.L.Burtt	Sneeuberg and (possibly) the Nuweveldberge.
Zaluzianskya schmitziae Hilliard & B.L.Burtt	Sneeuberg.
Zaluzianskya spathacea (Benth.) Walp.	Boschberg.

limit of an extended DAC comparable to the Witteberg section of the DAC, to which Carbutt and Edwards (2001) consider the Sneeuberg floristically similar. This link is supported by Nordenstam's (1969) "Sneeuwbergen Centre" (representing near-endemics shared by the Sneeuberg with its montane neighbours) and by Mucina and Rutherford's (2006) concept of the DAC.

The similarities between the Sneeuberg's high-altitude montane wetlands above 1 800 m (consisting of headwater sponges, rainwater pools, seeps, streams and floodplains) with Mucina and Rutherford's (2006) Drakensberg Wetlands further indicates links with the DAC. This is supported by the local dominance of *Haplocarpha nervosa* and the presence of other of Mucina and Rutherford's (2006) Drakensberg Wetlands Important Taxa e.g. *Wurmbea* cf. *elatior*, *Carex cognata* var. *cognata*, *Isolepis costata*, *Trifolium burchellianum* subsp. *burchellianum*, *Juncus dregeanus* subsp. *dregeanus* etc., and the presence of the DAC endemic *Isolepis angelica* (considered to be endemic to Mucina and Rutherford's, 2006, Lesotho Mires unit). Woody Drakensberg Wetlands Important Taxa in the Sneeuberg include *Buddleja salviifolia*, *Leucosidea sericea*, *Geranium* spp. and *Phygelius capensis*, although species such as *Cyathea dregei* Kunze are absent.

Biogeographical connections between the Sneeuberg and the DAC are relatively easy to explain. There is an almost continuous montane bridge between the Sneeuberg and the DAC via the Kikvorsberge and Suurberg onto the Stormberg and then across to the DAC (Fig. 2.1). The "Great Fish River Interval" between the Boschberg and Great Winterberg is also not that significant as many Afromontane species common in the moister areas of South Africa also occur on the Boschberg. Particular links between the DAC and Sneeuberg are likely explained by the Sneeuberg's overall high altitude, cold climate, massive dolerites producing turf clays analogous to those from basalt, and an amplification of altitude where the Sneeuberg runs parallel to latitude (Steele et al., 1998). The fragmentation of the southern Great Escarpment west of the Witteberg has been enough however to encourage local endemism on the Sneeuberg and Great Winterberg–Amatolas.

d) Sneeuberg–CFR links

It can be stated fairly certainly that no CFR-endemic families occur in the Sneeuberg. The alleged presence of two CFR-endemic families (Peneaceae and Grubbiaceae) on the Bankberg in the MZNP (Pond et al., 2002) created much interest after being mentioned in a popular article (Clark and Barker, 2006). Further investigation into their presence revealed that the data had been incorrectly grid-referenced in PRECIS from the Cradockberg behind George, Western Cape.

Nine CFR species are found in the Sneeuberg (*Rhodocoma capensis*, *Protea lorifolia*, *Senecio arenarius*, *Disa harveiana* subsp. *harveiana*, *Otholobium macradenium*, *Agathosma venusta*, *A.* cf.

capensis, *Cliffortia montana* and *Pelargonium laevigatum*; Bellstedt, pers. comm.; Stirton, pers. comm.; Trinder-Smith, pers. comm.; Whitehouse, pers. comm.) representing 0.8% of the Sneeuberg flora. In addition, and particularly interesting, is the range extension of the CFR-endemic genus *Acmadenia* onto the Kamdebooberge as *Acmadenia* sp. nov. (Trinder-Smith, pers. comm.). Many of these CFR connections are exclusively with the Swartberg and Baviaanskloofberge 120–150 km to the south and south-west of the Sneeuberg (*C. montana*, *D. harveiana* subsp. *harveiana*, *O. macradenium* and *Acmadenia sheilae*, the most similar species to *A.* sp. nov.; Linder and Kurzweil, 1999; Whitehouse, pers. comm.; Trinder-Smith, pers. comm.). The remaining species (*P. laevigatum*, *A. venusta*, *A. capensis*, *P. lorifolia* and *R. capensis*) are widespread in the CFR and extant populations occur on the Zuurberg just 60 km to the south of the Boschberg (Van Wyk et al., 1988; Rebelo, 2001). The exception is *S. arenarius*, a western CFR species with no obvious montane affinity. It is noteworthy that the majority of the Sneeuberg CFR species occur in the western Sneeuberg (i.e. the Kamdebooberge, Toorberg, Meelberg and Koudeveldberge) and on the Boschberg in the far east. The exceptions are *S. arenarius* and *O. macradenium* which occur on both sides of the local "Sundays River Interval" (these local intervals on the southern Great Escarpment are detailed in Chapter 6). A possible reason for this is that the western Sneeuberg and the Boschberg may have much more available moisture than the rest of the Sneeuberg and are therefore able to support these species whilst the remainder of the Sneeuberg is perhaps too dry, too high, too cold or experiences too much winter aridity. All the CFR species are locally abundant (and often locally dominant) except for *P. lorifolia* which requires rediscovery in the Boschberg (Rebelo, 2001; see Chapter 3). *O. macradenium* is a typical to dominant component of the drier "Sneeuberg Renosterveld" at medium altitudes (1 300–1 800 m) along the steep escarpment slopes.

Two possible and not mutually exclusive explanations for the Sneeuberg–CFR links can be postulated: (1) this pattern is a consequence of a series of dispersal events across the Karoo Interval onto the Sneeuberg, or along the Great Escarpment via the Komsberg and Nuweveldberge, or (2) the result of the contraction of a once much larger fynbos region with relicts now left in moister areas of the Sneeuberg (a vicariance scenario).

A dispersal explanation (explanation (1) above) is conceivable in that strong south-westerly winds during mid-latitude cyclones can blow seed from the high Swartberg (altitude mostly over 2 000 m; Linder et al., 1993) to the Sneeuberg (Fig. 2.3). Perhaps this would have been even more likely during the previous glacial maxima when mesic fynbos may have covered the now arid inland Cape Fold Ranges (e.g. the Grootrivierberge, Willowmore District), thereby decreasing the distance for effective dispersal. This is even more likely from the Zuurberg, only 60 km to the south of the Boschberg, but south-westerly winds would then blow seed onto the Great Winterberg rather than onto the Boschberg (this is also a possibility however). Random dispersal events would explain why only a few CFR species have colonised the Sneeuberg, and why they are mostly confined to the moister western Sneeuberg and the Boschberg. The flaw in this explanation is that none of the CFR species occurring in the Sneeuberg are typically wind dispersed (compare Levyns, 1938, 1964). It can be argued that such speculation is not strictly "science", as it will probably never be possible to prove or disprove such speculations. Nevertheless, the consideration of such scenarios can be informative, if only from a probability interest.

It is conceivable to invoke a dispersal scenario along a series of "stepping stones" with smaller intervals between them. For example, the Zuurberg links the mountain ranges of the CFR and the Great Escarpment (thus circumventing the Great Fish River valley; Weimarck, 1941; Stuckenberg, 1962; Fig. 2.3). This scenario is suggested for species such as *Cliffortia repens* Schltr., found in the DAC and again on the Zuurberg and again on Cockscomb peak (Weimarck, 1941). Another possible series of "stepping stones" is from the Swartberg, across to the Komsberg (Sutherland District), then via the Nuweveldberge to the Sneeuberg (Fig. 2.3), as suggested by *Cliffortia ramosissima* (found from the CFR, and along the Great Escarpment through to the DAC; Whitehouse, 2002; see Chapter 6).

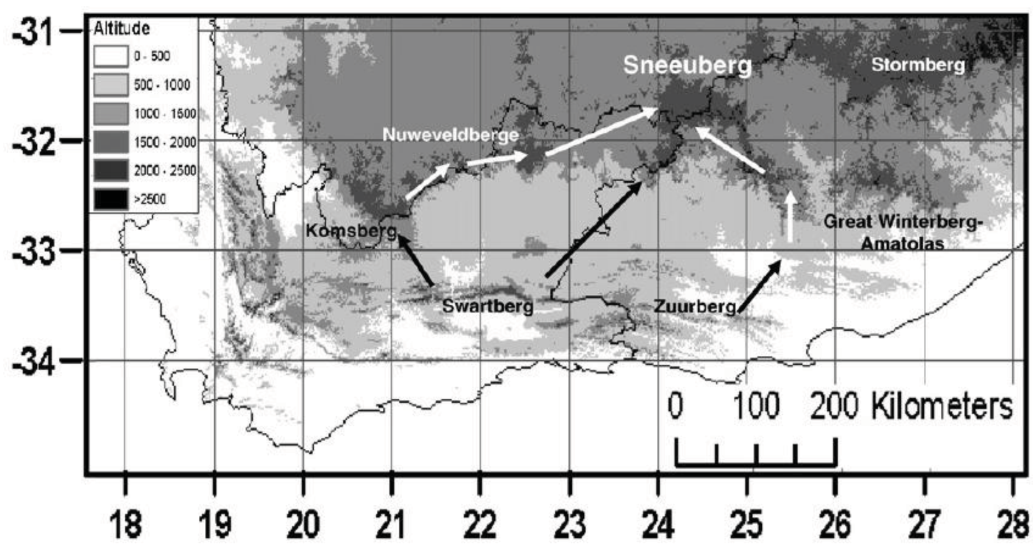


Figure 2.3: Possible dispersal scenarios of otherwise endemic Cape Floristic Region elements into the Sneeuberg.

This southern Great Escarpment track is not obviously a Cape connection today but is certainly a connection for Afromontane species in that the eastern Nuweveldberge is essentially a depauperate Afromontane grassland (see Chapter 4), and that several species e.g. *Brachypodium bolusii* are known to occur along the southern Great Escarpment from the Roggeveld to the Sneeuberg. Both scenarios may represent valid connections (Weimarck, 1941). The Zuurberg connection (Weimarck's SE connection) appears all the more plausible when Oliver et al.'s (1983) phytogeographical analysis of Cape taxa is considered, with a “flow” of species into the Great Escarpment in the Boschberg area being suggested, whilst no pure CFR taxa are currently known from the Komsberg and Nuweveldberge.

It is more difficult to find support for the alternative vicariance explanation. Weimarck (1941) speculates that the Karoo Interval may never have been occupied by a Cape flora, and previous blanket coverage of fynbos now relegated to a fraction of the current CFR (Levyns, 1938, 1964) is more difficult to explain from the current distributions. These ideas are considered further in Chapter 6.

e) Sneeuberg–Tropical African links

The discovery of *Faurea* sp. nov. (Rourke, pers. comm.) in the Kamdebooberge is one of the more bizarre finds in the Sneeuberg. This genus of Proteaceae is a Tropical African element, and is an unusual link connecting the Sneeuberg with more tropical African elements. This new species of *Faurea* has inflorescence and leaf morphologies that are most similar to *F. galpinii* E.Phillips, which is found in Afromontane forest patches along the Mpumalanga–Limpopo Escarpment some 1 000 km to the north (Rebelo, 2001).

f) Comparable faunal endemism and biogeographical connections

Where floral and faunal endemism are congruent, a strong case for a unified centre of endemism can be argued (e.g. the Cameroonian Highlands; Borrow and Demey, 2001). The little available data on faunal endemism in the Sneeuberg indicates that several faunal species, particularly invertebrates, are endemic to the range. Four butterfly species are endemic to the Sneeuberg (*Cassionympha camdeboo*, *Thestor compassbergae*, *T. camdeboo* and *Serradinga bowkeri bella*; Woodhall, 2005) and recently some 15 new Geometrid moth species have been collected in the Toorberg–Koudeveldberge region, including one new genus (Krüger, 2007). This number of new moth species is considered to be unusual, especially as most of them appear to be local endemics (Krüger, 2007; Krüger, pers. comm.). The adder *Bitis inornata* is endemic to the Sneeuberg plateau (Branch, 1998), and the land-snail *Prestonella nuptialis* is endemic to the Boschberg and Elandsberg (near Cradock), being confined to mesic niches at the base of scarps (Herbert, 2006). One land-snail (*Prestonella bowkeri*) is endemic to the Sneeuberg and the Nuweveldberge, and there are also links in the genus with the DAC (Herbert, 2006). Given that invertebrates in southern Africa are poorly known, local invertebrate endemism in the Sneeuberg is potentially very high. These few records suggest that faunal endemism may well match or even exceed floristic endemism, lending further support for the recognition of the Sneeuberg as an important centre of endemism.

Sneeuberg links to the DAC are supported by the bird *Chaetops aurantius* (Orange-breasted Rockjumper), which occurs from the DAC west to the Sneeuberg where it is common but restricted above 1 800 m throughout the Sneeuberg (Hockey et al., 2005; pers. obs.). Other faunal elements showing a similar distribution are montane butterflies such as *Pseudonympha trimenii ruthae* (montane areas from Graaff-Reinet to the Witteberg) and *Harpendyreus tsomo* (from the Kamdebooberge to Lesotho; Woodhall, 2005).

Faunal connections between the CFR and the eastern Great Escarpment regions of southern Africa include *Bitis atropos* (Berg Adder; Branch, 1998), the genus *Pseudobarbus* (southern African minnows), numerous butterfly species and genera (e.g. *Lepidochrysops variabilis* and *Aeropetes tulbaghia*; Woodhall, 2005), and the southern African endemic bird genera *Chaetops* and *Pseudochloroptila* (Hockey et al., 2005). The latter two genera each have only two species, one endemic to the CFR and the other to the DAC (Hocky et al., 2005) and represent perhaps one the strongest biogeographical links between the CFR and the Great Escarpment.

2.5. Conclusion

The highly dissected nature of the Sneeuberg and the strong moisture gradients from south to north indicate that this new centre of endemism will likely be strengthened by the discovery of more local endemics in time to come. This is particularly so considering that ten of the 28 Sneeuberg endemics have been discovered since 2004. The Sneeuberg Centre is thus the most recent addition to the Great Escarpment suite of centres of endemism, being unique in that it is a hub between the more arid Great Escarpment in the west (the Nuweveldberge and Roggeveldberge), the moister Great Escarpment in the east (the Stormberg, Great Winterberg–Amatolas and DAC), and the CFR in the south. Connections with the CFR are of particular interest in this study, and the role of the Boschberg and Groot-Bruintjieshoogde as the main link between the CFR and Afromontane region on the eastern Great Escarpment in this regard is considered further in Chapter 3.

Appendix 2: Flora of the Sneeuberg mountain complex (from Clark et al., 2009).

Family	Species	Collectors/References
Pteridophytes		
Anemiaceae	*Mohria nudiuscula* J.P.Roux	Clark VR, Coombs G 70
Aspidiaceae	*Athyrium schimperi* Moug. ex Fée	Clark VR, Ramdhani S 358
Aspidiaceae	*Dryopteris dracomontana* Schelpe & N.C.Anthony	Clark VR, Ngcobo L, Pienaar C 143
Aspidiaceae	*Dryopteris* cf. *inaequalis* (Schltdl.) Kuntze (J. Burrows, pers. comm.)	Clark VR, Rose M 516
Aspidiaceae	*Polystichum monticola* N.C.Anthony & Schelpe	Clark VR, Coombs G 107
Aspleniaceae	*Asplenium adiantum-nigrum* L. var. *adiantum-nigrum*	Clark VR, Coombs G 198
Aspleniaceae	*Asplenium aethiopicum* (Burm.f.) Bech.	Clark VR, Crause I 89
Aspleniaceae	*Asplenium cordatum* (Thunb.) Sw.	Clark VR, Coombs G 68
Aspleniaceae	*Asplenium platyneuron* (L.) Britton, Sterns & Poggenb.	Clark VR, Barker NP, Devos N 14
Aspleniaceae	*Asplenium trichomanes* subsp. *quadrivalens* D.E.Mey.	Clark VR, Coombs G 241
Azollaceae	*Azolla filiculoides* Lam.*	Henderson (2001)
Blechnaceae	*Blechnum australe* L. subsp. *australe*	Clark VR, Coombs G 69
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*	Clark VR, Crause I 92
Equisetaceae	*Equisetum ramosissimum* Desf. subsp. *ramosissimum*	Clark VR, Coombs G 600
Lycopodiaceae	*Huperzia saururus* (Lam.) Trevis.	Clark VR, Pienaar C 487
Ophioglossaceae	*Ophioglossum polyphyllum* A.Braun	Clark VR, Devos N, McKenzie RJ 7
Polypodiaceae	*Polypodium vulgare* L.	Clark VR, Coombs G 203
Pteridaceae	*Adiantum capillus-veneris* L.	Clark VR, Rose M 94
Pteridaceae	*Adiantum poiretii* Wikstr.	Clark VR, Coombs G 259
Pteridaceae	*Cheilanthes eckloniana* (Kunze) Mett.	Clark VR, Barker NP, Devos N 51
Pteridaceae	*Cheilanthes hirta* Sw.	Clark VR, Barker NP, Devos N 12
Pteridaceae	*Cheilanthes induta* Kunze	Clark VR, Pienaar C, Lochner EJ 330
Pteridaceae	*Cheilanthes multifida* (Sw.) Sw.	Burrows (1990)
Pteridaceae	*Cheilanthes parviloba* (Sw.) Sw.	Burrows (1990)
Pteridaceae	*Cheilanthes quadripinnata* (Forssk.) Kuhn	Clark VR, Barker NP, Devos N 8
Pteridaceae	*Pellaea calomelanos* (Sw.) Link var. *calomelanos*	Clark VR, Coombs G 71
Pteridaceae	*Pteris cretica* L.	Clark VR, Barker NP, Devos N 11
Pteridaceae	*Pteris dentata* Forssk.	Clark VR, Barker NP, Devos N 38
Woodsiaceae	*Cystopteris fragilis* (L.) Bernh.	Clark VR, Te Water Naudé T 181
Gymnosperms		
Zamiaceae	*Encephalartos lehmannii* Lehm.	Giddy (1974)
Pinaceae	*Pinus halepensis* Mill.*	Henderson (2001)
Podocarpaceae	*Podocarpus falcatus* (Thunb.) R.Br. ex Mirb.	Van der Walt (1972)
Cupressaceae	*Cupressus glabra* Sudw.*	Clark VR, Pienaar C 439
Monocotyledons		
Agapanthaceae	*Agapathus praecox* Willd.	Clark VR, Rose M 109
Agavaceae	*Agave americana* L.*	Henderson (2001)
Alliaceae	*Allium dregeanum* Kunth	Clark VR, Rose M 111
Alliaceae	*Tulbaghia acutiloba* Harv.	Clark VR, Pienaar C 422
Alliaceae	*Tulbaghia galpinii* Schltr.	Clark VR, Rose M 411
Amaryllidaceae	*Ammocharis coranica* (Ker Gawl.) Herb.	Clark VR, Pienaar C – Field Obs.
Amaryllidaceae	*Apodolirion bolusii* Baker	Bolus H 717
Amaryllidaceae	*Boophone disticha* (L.f.) Herb.	Clark VR, Te Water Naudé T 304

Amaryllidaceae	*Brunsvigia grandiflora* Lindl.	McKenzie RJ, Weston P, Clark VR 4
Amaryllidaceae	*Brunsvigia radulosa* Herb.	Clark VR, Coombs G 410
Amaryllidaceae	*Cyrtanthus breviflorus* Harv.	Clark VR, Pienaar C 477
Amaryllidaceae	*Cyrtanthus macowanii* Baker	Clark VR, Coombs G 644
Amaryllidaceae	*Cyrtanthus smithiae* Watt ex Harv.	MacOwan P 1580
Amaryllidaceae	*Cyrtanthus tuckii* Baker var. *tuckii*	Reid and Dyer (1984)
Amaryllidaceae	*Gethyllis longistyla* Bolus	Craib, pers. comm.
Amaryllidaceae	*Gethyllis transkarrooica* D.Müll.-Doblies	Clark VR, Coombs G 359
Amaryllidaceae	*Haemanthus albiflos* Jacq.	Snijman (1984)
Amaryllidaceae	*Haemanthus carneus* Ker Gawl.	Snijman (1984)
Amaryllidaceae	*Haemanthus humilis* Jacq. subsp. *humilis*	Clark VR, Coombs G 407
Amaryllidaceae	*Nerine angustifolia* (Baker) Baker	MacOwan P 1889
Amaryllidaceae	*Strumaria gemmata* Ker Gawl.	(Snijman, 1994)
Asparagaceae	*Asparagus asparagoides* (L.) Druce	*Clark VR, Coombs G 465*
Asparagaceae	*Asparagus burchellii* Baker	Clark VR, Ngcobo L, Pienaar C 309
Asparagaceae	*Asparagus denudatus* (Kunth) Baker	Clark VR, Coombs G 114
Asparagaceae	*Asparagus krebsianus* (Kunth.) Oberm.	Clark VR, Ramdhani S 414
Asparagaceae	*Asparagus microraphis* (Kunth) Baker	Clark VR, Ngcobo L, Pienaar C 75
Asparagaceae	*Asparagus mucronatus* Jessop	Clark VR, Ngcobo L, Pienaar C 281
Asparagaceae	*Asparagus retrofractus* L.	Clark VR, Coombs G 15
Asparagaceae	*Asparagus* sp. nov. 1 '*ferox*' S.M.Burrows (S.M. Burrows, pers. comm.)	Barker NP 1502
Asparagaceae	*Asparagus striatus* (L.f.) Thunb.	Clark VR, Ramdhani S 421
Asparagaceae	*Asparagus suaveolens* Burch.	Clark VR, Ramdhani S 36
Asphodelaceae	*Aloe aristata* Haw.	Clark VR, Barker NP, Devos N 69
Asphodelaceae	*Aloe broomii* Schönland var. *broomii*	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe broomii* var. *tarkaensis* Reynolds	McKenzie RJ, Weston P, Clark VR 9
Asphodelaceae	*Aloe claviflora* Burch.	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe ferox* Mill.	Clark VR, Ramdhani S 420
Asphodelaceae	*Aloe humilis* (L.) Mill.	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe longistyla* Baker	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe microstigma* Salm-Dyck	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe striata* Haw. subsp. *striata*	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe striatula* var. *caesia* Reynolds	Van Wyk and Smith (1996)
Asphodelaceae	*Aloe striatula* Haw. var. *striatula*	Clark VR, Ramdhani S 263
Asphodelaceae	*Aloe variegata* L.	Clark VR, Ramdhani S 318
Asphodelaceae	*Bulbine abyssinica* A.Rich.	Clark VR, Coombs G 157
Asphodelaceae	*Bulbine frutescens* (L.) Willd.	Clark VR, Coombs G 246
Asphodelaceae	*Bulbine latifolia* (L.f.) Schult. & Schult.f.	Clark VR, Coombs G 552
Asphodelaceae	*Bulbine narcissifolia* Salm-Dyck	Clark VR, Coombs G 355B
Asphodelaceae	*Haworthia bolusii* (Haw.) Bak. var. *bolusii*	Bayer (1982)
Asphodelaceae	*Haworthia marumiana* var. *batesiana* (Uitewaal) M.B.Bayer	Clark VR, Crause I 275
Asphodelaceae	*Haworthia venosa* subsp. *tessellata* (Haw.) M.B.Bayer	Clark VR, Pienaar C, Lochner EJ 120
Asphodelaceae	*Kniphofia acraea* Codd	McKenzie RJ, Weston P, Clark VR 1
Asphodelaceae	*Kniphofia baurii* Baker	Clark VR, McKenzie RJ 47
Asphodelaceae	*Kniphofia caulescens* Baker	Clark VR, Crause I 269
Asphodelaceae	*Kniphofia linearifolia* Baker	Codd (1968)
Asphodelaceae	*Kniphofia stricta* Codd	Clark VR, Coombs G 377
Asphodelaceae	*Kniphofia triangularis* Kunth subsp. *triangularis*	Clark VR, Coombs G 419
Asphodelaceae	*Kniphofia uvaria* (L.) Oken	McKenzie RJ, Weston P, Clark VR 2
Asphodelaceae	*Trachyandra asperata* var. *macowanii* (Baker) Oberm.	Clark VR, Coombs G 129
Asphodelaceae	*Trachyandra giffenii* (F.M.Leight.) Oberm.	Obermeyer (1962)
Colchicaceae	*Androcymbium striatum* A.Rich.	Clark VR, Coombs G 446
Colchicaceae	*Wurmbea* cf. *elatior* B.Nord. (Manning, pers. comm.)	Clark VR, McKenzie RJ 326
Commelinaceae	*Commelina africana* L. var. *africana*	Obermeyer and Faden (1985)
Commelinaceae	*Commelina africana* var. *lancispatha* C.B.Clarke	Obermeyer and Faden (1985)
Cyperaceae	*Bulbostylis contexta* (Nees) M.Bodard	Clark VR, Coombs G 379
Cyperaceae	*Bulbostylis humilis* (Kunth) C.B.Clarke	Clark VR, Ngcobo L, Pienaar C 93b
Cyperaceae	*Carex aethiopica* Schkuhr	Clark VR, Coombs G 83
Cyperaceae	*Carex cognata* Kunth var. *cognata*	Clark VR, McKenzie RJ 3
Cyperaceae	*Carex glomerabilis* Krecz.	Clark VR, Coombs G 26
Cyperaceae	*Cyperus albostriatus* Schrad.	MacOwan P 1690
Cyperaceae	*Cyperus congestus* Vahl	Clark VR, Coombs G 1
Cyperaceae	*Cyperus longus* L. var. *longus*	Sonnenberg (1993)

Cyperaceae	*Cyperus margaritaceus* Vahl var. *margaritaceus*	Clark VR, Te Water Naudé T 379
Cyperaceae	*Cyperus marginatus* Thunb.	Clark VR, Devos N, McKenzie RJ 87
Cyperaceae	*Cyperus rupestris* Kunth var. *rupestris*	Sonnenberg (1993)
Cyperaceae	*Cyperus semitrifidus* Schrad.	Sonnenberg (1993)
Cyperaceae	*Cyperus* sp. no. 1 (Muasya, pers. comm.)	Clark VR, Te Water Naudé T 48
Cyperaceae	*Cyperus squarrosus* L.	Clark VR, Ngcobo L, Pienaar C 330
Cyperaceae	*Cyperus usitatus* Burch. var. *usitatus*	Clark VR, Coombs G 470
Cyperaceae	*Eleocharis dregeana* Steud.	Sonnenberg (1993)
Cyperaceae	*Eleocharis limosa* (Schrad.) Schult.	Clark VR, Te Water Naudé T 223
Cyperaceae	*Ficinia compasbergensis* Drège	Clark VR, Barker NP, Devos N 53
Cyperaceae	*Ficinia fascicularis* Nees	Sonnenberg (1993)
Cyperaceae	*Ficinia ramosissima* Kunth	Clark VR, Ramdhani S 55
Cyperaceae	*Ficinia* sp. no. 1 (Muasya, pers. comm.)	Clark VR, Ramdhani S 223
Cyperaceae	*Ficinia stolonifera* Boeck.	Sonnenberg (1993)
Cyperaceae	*Fuirena coerulescens* Steud.	Clark VR, Devos N, McKenzie RJ 59
Cyperaceae	*Isolepis angelica* B.L.Burtt	Clark VR, Te Water Naudé T 296
Cyperaceae	*Isolepis cernua* (Vahl) Roem. & Schult. var. *cernua*	Clark VR, Coombs G 51
Cyperaceae	*Isolepis costata* A.Rich.	Clark VR, Coombs G 84
Cyperaceae	*Isolepis diabolica* (Steud.) Schrad.	Clark VR, Te Water Naudé T 295
Cyperaceae	*Isolepis ludwigii* (Steud.) Kunth	Sonnenberg (1993)
Cyperaceae	*Isolepis marginata* (Thunb.) A.Dietr.	Clark VR, Te Water Naudé T 327a
Cyperaceae	*Isolepis natans* (Thunb.) A.Dietr.	Sonnenberg (1993)
Cyperaceae	*Isolepis setacea* (L.) R.Br.	Clark VR, Te Water Naudé T 327b
Cyperaceae	*Pseudoschoenus inanis* (Thunb.) Oteng-Yeb.	Clark VR, Ngcobo L, Pienaar C 238
Cyperaceae	*Schoenoplectus paludicola* (Kunth) J.Raynal	Clark VR, Ngcobo L, Pienaar C 286
Cyperaceae	*Schoenoxiphium* sp. aff. *basutorum* Turrill (Muasya, pers. comm.)	Clark VR, Te Water Naudé T 340
Cyperaceae	*Schoenoxiphium lanceum* (Thunb.) Kük.	Clark VR, Coombs G 53
Cyperaceae	*Schoenoxiphium lehmannii* (Nees) Steud.	Clark VR, Ngcobo L, Pienaar C 229
Cyperaceae	*Schoenoxiphium rufum* Nees	Clark VR, Devos N, McKenzie RJ 99
Cyperaceae	*Schoenoxiphium schweickerdtii* Merxm. & Podlech	Clark VR, Ngcobo L, Pienaar C 171
Cyperaceae	*Schoenoxiphium sparteum* (Wahlenb.) C.B.Clarke	Clark VR, Coombs G 266
Cyperaceae	*Scirpoides dioecus* (Kunth) Browning	Sonnenberg (1993)
Cyperaceae	*Scirpus falsus* C.B.Clarke	McKenzie RJ, Weston P, Clark VR 159
Cyperaceae	*Tetraria cuspidata* (Rottb.) C.B.Clarke	MacOwan P 1954
Dracaenaceae	*Sansevieria aethiopica* Thunb.	Obermeyer et al. (1992)
Eriospermaceae	*Eriospermum alcicorne* Baker	Bolus H 838
Eriospermaceae	*Eriospermum corymbosum* Baker	Clark VR, Coombs G 409
Hyacinthaceae	*Albuca aurea* Jacq.	Clark VR, Rose M 107
Hyacinthaceae	*Albuca caudata* Jacq.	Baker (1897)
Hyacinthaceae	*Albuca collina* Baker	Clark VR, Rose M 168
Hyacinthaceae	*Albuca exsuviata* Baker	Baker (1897)
Hyacinthaceae	*Albuca fastigiata* Dryand	Baker (1897)
Hyacinthaceae	*Albuca* cf. *humilis* Baker (Manning, pers. comm.)	Clark VR, Pienaar C 56
Hyacinthaceae	*Albuca macowanii* Baker	Baker (1897)
Hyacinthaceae	*Albuca polyphylla* Baker	Baker (1897)
Hyacinthaceae	*Albuca* cf. *rupestris* Hilliard & B.L.Burtt (Manning, pers. comm.)	Clark VR, Pienaar C 368
Hyacinthaceae	*Albuca setosa* Jacq.	Clark VR, Devos N, McKenzie RJ 35
Hyacinthaceae	*Dipcadi brevifolium* (Thunb.) Fourc.	Clark VR, Rose M 167
Hyacinthaceae	*Drimia anomala* (Baker) Benth.	McKenzie RJ, Weston P, Clark VR 189
Hyacinthaceae	*Drimia calcarata* (Baker) Stedje	Clark VR, Rose M 503
Hyacinthaceae	*Drimia* cf. *elata* Jacq. (Manning, pers. comm.)	Clark VR, Pienaar C 164
Hyacinthaceae	*Eucomis autumnalis* (Mill.) Chitt. subsp. *autumnalis*	Clark VR, Ngcobo L, Pienaar C 10
Hyacinthaceae	*Lachenalia campanulata* Baker	Clark VR, Coombs G 171
Hyacinthaceae	*Ledebouria* sp. nov. 1 '*minima*' J.C.Manning & Snijman (Manning, pers. comm.)	Clark VR, Coombs G 3
Hyacinthaceae	*Massonia depressa* Houtt.	Clark VR, Ramdhani S 385
Hyacinthaceae	*Massonia echinata* L.f.	Summerfield (2005)
Hyacinthaceae	*Massonia jasminiflora* Burch. ex Baker	Clark VR, McKenzie RJ 459
Hyacinthaceae	*Ornithogalum constrictum* Leighton	Obermeyer (1978)
Hyacinthaceae	*Ornithogalum fimbrimarginatum* Leighton	Obermeyer (1978)
Hyacinthaceae	*Ornithogalum graminifolium* Thunb.	Clark VR, Ramdhani S 209
Hyacinthaceae	*Ornithogalum juncifolium* Jacq.	Clark VR, Pienaar C 48
Hyacinthaceae	*Ornithogalum paludosum* Baker	Obermeyer (1978)
Hyacinthaceae	*Ornithogalum prasinum* Lindl	Obermeyer (1978)
Hyacinthaceae	*Ornithogalum* sp. nov. 1 aff. *flexuosum* (Thunb.) U. & D. Müller-Doblies (Manning, pers. comm.)	Clark VR, Pienaar C 414

Hyacinthaceae	*Empodium elongatum* (Nel) B.L.Burtt	Clark VR, Rose M 413
Hypoxidaceae	*Hypoxis argentea* var. *sericea* (Baker) Baker	Clark VR, Coombs G 436
Iridaceae	*Dierama grandiflorum* G.J.Lewis	Hilliard and Burtt (1991)
Iridaceae	*Dierama robustum* N.E.Br.	Clark VR, Coombs G 482
Iridaceae	*Freesia andersoniae* L.Bolus	Barker NP 1493
Iridaceae	*Gladiolus longicollis* Baker subsp. *longicollis*	Clark VR, Te Water Naudé T 226
Iridaceae	*Gladiolus mortonius* Herb.	Goldblatt and Manning (1998)
Iridaceae	*Gladiolus permeabilis* subsp. *edulis* (Burch. ex Ker Gawl.) Oberm.	Clark VR, Ngcobo L, Pienaar C 142
Iridaceae	*Hesperantha bulbifera* Baker	Clark VR, Te Water Naudé T 63
Iridaceae	*Hesperantha helmei* Goldblatt & J.C.Manning	Goldblatt and Manning (2007)
Iridaceae	*Hesperantha longituba* (Klatt) Baker	Goldblatt (1984)
Iridaceae	*Hesperantha radiata* (Jacq.) Ker Gawl.	Clark VR, Te Water Naudé T 65
Iridaceae	*Moraea bipartita* L.Bolus	Goldblatt (1984)
Iridaceae	*Moraea cookii* (L.Bolus) Goldblatt	Barker NP 1462
Iridaceae	*Moraea ciliata* (L.f.) Ker Gawl	Goldblatt (1984)
Iridaceae	*Moraea crispa* Thunb.	Goldblatt (1984)
Iridaceae	*Moraea elliotii* Baker	Clark VR, Ramdhani S 112
Iridaceae	*Moraea huttonii* (Baker) Oberm.	Goldblatt (1984)
Iridaceae	*Moraea polystachya* (Thunb.) Ker Gawl.	Clark VR, Ngcobo L, Pienaar C 269
Iridaceae	*Moraea spathulata* (L.f.) Klatt	Clark VR, Coombs G 155
Iridaceae	*Moraea stricta* Baker	Clark VR, Te Water Naudé T 62
Iridaceae	*Moraea unguiculata* Ker Gawl.	Goldblatt and Anderson, 1986
Iridaceae	*Romulea atrandra* G.J. Lewis	Barker NP 1488
Iridaceae	*Romulea macowanii* Baker var. *macowanii*	De Vos (1972)
Iridaceae	*Syringodea pulchella* Hook.f.	De Vos (1983)
Iridaceae	*Tritonia disticha* subsp. *rubrolucens* (R.C.Foster) M.P.de Vos	Clark VR, Ramdhani S 134
Iridaceae	*Tritonia laxifolia* (Klatt) Benth. & Hook.f.	De Vos and Goldblatt (1999)
Iridaceae	*Tritonia securigera* (Aiton) Ker Gawl.	De Vos and Goldblatt (1999)
Iridaceae	*Watsonia pillansii* L.Bolus	Goldblatt (1989)
Juncaceae	*Juncus dregeanus* Kunth subsp. *dregeanus*	Clark VR, Coombs G 260
Juncaceae	*Juncus exsertus* Buchenau subsp. *exsertus*	Clark VR, Coombs G 342
Juncaceae	*Juncus inflexus* L.	Clark VR, Coombs G 87
Juncaceae	*Juncus oxycarpus* E.Mey. ex Kunth	Clark VR, Coombs G 521
Juncaceae	*Juncus punctorius* L.f.	Clark VR, Ramdhani S 233
Juncaceae	*Luzula africana* Drège ex Steud.	Clark VR, Coombs G 173
Orchidaceae	*Corycium flanaganii* (Bolus) Kurzweil & H.P.Linder	Clark VR, Ramdhani S 206
Orchidaceae	*Disa harveiana* Lindl. subsp. *harveiana*	Clark VR, Te Water Naudé T 305
Orchidaceae	*Disperis macowanii* H.Bolus	McKenzie RJ, Weston P, Clark VR 110
Orchidaceae	*Holothrix* cf. *villosa* Lindl. (Bellstedt, pers. comm.)	Clark VR, Ramdhani S 383
Poaceae	*Agrostis lachnantha* Nees var. *lachnantha*	Clark VR, Te Water Naudé T 222
Poaceae	*Aira cupaniana* Guss.*	Clark VR, Ramdhani S 379
Poaceae	*Andropogon appendiculatus* Nees	MacOwan P 166
Poaceae	*Aristida adscensionis* L.	Bolus H 678
Poaceae	*Aristida congesta* subsp. *barbicollis* (Trin. & Rupr.) De Winter	Bolus H 677
Poaceae	*Aristida congesta* Roem. & Schult. subsp. *congesta*	Clark VR, Ngcobo L, Pienaar C 71
Poaceae	*Aristida diffusa* subsp. *burkei* (Stapf) Melderis	Clark VR, Devos N, McKenzie RJ 92
Poaceae	*Arundo donax* L.*	Henderson (2001)
Poaceae	*Brachiaria serrata* (Thunb.) Stapf	MacOwan P 1307
Poaceae	*Brachypodium bolusii* Stapf	Clark VR, Devos N, McKenzie RJ 38
Poaceae	*Brachypodium flexum* Nees	MacOwan P 1495
Poaceae	*Bromus catharticus* Vahl*	Clark VR, Coombs G 162
Poaceae	*Bromus commutatus* Schrad.*	Clark VR, Ramdhani S 123
Poaceae	*Bromus leptoclados* Nees	Clark VR, Coombs G 102
Poaceae	*Bromus pectinatus* Thunb.	Gibbs Russell et al. (1990)
Poaceae	*Cenchrus ciliaris* L.	Gibbs Russell et al. (1990)
Poaceae	*Chloris virgata* Swartz	Gibbs Russell et al. (1990)
Poaceae	*Cymbopogom prolixus* (Stapf) Phill.	Clark VR, Te Water Naudé T 333
Poaceae	*Cymbopogon pospischilii* (K.Schum.) C.E.Hubb.	Clark VR, Ngcobo L, Pienaar C 306
Poaceae	*Cynodon incompletus* Nees	Clark VR, Devos N, McKenzie RJ 98
Poaceae	*Digitaria eriantha* Steud.	Clark VR, Devos N, McKenzie RJ 60
Poaceae	*Ehrharta calycina* J.E.Sm. var. *calycina*	Barker NP 1492
Poaceae	*Ehrharta erecta* Lam. var. *erecta*	Clark VR, Coombs G 533
Poaceae	*Ehrharta longigluma* C.E.Hubb.	Clark VR, Coombs G 189

Poaceae	*Elionurus muticus* (Spreng.) Kunth	McKenzie RJ, Weston P, Clark VR 95
Poaceae	*Enneapogon desvauxii* Beauverd	Tyson W s.n.
Poaceae	*Enneapogon scaber* Lehm	Bolus H s.n.
Poaceae	*Enneapogon scoparius* Stapf	Clark VR, Ngcobo L, Pienaar C 288
Poaceae	*Eragostis procumbens* Nees	Clark VR, Ngcobo L, Pienaar C 198
Poaceae	*Eragrostis bergiana* (Kunth) Trin.	Bolus H 552
Poaceae	*Eragrostis caesia* Stapf	Clark VR, McKenzie RJ 308
Poaceae	*Eragrostis capensis* (Thunb.) Trin.	Clark VR, Coombs G 427
Poaceae	*Eragrostis chloromelas* Steud.	Clark VR, Ngcobo L, Pienaar C 303
Poaceae	*Eragrostis curvula* (Schrad.) Nees	Clark VR, Coombs G 450
Poaceae	*Eragrostis homomalla* Nees	Clark VR, Coombs G 42
Poaceae	*Eragrostis lehmanniana* Nees var. *lehmanniana*	Clark VR, Ngcobo L, Pienaar C 301
Poaceae	*Eragrostis obtusa* Munro ex Fical. & Hiern	Clark VR, Ngcobo L, Pienaar C 249
Poaceae	*Eustachys paspaloides* (Vahl) Lanza & Mattei subsp. *paspaloides*	Clark VR, Ngcobo L, Pienaar C 349
Poaceae	*Festuca arundinacea* Schreb.*	Clark VR, McKenzie RJ 404
Poaceae	*Festuca caprina* Nees	Clark VR, Coombs G 610
Poaceae	*Festuca scabra* Vahl	Clark VR, Ramdhani S 221
Poaceae	*Fingerhuthia africana* Lehm.	Gibbs Russell et al. (1990)
Poaceae	*Fingerhuthia sesleriiformis* Nees	Clark VR, Coombs G 670
Poaceae	*Harpochloa falx* (L.f.) Kuntze	Clark VR, Coombs G 264
Poaceae	*Helictotrichon hirtulum* (Steud.) Schweick.	Clark VR, Devos N, McKenzie RJ 96
Poaceae	*Helictotrichon longifolium* (Nees) Schweick.	Clark VR, Coombs G 191
Poaceae	*Helictotrichon natalense* (Stapf) Schweick.	Clark VR, Ngcobo L, Pienaar C 53
Poaceae	*Helictotrichon turgidulum* (Stapf) Schweick.	Clark VR, Coombs G 412
Poaceae	*Heteropogon contortus* (L.) Beauverd ex Roem. & Schult.	Clark VR, Ramdhani S 131
Poaceae	*Hordeum capense* Thunb.	Clark VR, Te Water Naudé T 217
Poaceae	*Hordeum murinum* subsp. *glaucum* (Steud.) Tzvelev*	Clark VR, Ramdhani S 215
Poaceae	*Hordeum stenostachys* Godr.*	Gibbs Russell et al. (1990)
Poaceae	*Hyparrhenia hirta* (L.) Stapf.	Clark VR, Coombs G 13
Poaceae	*Imperata cylindrica* (L.) Raeusch.	Clark VR, Ramdhani S 294
Poaceae	*Karroochloa curva* (Nees) Conert & Tuerpe	Clark VR, Ramdhani S 121
Poaceae	*Karroochloa purpurea* (L.f.) Conert & Tuerpe	Clark VR, Coombs G 211
Poaceae	*Koeleria capensis* (Steud.) Nees	Clark VR, Coombs G 146
Poaceae	*Lolium perenne* L.*	Clark VR, Te Water Naudé T 215
Poaceae	*Melica decumbens* Thunb.	Clark VR, Te Water Naudé T 142
Poaceae	*Melica racemosa* Thunb.	Clark VR, Te Water Naudé T 263
Poaceae	*Melinis nerviglumis* (Franch.) Zizka	Clark VR, Ngcobo L, Pienaar C 291
Poaceae	*Merxmuellera disticha* (Nees) Conert	Clark VR, Coombs G 201
Poaceae	*Merxmuellera macowanii* (Stapf) Conert	Clark VR, Coombs G 185
Poaceae	*Merxmuellera stricta* (Schrad.) Conert	Clark VR, Barker NP, Devos N 56
Poaceae	*Microchloa caffra* Nees	Clark VR, Pienaar C 412
Poaceae	*Miscanthus capensis* (Nees) Anderss.	Clark VR, Coombs G 55
Poaceae	*Nassella neesiana* (Trin. & Rupr.) Barkworth*	Clark VR, Coombs G 543
Poaceae	*Nassella trichotoma* (Nees) Hack. ex Arechav.*	Clark VR, Coombs G 307
Poaceae	*Panicum coloratum* L. var. *coloratum*	Clark VR, Coombs G 506
Poaceae	*Panicum deustum* Thunb.	Pond et al. (2002)
Poaceae	*Paspalum dilatatum* Poir.*	McKenzie RJ, Weston P, Clark VR 164
Poaceae	*Pennisetum clandestinum* Hochst. ex Chiov.*	Field Observation
Poaceae	*Pennisetum macrourum* Trin.	Clark VR, Coombs G 504
Poaceae	*Pennisetum setaceum* (Forssk.) Chiov.*	Henderson (2001)
Poaceae	*Pennisetum sphacelatum* (Nees) Dur. & Schinz	Clark VR, McKenzie RJ 304
Poaceae	*Pennisetum thunbergii* Kunth	Clark VR, Coombs G 80
Poaceae	*Pentaschistis airoides* (Nees) Stapf subsp. *airoides*	MacOwan P 1291
Poaceae	*Pentaschistis airoides* subsp. *jugorum* (Stapf) H.P.Linder	Clark VR, Coombs G 130
Poaceae	*Pentaschistis glandulosa* (Schrad.) H.P.Linder	Clark VR, Coombs G 305
Poaceae	*Pentaschistis setifolia* (Thunb.) McClean	Clark VR, Te Water Naudé T 236
Poaceae	*Phragmites australis* subsp. *altissimus* (Benth.) Clayton	Clark VR, Ngcobo L, Pienaar C 234
Poaceae	*Poa binata* Nees	Clark VR, Coombs G 656f
Poaceae	*Poa pratensis* L.*	Clark VR, Te Water Naudé T 165
Poaceae	*Polypogon viridis* (Gouan) Breistr.*	Clark VR, Coombs G 665
Poaceae	*Schismus barbatus* (Loefl. ex L.) Thell.	Gibbs Russell et al. (1990)
Poaceae	*Schismus inermis* (Stapf) C.E.Hubb.	Gibbs Russell et al. (1990)
Poaceae	*Setaria sphacelata* (Schumach.) Stapf & C.E.Hubb. ex M.B.Moss var. *sphacelata*	Bolus H 675
Poaceae	*Setaria verticillata* (L.) Beauverd	Pond et al. (2002)

Poaceae	*Sporobolus africanus* (Poir.) Robyns & Tournay	Clark VR, Coombs G 551
Poaceae	*Sporobolus discoporus* Nees	Clark VR, Pienaar C 419
Poaceae	*Sporobolus fimbriatus* (Trin.) Nees	Clark VR, Coombs G 540
Poaceae	*Sporobolus ioclados* (Trin.) Nees	Clark VR, Ngcobo L, Pienaar C 290
Poaceae	*Stipa dregeana* Steud. var. *dregeana*	Clark VR, Ramdhani S 480
Poaceae	*Stipa dregeana* var. *elongata* (Nees) Stapf	MacOwan P 1520
Poaceae	*Stipagrostis ciliata* var. *capensis* (Trin. & Rupr.) De Winter	Gibbs Russell et al. (1990)
Poaceae	*Stipagrostis obtusa* (Del.) Nees	Gibbs Russell et al. (1990)
Poaceae	*Tetrachne dregei* Nees	Clark VR, Devos N, McKenzie RJ 97
Poaceae	*Themeda triandra* Forssk.	Clark VR, Coombs G 187
Poaceae	*Tragus berteronianus* Schult.	Gibbs Russell et al. (1990)
Poaceae	*Tragus koelerioides* Aschers.	Gibbs Russell et al. (1990)
Poaceae	*Tragus racemosus* (L.) All.	Clark VR, Ngcobo L, Pienaar C 36
Poaceae	*Tribolium hispidum* (Thunb.) Desv.	McKenzie RJ, Weston P, Clark VR 118
Poaceae	*Tristachya leucothrix* Trin. ex Nees	MacOwan P 789
Poaceae	*Urochloa panicoides* Beauverd	Pond et al. (2002)
Poaceae	*Vulpia bromoides* (L.) S.F.Gray*	Clark VR, Coombs G 218
Poaceae	*Vulpia myuros* (L.) C.Gmel.*	Gibbs Russell et al. (1990)
Restionaceae	*Ischyrolepis distracta* (Mast.) H.P.Linder	Clark VR, Barker NP, Devos N 54
Restionaceae	*Rhodocoma capensis* Steud.	Clark VR, Crause I 268
Tecophilaeaceae	*Cyanella lutea* L.f.	Clark VR, Ramdhani S 234
Typhaceae	*Typha capensis* (Rohrb.) N.E.Br.	Clark VR, Ramdhani S 116
Dicotyledons		
Acanthaceae	*Barleria irritans* Nees	Bolus H 363
Acanthaceae	*Blepharis capensis* (L.f.) Pers.	Clark VR, Ngcobo L, Pienaar C 296
Acanthaceae	*Hypoestes forskaolii* (Vahl) R.Br.	Balkwill and Norris (1985)
Acanthaceae	*Justicia orchioides* L.f.	Barker NP 1454
Acanthaceae	*Monechma divaricatum* (Nees) C.B.Clarke	Bolus H 748
Achariaceae	*Guthriea capensis* H.Bolus	Clark VR, Barker NP, Devos N 24
Adoxaceae	*Sambucus nigra* L.*	Clark VR, Pienaar C 397
Aizoaceae	*Aizoon glinoides* L.f.	Barker NP 1514
Aizoaceae	*Aizoon rigidum* L.f.	Rogers FA 147
Aizoaceae	*Galenia procumbens* L.f.	Bolus H 182
Aizoaceae	*Galenia prostrata* Schellenb.	Adamson (1956)
Aizoaceae	*Galenia sarcophylla* Fenzl.	Adamson (1956)
Aizoaceae	*Galenia secunda* (L.f.) Sond.	Adamson (1956)
Aizoaceae	*Tetragonia acanthocarpa* Adamson	Adamson (1955a)
Aizoaceae	*Tetragonia arbuscula* Fenzl	Adamson (1955a)
Aizoaceae	*Tetragonia echinata* Aiton	Adamson (1955a)
Aizoaceae	*Tetragonia fruticosa* L.	Adamson (1955a)
Aizoaceae	*Tetragonia microptera* Fenzl	Bolus H s.n.
Aizoaceae	*Tetragonia portulacoides* Fenzl	Adamson (1955a)
Aizoaceae	*Tetragonia sarcophylla* Fenzl	Adamson (1955a)
Aizoaceae	*Tetragonia spicata* L.f.	Bolus H 107
Amaranthaceae	*Achyranthes aspera* L.*	Clark VR, Crause I 107
Amaranthaceae	*Alternanthera pungens* Kunth*	Francis M 25
Amaranthaceae	*Amaranthus capensis* Thell. subsp. *capensis*	Brenan (1981)
Amaranthaceae	*Amaranthus deflexus* L.*	Brenan (1981)
Amaranthaceae	*Amaranthus dinteri* Schinz.	Brenan (1981)
Amaranthaceae	*Amaranthus hybridus* L. subsp. *hybridus**	Clark VR, Ngcobo L, Pienaar C 193
Amaranthaceae	*Amaranthus praetermissus* Brenan	Brenan (1981)
Amaranthaceae	*Amaranthus retroflexus* L. var. *retroflexus**	Brenan (1981)
Amaranthaceae	*Amaranthus thunbergii* Moq.	Brenan (1981)
Amaranthaceae	*Cyathula uncinulata* (Schrad.) Schinz	Clark VR, Coombs G 391
Amaranthaceae	*Gomphrena celosioides* Mart.*	Clark VR, Ngcobo L, Pienaar C 256
Amaranthaceae	*Guilleminea densa* (Willd. ex Roem. & Schult.) Moq.*	Clark, VR, Rose M 221
Anacardiaceae	*Schinus molle* L.*	Clark VR, Te Water Naudé T 210
Anacardiaceae	*Searsia bolusii* (Sond. ex Engl.) Moffett	Moffett (1993)
Anacardiaceae	*Searsia burchellii* (Sond. ex Engl.) Moffett	Clark VR, Ngcobo L, Pienaar C 340
Anacardiaceae	*Searsia dentata* (Thunb.) F.A.Barkley	Clark VR, Te Water Naudé T 72
Anacardiaceae	*Searsia divaricata* (Eckl. & Zeyh.) Moffett	Clark VR, Coombs G 239
Anacardiaceae	*Searsia dregeana* (Sond.) Moffett	Clark VR, Barker NP, Devos N 21

Anacardiaceae	*Searsia erosa* (Thunb.) Moffett	Clark VR, Ngcobo L, Pienaar C 218
Anacardiaceae	*Searsia incisa* var. *effusa* (C.Presl) Moffett	Moffett (1993)
Anacardiaceae	*Searsia krebsiana* (C.Presl ex Engl.) Moffett	Clark VR, Ramdhani S 183
Anacardiaceae	*Searsia lancea* (L.f.) F.A.Barkley	Clark VR, Te Water Naudé T 4
Anacardiaceae	*Searsia longispina* (Eckl. & Zeyh.) Moffett	Clark VR, Pienaar C 600
Anacardiaceae	*Searsia lucida* (L.) F.A.Barkley forma *lucida*	Moffett (1993)
Anacardiaceae	*Searsia pallens* (Eckl. & Zeyh.) Moffett	Barker NP 1505
Anacardiaceae	*Searsia pyroides* var. *gracilis* (Engl.) Moffett	Moffett (1993)
Anacardiaceae	*Searsia pyroides* (Burch.) Moffett var. *pyroides*	Clark VR, Coombs G 61
Anacardiaceae	*Searsia refracta* (Eckl. & Zeyh.) Moffett	Moffett (1993)
Anacardiaceae	*Searsia rehmanniana* var. *glabrata* (Sond.) Moffett	Clark VR, Rose M 33
Apiaceae	*Alepidea* cf. *acutidens* Weim. (possibly sp. nov.; Winter, pers. comm.)	Clark VR, Crause I 5
Apiaceae	*Alepidea delicatula* Weim.	Clark VR, Coombs G 237
Apiaceae	*Alepidea macowanii* Dummer	Winter, pers. comm.
Apiaceae	*Berula erecta* subsp. *thunbergii* (DC.) B.L.Burtt	Clark VR, Coombs G 47
Apiaceae	*Bupleurum mundii* Cham. & Schltdl.	Clark VR, Coombs G 167
Apiaceae	*Chamarea longipedicellata* B.L.Burtt	Clark VR, Pienaar C 173
Apiaceae	*Conium chaerophylloides* (Thunb.) Sond.	Clark VR, Pienaar C, Lochner EJ 87
Apiaceae	*Conium* sp. no. 3 (Hilliard and Burtt, 1985b)	Clark VR, Crause I 69
Apiaceae	*Conium* sp. no. 4 (Hilliard and Burtt, 1985b)	Clark VR, Crause I 25
Apiaceae	*Cyclospermum leptophyllum* (Pers.) Sprague*	Clark VR, Te Water Naudé T 57
Apiaceae	*Deverra burchellii* (DC.) Eckl. & Zeyh.	Clark VR, Pienaar C, Lochner EJ 17
Apiaceae	*Heteromorpha arborescens* (Spreng.) Cham. & Schltdl. var. *arborescens* (interior form)	Clark VR, Te Water Naudé T 49
Apiaceae	*Notobubon laevigatum* (Aiton) A.R.Magee	McKenzie RJ, Weston P, Clark VR 138
Apiaceae	*Pimpinella caffra* (Eckl. & Zeyh.) D.Dietr.	Clark VR, Crause I 12
Apiaceae	*Polemannia grossulariifolia* Eckl. & Zeyh.	Clark VR, Coombs G 337
Apiaceae	*Sanicula elata* Buch.-Ham. ex D.Don	MacOwan P 1499
Apocynaceae	*Asclepias gibba* (E.Mey.) Schltr.	MacOwan P 2028
Apocynaceae	*Asclepias humilis* (E.Mey.) Schltr.	Clark VR, Coombs G 205
Apocynaceae	*Carissa bispinosa* (L.) Desf. ex Brenan	Clark VR, Ramdhani S 416
Apocynaceae	*Cordylogyne globosa* E.Mey.	Bruyns (2005)
Apocynaceae	*Cynanchum capense* Thunb.	Burchell W 2879
Apocynaceae	*Duvalia corderoyi* (Hook.f.) N.E.Br.	Bruyns (2005)
Apocynaceae	*Duvalia caespitosa* (Masson) Haw. subsp. *caespitosa*	Bruyns (2005)
Apocynaceae	*Duvalia modesta* N.E.Br.	Bruyns (2005)
Apocynaceae	*Gomphocarpus fruticosus* (L.) W.T.Aiton subsp. *fruticosus*	Clark VR, Coombs G 54
Apocynaceae	*Huernia barbata* (Masson) Haw.	Bruyns (2005)
Apocynaceae	*Huernia humilis* (Masson) Haw.	Bruyns (2005)
Apocynaceae	*Huernia kennedyana* Lavranos	Bruyns (2005)
Apocynaceae	*Huernia piersii* N.E.Br.	Bruyns (2005)
Apocynaceae	*Huernia thurettii* F.Cels	Bruyns (2005)
Apocynaceae	*Microloma armatum* (Thunb.) Schltr. ex Gilg var. *armatum*	Bolus H 365
Apocynaceae	*Orbea verrucosa* (Masson) L.C.Leach	Bruyns (2005)
Apocynaceae	*Pachycarpus vexillaris* E.Mey.	Clark VR, Devos N, McKenzie RJ 28
Apocynaceae	*Sarcostemma viminale* (L.) R.Br. subsp. *viminale*	MacOwan P s.n.
Apocynaceae	*Schizoglossum bidens* E.Mey. subsp. *bidens*	Clark VR, Te Water Naudé T 180
Apocynaceae	*Schizoglossum hamatum* E.Mey.	MacOwan P 1637
Apocynaceae	*Stapelia grandiflora* Masson var. *grandiflora*	Clark VR, Pienaar C 524
Apocynaceae	*Stapelia olivacea* N.E.Br.	Bruyns (2005)
Apocynaceae	*Xysmalobium gomphocarpoides* (E.Mey.) D.Dietr. var. *gomphocarpoides*	Clark VR, Devos N, McKenzie RJ 154
Araliaceae	*Cussonia paniculata* Eckl. & Zeyh. subsp. *paniculata*	Clark VR, Barker NP, Devos N 42
Araliaceae	*Cussonia spicata* Thunb.	Clark VR, Ramdhani S 11
Asteraceae	*Amellus strigosus* (Thunb.) Less.	Clark VR, Coombs G 251
Asteraceae	*Amellus tridactylis* DC.	Clark VR, Crause I 59
Asteraceae	*Arctotheca calendula* (L.) Levyns	Francis M 11
Asteraceae	*Arctotis arctotoides* (L.f.) O.Hoffm.	Clark VR, Coombs G 171
Asteraceae	*Arctotis dregei* Turcz.	Clark VR, Ngcobo L, Pienaar C 20
Asteraceae	*Artemisia afra* Jacq. ex Willd. var. *afra*	Clark VR, Ngcobo L, Pienaar C 248
Asteraceae	*Aster bakerianus* Burtt Davy ex C.A.Sm.	Clark VR, Te Water Naudé T 264
Asteraceae	*Athrixia angustissima* DC.	Clark VR, Ramdhani S 373
Asteraceae	*Berkheya buphthalmoides* (DC.) Schltr.	Clark VR, Coombs G 142
Asteraceae	*Berkheya cardopatifolia* (DC.) Roessler	Clark VR, Te Water Naudé T 365
Asteraceae	*Berkheya decurrens* (Thunb.) Willd.	Clark VR, Crause I 129
Asteraceae	*Berkheya heterophylla* (Thunb.) O.Hoffm. var. *heterophylla*	Clark VR, Ngcobo L, Pienaar C 76

Asteraceae	*Chrysocoma ciliata* L.	Barker NP 1513
Asteraceae	*Chrysocoma microphylla* Thunb.	Clark VR, Ngcobo L, Pienaar C 111
Asteraceae	*Cichorium intybus* L. subsp. *intybus*	Clark VR, Pienaar C 346
Asteraceae	*Cineraria aspera* Thunb.	Clark VR, Devos N, McKenzie RJ 48
Asteraceae	*Cineraria erodioides* DC. var. *erodioides*	Clark VR, Ramdhani S 336
Asteraceae	*Cineraria geraniifolia* DC.	Clark VR, Coombs G 6
Asteraceae	*Cineraria lobata* L'Hér.	Clark VR, Te Water Naudé T 116
Asteraceae	*Cineraria mollis* E.Mey. ex DC.	Clark VR, Coombs G 248
Asteraceae	*Cineraria platycarpa* DC.	Bolus H 98
Asteraceae	*Cirsium vulgare* (Savi) Ten.*	Clark VR, McKenzie RJ 398
Asteraceae	*Conyza canadensis* (L.) Cronquist*	Clark VR, McKenzie RJ 342
Asteraceae	*Conyza pinnata* (L.f.) Kuntze	Clark VR, McKenzie RJ 206
Asteraceae	*Conyza podocephala* DC.	Clark VR, Ngcobo L, Pienaar C 103
Asteraceae	*Conyza scabrida* DC.	Clark VR, McKenzie RJ 58
Asteraceae	*Cotula coronopifolia* L.	Clark VR, Pienaar C 311
Asteraceae	*Cotula hispida* (DC.) Harv.	Clark VR, Coombs G 141
Asteraceae	*Cotula microglossa* (DC.) O.Hoffm. & Kuntze ex Kuntze complex sp. no. 1 (Mucina, pers. comm.)	Clark VR, McKenzie RJ 145
Asteraceae	*Cotula microglossa* (DC.) O.Hoffm. & Kuntze ex Kuntze complex sp. no. 2 (Mucina, pers. comm.)	Barker NP 1471
Asteraceae	*Cotula* sp. no. 1 (Mucina, pers. comm.)	Clark VR, Ngcobo L, Pienaar C 326
Asteraceae	*Cuspidia cernua* subsp. *annua* (Less.) Roessler	Bolus H 540
Asteraceae	*Dicerothamnus rhinocerotis* (L.f.) Koekemoer	Clark VR, Barker NP, Devos N 29
Asteraceae	*Dicoma capensis* Less.	Bolus H 447
Asteraceae	*Dicoma spinosa* (L.) Druce	Weale JM 145
Asteraceae	*Dimorphotheca cuneata* (Thunb.) Less.	Clark VR, Devos N, McKenzie RJ 111
Asteraceae	*Eriocephalus aromaticus* C.A.Sm.	Clark VR, Barker NP, Devos N 26
Asteraceae	*Eriocephalus ericoides* (L.f.) Druce subsp. *ericoides*	Clark VR, Ngcobo L, Pienaar C 315
Asteraceae	*Eriocephalus eximius* DC.	Müller et al. (2001)
Asteraceae	*Eriocephalus tenuifolius* DC.	Müller et al. (2001)
Asteraceae	*Eumorphia dregeana* DC.	McKenzie RJ, Weston P, Clark VR 156
Asteraceae	*Euryops annae* E.Phillips	Clark VR, Coombs G 81
Asteraceae	*Euryops candollei* Harv.	McKenzie RJ, Weston P, Clark VR 120
Asteraceae	*Euryops* cf. *abrotanifolius* (L.) DC. (Devos, pers. comm.)	McKenzie RJ, Weston P, Clark VR 134
Asteraceae	*Euryops dentatus* B.Nord.	Clark VR, Pienaar C 381
Asteraceae	*Euryops empetrifolius* DC.	Clark VR, Pienaar C 396
Asteraceae	*Euryops floribundus* N.E.Br.	Clark VR, Te Water Naudé T 143
Asteraceae	*Euryops galpinii* Bolus	McKenzie RJ, Weston P, Clark VR 176
Asteraceae	*Euryops lateriflorus* (L.f.) DC.	Clark VR, Ngcobo L, Pienaar C 295
Asteraceae	*Euryops munitus* (L.f.) B.Nord.	Clark VR, Ngcobo L, Pienaar C 38A
Asteraceae	*Euryops oligoglossus* DC. subsp. *oligoglossus*	Bolus H 1793
Asteraceae	*Euryops petraeus* B.Nord.	Clark VR, Devos N, McKenzie RJ 2
Asteraceae	*Euryops exsudans* B.Nord. & V.R.Clark	Clark VR, Coombs G 110
Asteraceae	*Euryops proteoides* B.Nord. & V.R.Clark	Clark VR, Coombs G 105
Asteraceae	*Euryops subcarnosus* subsp. *vulgaris* B.Nord.	Nordenstam (1969)
Asteraceae	*Euryops trilobus* Harv.	Clark VR, Coombs G 256
Asteraceae	*Felicia burkei* (Harv.) L.Bolus	MacOwan P 1629
Asteraceae	*Felicia fascicularis* DC.	Clark VR, Coombs G 574
Asteraceae	*Felicia filifolia* subsp. *bodkinii* (Compton) Grau	Clark VR, Te Water Naudé T 351
Asteraceae	*Felicia hirsuta* DC.	Clark VR, Rose M 455
Asteraceae	*Felicia ovata* (Thunb.) Compton	Bolus H s.n.
Asteraceae	*Felicia rosulata* Yeo	Clark VR, Coombs G 174
Asteraceae	*Foveolina* sp. no. 1 (Mucina, pers. comm.)	Clark VR, Rose M 365
Asteraceae	*Garuleum bipinnatum* (Thunb.) Less	Bolus H 2060
Asteraceae	*Garuleum pinnatifidum* (Thunb.) DC.	Clark VR, Te Water Naudé T 248
Asteraceae	*Gazania caespitosa* Bolus	Clark VR, Ramdhani S 448
Asteraceae	*Gazania heterochaeta* DC.	Clark VR, Devos N, McKenzie RJ 159
Asteraceae	*Gazania krebsiana* Less. subsp. *krebsiana*	Clark VR, Coombs G 350
Asteraceae	*Gazania linearis* (Thunb.) Druce var. *linearis*	McKenzie RJ, Weston P, Clark VR 42
Asteraceae	*Geigeria filifolia* Mattf.	Clark VR, Pienaar C, Lochner EJ 271
Asteraceae	*Geigeria ornativa* O.Hoffm. subsp. *ornativa*	Bolus H 369
Asteraceae	*Gerbera piloselloides* (L.) Cass.	Clark VR, Coombs G 99
Asteraceae	*Gnaphalium capense* Hilliard	Hilliard (1983)

Asteraceae	*Gnaphalium confine* Harv.	Clark VR, Coombs G 324
Asteraceae	*Gnaphalium vestitum* Thunb.	Hilliard (1983)
Asteraceae	*Gymnopentzia bifurcata* Benth.	Clark VR, McKenzie RJ 297
Asteraceae	*Haplocarpha nervosa* (Thunb.) Beauverd	Clark VR, Te Water Naudé T 232
Asteraceae	*Haplocarpha scaposa* Harv.	Clark VR, Coombs G 365
Asteraceae	*Helichrysum albo-brunneum* S.Moore	Clark VR, Coombs G 138
Asteraceae	*Helichrysum anomalum* Less.	Clark VR, Barker NP, Devos N 37
Asteraceae	*Helichrysum asperum* var. *appressifolium* (Moeser) Hilliard	Clark VR, Coombs G 128
Asteraceae	*Helichrysum aureum* (Houtt.) Merr. var. *aureum*	Clark VR, Coombs G 132
Asteraceae	*Helichrysum cerastioides* DC. var. *cerastioides*	Barker NP 1518
Asteraceae	*Helichrysum cooperi* Harv.	Clark VR, Crause I 191
Asteraceae	*Helichrysum dregeanum* Sond. & Harv.	Clark VR, Ngcobo L, Pienaar C 358
Asteraceae	*Helichrysum grandibracteatum* M.D.Hend.	Hilliard (1983)
Asteraceae	*Helichrysum hamulosum* E.Mey. ex DC.	Clark VR, Coombs G 394
Asteraceae	*Helichrysum melanacme* DC.	Hilliard (1983)
Asteraceae	*Helichrysum miconiifolium* DC.	Clark VR, Coombs G 117
Asteraceae	*Helichrysum montanum* DC.	Clark VR, Coombs G 135
Asteraceae	*Helichrysum mundtii* Harv.	Clark VR, Crause I 83
Asteraceae	*Helichrysum nanum* Klatt	MacOwan P 1472
Asteraceae	*Helichrysum nudifolium* (L.) Less. var. *nudifolium*	Clark VR, Coombs G 326
Asteraceae	*Helichrysum nudifolium* var. *oxyphyllum* (DC.) Beentje	MacOwan P s.n.
Asteraceae	*Helichrysum nudifolium* var. *pilosellum* (L.f.) Beentje	Clark VR, Ramdhani S 271
Asteraceae	*Helichrysum odoratissimum* (L.) Sweet	McKenzie RJ, Weston P, Clark VR 362
Asteraceae	*Helichrysum pallidum* DC.	Hilliard (1983)
Asteraceae	*Helichrysum pedunculatum* Hilliard & B.L.Burtt	Hilliard (1983)
Asteraceae	*Helichrysum psilolepis* Harv.	Hilliard (1983)
Asteraceae	*Helichrysum pumilio* (O.Hoffm.) Hilliard & B.L.Burtt subsp. *pumilio*	Hilliard (1983)
Asteraceae	*Helichrysum rosum* var. *arcuatum* Hilliard	Barker NP 1525
Asteraceae	*Helichrysum rosum* (P.J.Bergius) Less. var. *rosum*	McKenzie RJ, Weston P, Clark VR 106A
Asteraceae	*Helichrysum rugulosum* Less.	Clark VR, Coombs G 480
Asteraceae	*Helichrysum rutilans* (L.) D.Don.	Clark VR, Ngcobo L, Pienaar C 202
Asteraceae	*Helichrysum scitulum* Hilliard & B.L.Burtt	Clark VR, Barker NP, Devos N 25
Asteraceae	*Helichrysum sessile* DC.	Clark VR, Barker NP, Devos N 19
Asteraceae	*Helichrysum* sp. no. 1	Clark VR, Crause I 60
Asteraceae	*Helichrysum splendidum* (Thunb.) Less.	Clark VR, Coombs G 57
Asteraceae	*Helichrysum stoloniferum* (L.f.) Willd.	Hilliard (1983)
Asteraceae	*Helichrysum subglomeratum* Less.	Clark VR, Coombs G 338
Asteraceae	*Helichrysum tenuiculum* DC.	Clark VR, Barker NP, Devos N 49
Asteraceae	*Helichrysum tinctum* (Thunb.) Hilliard & B.L.Burtt	Hilliard (1983)
Asteraceae	*Helichrysum trilineatum* DC.	Clark VR, Barker NP, Devos N 25
Asteraceae	*Helichrysum tysonii* Hilliard	Hilliard (1983)
Asteraceae	*Helichrysum umbraculigerum* Less.	Clark VR, Coombs G 143
Asteraceae	*Helichrysum xerochrysum* DC.	MacOwan P 568
Asteraceae	*Helichrysum zeyheri* Less.	Clark VR, Coombs G 660
Asteraceae	*Ifloga decumbens* (Thunb.) Schltr.	Hilliard (1981)
Asteraceae	*Ifloga glomerata* (Harv.) Schltr.	Clark VR, Pienaar C 427
Asteraceae	*Kleinia longiflora* DC.	Bolus H 99
Asteraceae	*Lactuca inermis* Forssk.	Clark VR, Coombs G 202
Asteraceae	*Lactuca serriola* L.*	Field Observation
Asteraceae	*Lasiospermum bipinnatum* (Thunb.) Druce	Clark VR, Coombs G 88
Asteraceae	*Leysera gnaphalodes* (L.) L.	Clark VR, Barker NP, Devos N 4
Asteraceae	*Microglossa mespilifolia* (Less.) B.L.Rob.	Bolus H 308
Asteraceae	*Nidorella agria* Hilliard	Clark VR, Coombs G 378
Asteraceae	*Oligocarpus calendulaceus* (L.f.) Less.	Tyson W 40
Asteraceae	*Oncosiphon piluliferum* (L.f.) Källersjö	Leistner OA 489
Asteraceae	*Osteospermum grandidentatum* DC.	Clark VR, Devos N, McKenzie RJ 134
Asteraceae	*Osteospermum herbaceum* L.f.	Bolus H 1750
Asteraceae	*Othonna auriculifolia* Licht. ex Less.	Bolus H 602
Asteraceae	*Othonna carnosa* Less. var. *carnosa*	Clark VR, Coombs G 634
Asteraceae	*Othonna patula* Schltr.	Clark VR, Devos N, McKenzie RJ 5
Asteraceae	*Othonna pavonia* E.Mey. ex DC.	Clark VR, Pienaar C, Lochner EJ 346
Asteraceae	*Pegolettia baccharidifolia* Less.	Clark VR, Ramdhani S 396
Asteraceae	*Pegolettia retrofracta* (Thunb.) Kies	Clark VR, McKenzie RJ 85
Asteraceae	*Pentzia cooperi* Harv.	Clark VR, Coombs G 124

Asteraceae	*Sonchus asper* (L.) Hill*	Clark VR, Rose M 128
Asteraceae	*Sonchus dregeanus* DC.	Clark VR, Coombs G 202
Asteraceae	*Sonchus oleraceus* L.*	Clark VR, Pienaar C s.n.
Asteraceae	*Tagetes minuta* L.*	Field Observation
Asteraceae	*Taraxacum officinale* Weber (sens. lat.)*	Clark VR, Ramdhani S 220
Asteraceae	*Tarchonanthus minor* Less.	Clark VR, Te Water Naudé T 358
Asteraceae	*Tolpis capensis* (L.) Sch.Bip.	Clark VR, Coombs G 108
Asteraceae	*Troglophyton capillaceum* subsp. *diffusum* (DC.) Hilliard	Clark VR, Barker NP, Devos N 44
Asteraceae	*Ursinia montana* subsp. *apiculata* (DC.) Prassler	Clark VR, Devos N, McKenzie RJ 165
Asteraceae	*Verbesina encelioides* (Cav.) Benth. & Hook.f. ex A.Gray var. *encelioides**	Pond et al. (2002)
Asteraceae	*Vernonia capensis* (Houtt.) Druce	Clark VR, Te Water Naudé T 144
Asteraceae	*Xanthium spinosum* L.*	Clark VR, Pienaar C 392
Bignoniaceae	*Rhigozum obovatum* Burch.	Barker NP 1455
Boraginaceae	*Anchusa capensis* Thunb.	Clark VR, Coombs G 188
Boraginaceae	*Anchusa riparia* DC.	Wright (1904)
Boraginaceae	*Cynoglossum geometricum* Baker & C.H.Wright	Wright (1904)
Boraginaceae	*Cynoglossum hispidum* Thunb.	Clark VR, McKenzie RJ 131
Boraginaceae	*Cynoglossum lanceolatum* Forssk.	Wright (1904)
Boraginaceae	*Echium vulgare* L.*	Barker NP 1467
Boraginaceae	*Ehretia rigida* (Thunb.) Druce subsp. *rigida*	Clark VR, Ramdhani S 422
Boraginaceae	*Lappula capensis* (A.DC.) Gürke	Barker NP 1521
Boraginaceae	*Lappula squarrosa* (Retz.) Dumort.*	Wright (1904)
Boraginaceae	*Lithospermum affine* A.DC.	McKenzie RJ, Weston P, Clark VR 131
Boraginaceae	*Lithospermum cinereum* A.DC.	Wright (1904)
Boraginaceae	*Lithospermum scabrum* Thunb.	Wright (1904)
Boraginaceae	*Lobostemon argenteus* (P.J.Bergius) H.Buek	Wright (1904)
Boraginaceae	*Lobostemon echioides* Lehm.	Weimarck (1941)
Boraginaceae	*Myosotis arvensis* (L.) Hill*	Wright (1904)
Boraginaceae	*Myosotis sylvatica* Hoffm.*	Wright (1904)
Brassicaceae	*Arabidopsis thaliana* (L.) Heynh.	Marais (1970)
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.*	Pond et al. (2002)
Brassicaceae	*Cardamine africana* L.	MacOwan P 210
Brassicaceae	*Cardaria draba* (L.) Desv.*	Pond et al. (2002)
Brassicaceae	*Cleome angustifolia* subsp. *diandra* (Burch.) Kers.	Bolus H 773
Brassicaceae	*Descurainia sophia* (L.) Webb ex Prantl*	Bolus H s.n.
Brassicaceae	*Erucastrum arabicum* Fisch. & C.A.Mey.	Clark VR, Coombs G 63
Brassicaceae	*Erucastrum strigosum* (Thunb.) O.E.Schulz	Bolus H 204
Brassicaceae	*Heliophila carnosa* (Thunb.) Steud.	Marais (1970)
Brassicaceae	*Heliophila rigidiuscula* Sond.	McKenzie RJ, Weston P, Clark VR 150
Brassicaceae	*Heliophila suavissima* Burch. ex DC.	Barker NP 1441
Brassicaceae	*Heliophila subulata* Burch. ex DC.	McKenzie RJ, Weston P, Clark VR 77
Brassicaceae	*Lepidium transvaalense* Marais	Clark VR, Devos N, McKenzie RJ 21
Brassicaceae	*Matthiola torulosa* DC.	Bolus H 647
Brassicaceae	*Nasturtium officinale* R.Br.	Clark VR, McKenzie RJ 403
Brassicaceae	*Rorippa fluviatilis* (E. Mey. ex Sond.) Thell.	MacOwan P 1429
Brassicaceae	*Rorippa nudiuscula* Thell.	MacOwan P 1592
Brassicaceae	*Sisymbrium capense* Thunb.	Clark VR, Coombs G 286
Brassicaceae	*Sisymbrium thellungii* O.E.Schulz	MacOwan P 955
Brassicaceae	*Sisymbrium turczaninowii* Sond.	Clark VR, Coombs G 113
Brassicaceae	*Turritis glabra* L.*	Clark VR, Rose M 520
Buddlejaceae	*Buddleja auriculata* Benth.	Verdoorn (1963)
Buddlejaceae	*Buddleja glomerata* H.L.Wendl.	Clark VR, Coombs G 11
Buddlejaceae	*Buddleja salviifolia* (L.) Lam.	Clark VR, Coombs G 60
Buddlejaceae	*Gomphostigma virgatum* (L.f.) Baill.	Clark VR, Te Water Naudé T 369
Cactaceae	*Opuntia ficus-indica* (L.) Mill.*	Henderson (2001)
Cactaceae	*Opuntia imbricata* (Haw.) DC.*	Henderson (2001)
Cactaceae	*Echinopsis spachiana* (Lem.) Friedrich & G.D.Rowley*	Henderson (2001)
Campanulaceae	*Craterocapsa montana* (A.DC.) Hilliard & B.L.Burtt	Clark VR, Ramdhani S 168
Campanulaceae	*Wahlenbergia albens* (Spreng. ex A.DC.) Lammers	Clark VR, Coombs G 424
Campanulaceae	*Wahlenbergia* cf. *androsacea* A.DC. (Cupido, pers. comm.)	Clark VR, Devos N, McKenzie RJ 161
Campanulaceae	*Wahlenbergia denticulata* (Burch.) A.DC.	Adamson (1955b)
Campanulaceae	*Wahlenbergia grandiflora* Brehmer*	Clark VR, Coombs G 193
Campanulaceae	*Wahlenbergia juncea* (H.Buek) Lammers	McKenzie RJ, Weston P, Clark VR 191
Campanulaceae	*Wahlenbergia krebsii* Cham. subsp. *krebsii*	Clark VR, Coombs G 180

Campanulaceae	*Wahlenbergia laxiflora* (Sond.) Lammers	Adamson (1955b)
Campanulaceae	*Wahlenbergia nodosa* (H.Buek) Lammers	Clark VR, Devos N, McKenzie RJ 15
Campanulaceae	*Wahlenbergia tenella* (L.f.) Lammers var. *tenella*	Adamson (1955b)
Campanulaceae	*Wahlenbergia thunbergiana* (H.Buek.) Lammers	Adamson (1955b)
Campanulaceae	*Wahlenbergia undulata* (L.f.) A.DC.	Clark VR, Coombs G 489
Capparaceae	*Boscia oleoides* (Burch. ex DC.) Tölken	Clark VR, Ramdhani S 415
Caryophyllaceae	*Cerastium capense* Sond.	Clark VR, Coombs G 190
Caryophyllaceae	*Cerastium glomeratum* Thuill.	Clark VR, Coombs G 583
Caryophyllaceae	*Dianthus caespitosa* Thunb.	Tyson W 17
Caryophyllaceae	*Dianthus micropetalus* Ser.	Clark VR, Barker NP, Devos N 35
Caryophyllaceae	*Dianthus namaensis* Schinz var. *namaensis*	Hooper (1959)
Caryophyllaceae	*Scleranthus annuus* L.*	Clark VR, Pienaar C 428
Caryophyllaceae	*Silene burchellii* var. *angustifolia* Sond.	Clark VR, Coombs G 228
Caryophyllaceae	*Silene undulata* Aiton	Clark VR, Coombs G 161
Caryophyllaceae	*Stellaria media* (L.) Vill.*	Clark VR, Pienaar C 53
Celastraceae	*Gymnosporia buxifolia* (L.) Szyszyl.	Clark VR, Coombs G 17
Celastraceae	*Gymnosporia linearis* (L.f.) Loes. subsp. *linearis*	Clark VR, Ramdhani S 406
Celastraceae	*Gymnosporia polyacanthus* (Sond.) Szyszyl. subsp. *polyacanthus*	Rogers FA 2762
Celastraceae	*Maytenus acuminata* (L.f.) Loes. var. *acuminata*	Clark VR, Te Water Naudé T 15
Celastraceae	*Maytenus undata* (Thunb.) Blakelock	Clark VR, Te Water Naudé T 371
Celastraceae	*Mystroxylon aethiopicum* (Thunb.) Loes. subsp. *aethiopicum*	Clark VR, Rose M 32
Chenopodiaceae	*Atriplex erosa* Brueckner & Verdoom	Bolus H 656
Chenopodiaceae	*Atriplex lindleyi* subsp. *inflata* (F.Muell.) P.G.Wilson*	Henderson (2001)
Chenopodiaceae	*Atriplex nummalaria* Lindl. subsp. *nummalaria**	Henderson (2001)
Chenopodiaceae	*Atriplex vestita* (Thunb.) Aellen	Bolus H 661
Chenopodiaceae	*Chenopodium ambrosioides* L.*	Bolus H 67
Chenopodiaceae	*Chenopodium album* L.*	Clark VR, Coombs G 360
Chenopodiaceae	*Chenopodium carinatum* R.Br. *	Clark VR, Ngcobo L, Pienaar C 285
Chenopodiaceae	*Chenopodium foliosum* Asch.	Clark VR, Ngcobo L, Pienaar C 137
Chenopodiaceae	*Chenopodium murale* L. var. *murale**	MacOwan P s.n.
Chenopodiaceae	*Chenopodium schraderianum* Roem. & Schult.*	Clark VR, Ngcobo L, Pienaar C 97
Chenopodiaceae	*Salsola aphylla* L.f.	Henderson (2001)
Chenopodiaceae	*Salsola kali* L.*	Henderson (2001)
Chenopodiaceae	*Suaeda fruticosa* (L.) Forssk.	Dyer RA 1029
Convolvulaceae	*Convolvulus galpinii* C.H.Wright	Clark VR, Ngcobo L, Pienaar C 108
Convolvulaceae	*Convolvulus sagittatus* Thunb.	Clark VR, Coombs G 471
Convolvulaceae	*Cuscuta campestris* Yunck.*	Clark VR, Pienaar C, Lochner EJ 286
Convolvulaceae	*Dichondra micrantha*Urb.*	Clark VR, Pienaar C 624
Convolvulaceae	*Falckia oblonga* Bernh. ex Kraus	Meeuse and Welman (2000)
Convolvulaceae	*Ipomoea oenotheroides* (L.f.) Raf. ex Hallier f.	Clark VR, Pienaar C, Lochner EJ 172
Crassulaceae	*Adromischus bicolor* P.C.Hutch.	Tölken (1985)
Crassulaceae	*Adromischus cooperi* (Baker) A.Berger	Tölken (1985)
Crassulaceae	*Adromischus cristatus* (Harv.) Lem. subsp. *cristatus*	Tölken (1985)
Crassulaceae	*Adromischus fallax* Tölken	Tölken (1978, 1985)
Crassulaceae	*Adromischus sphenophyllus* C.A.Sm.	Tölken (1985)
Crassulaceae	*Adromischus trigynus* (Burch.) V.Poelln.	Bolus H 187
Crassulaceae	*Cotyledon campanulata* Marloth	Clark VR, Te Water Naudé T 366
Crassulaceae	*Cotyledon orbiculata* var. *oblonga* (Haw.) DC.	Van Jaarsveld and Koutnik (2004)
Crassulaceae	*Cotyledon orbiculata* L. var. *orbiculata*	Van Jaarsveld and Koutnik (2004)
Crassulaceae	*Cotyledon papillaris* L.f.	Clark VR, Pienaar C 197
Crassulaceae	*Cotyledon velutina* Hook.f.	Van Jaarsveld and Koutnik (2004)
Crassulaceae	*Crassula capitella* Thunb. subsp. *capitella*	Tölken (1977)
Crassulaceae	*Crassula capitella* subsp. *thyrsiflora* (Thunb.) Tölken	Tölken (1977)
Crassulaceae	*Crassula corallina* Thunb. subsp. *corallina*	Clark VR, Te Water Naudé T 221
Crassulaceae	*Crassula cultrata* L.	Clark VR, Coombs G 52
Crassulaceae	*Crassula dependens* Bolus	Clark VR, Coombs G 36
Crassulaceae	*Crassula exilis* subsp. *cooperi* (Regel) Tölken	Clark VR, Crause I 27
Crassulaceae	*Crassula expansa* Dryand. subsp. *expansa*	Tölken (1977)
Crassulaceae	*Crassula lanceolata* (Eckl. & Zeyh.) Endl. ex Walp. subsp. *lanceolata*	Clark VR, Coombs G 39
Crassulaceae	*Crassula lanceolata* subsp. *transvaalensis* (Kuntze) Tölken	Clark VR, Ngcobo L, Pienaar C 214
Crassulaceae	*Crassula lanuginosa* Harv. var. *lanuginosa*	Clark VR, Ramdhani S 84
Crassulaceae	*Crassula lanuginosa* var. *pachystemon* (Schönland & Baker f.) Tölken	Clark VR, Devos N, McKenzie RJ 43
Crassulaceae	*Crassula montana* subsp. *triangularis* (Schönland.) Tölken	Clark VR, Ramdhani S 382

Crassulaceae	*Crassula muscosa* L. var. *muscosa*	Tölken (1977)
Crassulaceae	*Crassula muscosa* var. *parvula* (Eckl. & Zeyh.) Tölken	Tölken (1977)
Crassulaceae	*Crassula muscosa* var. *polpodacea* (Eckl. & Zeyh.) G.D.Rowley	Clark VR, Ramdhani S 372
Crassulaceae	*Crassula natans* Thunb. var. *natans*	Clark VR, Te Water Naudé T 318
Crassulaceae	*Crassula nemorosa* (Eckl. & Zeyh.) Endl. ex Walp.	Clark VR, Ramdhani S 171
Crassulaceae	*Crassula nudicaulis* var. *nudicaulis*	Tölken (1977)
Crassulaceae	*Crassula obovata* Haw. var. *obovata*	Clark VR, Coombs G 417
Crassulaceae	*Crassula orbicularis* L.	Tölken (1977)
Crassulaceae	*Crassula ovata* (Mill.) Druce	Tölken (1977)
Crassulaceae	*Crassula pellucida* subsp. *brachypetala* (Drège ex Harv.) Tölken	Clark VR, Barker NP, Devos N 2
Crassulaceae	*Crassula perforata* Thunb.	Clark VR, Coombs G 547
Crassulaceae	*Crassula pubescens* subsp. *rattrayi* (Schönland & Baker f.) Tölken	Tölken (1977)
Crassulaceae	*Crassula rupestris* Thunb. subsp. *rupestris*	Tölken (1977)
Crassulaceae	*Crassula sarcocaulis* Eckl. & Zeyh. subsp. *sarcocaulis*	Clark VR, Coombs G 232
Crassulaceae	*Crassula saxifraga* Harv.	Tölken (1977)
Crassulaceae	*Crassula setulosa* Harv. var. *setulosa*	Clark VR, Barker NP, Devos N 1
Crassulaceae	*Crassula spathulata* Thunb.	Tölken (1977)
Crassulaceae	*Crassula subaphylla* (Eckl. & Zeyh.) Harv.	Clark VR, Pienaar C, Lochner EJ 335
Crassulaceae	*Crassula tetragona* subsp. *acutifolia* (Lam.) Tölken	Tölken (1977)
Crassulaceae	*Crassula vaillantii* (Willd.) Roth	Clark VR, Ngcobo L, Pienaar C 127
Crassulaceae	*Tylecodon reticulatus* (L.f.) Tölken subsp. *reticulatus*	Van Jaarsveld and Koutnik (2004)
Crassulaceae	*Tylecodon ventricosus* (Burm.f.) Tölken	Van Jaarsveld and Koutnik (2004)
Cucurbitaceae	*Coccinea sessilifolia* (Sond.) Cogn.	Clark VR, Pienaar C, Lochner EJ 224
Cucurbitaceae	*Cucumis* cf. *myriocarpus* Naud.	Clark VR, Ngcobo L, Pienaar C 107
Cucurbitaceae	*Kedrostis africana* (L.) Cogn.	Clark VR, Ngcobo L, Pienaar C 339
Dipsacaceae	*Scabiosa columbaria* L.	Clark VR, Coombs G 172
Ebenaceae	*Diospyros austro-africana* var. *microphylla* (Burch.) De Winter	Clark VR, Barker NP, Devos N 36
Ebenaceae	*Diospyros lycioides* Desf. subsp. *lycioides*	Clark VR, Barker NP, Devos N 9
Ebenaceae	*Diospyros scabrida* var. *cordata* (E.Mey. ex A.DC.) De Winter	Clark VR, Coombs G 562
Ebenaceae	*Euclea coriacea* A.DC.	Clark VR, Coombs G 93
Ebenaceae	*Euclea crispa* (Thunb.) Gürke subsp. *crispa*	Clark VR, Coombs G 16
Ebenaceae	*Euclea crispa* subsp. *ovata* (Burch.) F.White	Clark VR, Ngcobo L, Pienaar C 67
Ericaceae	*Erica alopecurus* Harv. var. *alopecurus*	Baker and Oliver (1967)
Ericaceae	*Erica amatolensis* E.G.H.Oliv.	Weimarck (1941)
Ericaceae	*Erica brownleeae* Bolus	Baker and Oliver (1967)
Ericaceae	*Erica caespitosa* Hilliard & B.L.Burtt	Clark VR, Ramdhani S 445
Ericaceae	*Erica caffrorum* Bolus var. *caffrorum*	Clark VR, Ramdhani S 447
Ericaceae	*Erica leucopelta* Tausch	Clark VR, Ramdhani S 289
Ericaceae	*Erica passerinoides* (Bolus) E.G.H.Oliv.	Oliver, pers. comm.
Ericaceae	*Erica* sp. aff. *reenensis* Zahlbr. (Oliver, pers. comm.)	Clark VR, Coombs G 164
Ericaceae	*Erica woodii* Bolus var. *woodii*	Clark VR, Coombs G 386
Euphorbiaceae	*Adenocline pauciflora* Turcz.	Clark VR, Te Water Naudé T 70
Euphorbiaceae	*Clutia alaternoides* L.	Clark VR, Crause I 10
Euphorbiaceae	*Clutia hirsuta* (Sond.) Müll.Arg. var. *hirsuta*	Brown et al. (1925)
Euphorbiaceae	*Clutia impedita* Prain	Clark VR, Coombs G 319
Euphorbiaceae	*Clutia monticola* S.Moore var. *monticola*	Clark VR, Coombs G 569
Euphorbiaceae	*Clutia pulchella* L. var. *pulchella*	Clark VR, Coombs G 46
Euphorbiaceae	*Euphorbia aggregata* A.Berger var. *aggregata*	Pond et al. (2002)
Euphorbiaceae	*Euphorbia aequoris* N.E.Br.	White et al. (1941)
Euphorbiaceae	*Euphorbia caterviflora* N.E.Br.	Pond et al. (2002)
Euphorbiaceae	*Euphorbia clavarioides* Boiss. var. *clavarioides*	Clark VR, Ngcobo L, Pienaar C 263
Euphorbiaceae	*Euphorbia epicyparissias* E.Mey. ex Boiss.	Clark VR, Barker NP, Devos N 22
Euphorbiaceae	*Euphorbia mauritanica* L. var. *mauritanica*	Clark VR, Ramdhani S 249
Euphorbiaceae	*Euphorbia micracantha* Boiss.	Pond et al. (2002)
Euphorbiaceae	*Euphorbia rhombifolia* N.E.Br.	White et al. (1941)
Fabaceae	*Acacia karroo* Hayne	Clark VR, Te Water Naudé T 209
Fabaceae	*Argyrolobium argenteum* (Jacq.) Eckl. & Zeyh.	Clark VR, Ngcobo L, Pienaar C 182
Fabaceae	*Argyrolobium candicans* Eckl. & Zeyh.	Clark VR, Coombs G 335
Fabaceae	*Argyrolobium rarum* Dummer	Clark VR, Coombs G 150
Fabaceae	*Argyrolobium tomentosum* (Andrews) Druce	Clark VR, Coombs G 2
Fabaceae	*Aspalathus acicularis* E.Mey. subsp. *acicularis*	Clark VR, Coombs G 439
Fabaceae	*Dichilus gracilis* Eckl. & Zeyh.	Bolus H 445
Fabaceae	*Dolichos angustifolius* Eckl. & Zeyh.	Clark VR, Coombs G 452
Fabaceae	*Dolichos linearis* E.Mey.	Clark VR, Ramdhani S 188

Fabaceae	*Gleditsia triacanthos* L.*	Henderson (2001)
Fabaceae	*Indigastrum argyraeum* (Eckl. & Zeyh.) Schrire	Clark VR, Ramdhani S 391
Fabaceae	*Indigofera alpina* Eckl. & Zeyh.	Clark VR, Barker NP, Devos N 10
Fabaceae	*Indigofera alternans* DC. var. *alternans*	Clark VR, McKenzie RJ 55
Fabaceae	*Indigofera alternans* var. *effusa* (E.Mey.) Schrire ined. (Schrire, pers. comm.)	Clark VR, Pienaar C, Lochner EJ 125
Fabaceae	*Indigofera burchellii* DC.	Clark VR, Coombs G 14
Fabaceae	*Indigofera cuneifolia* Eckl. & Zeyh. var. *cuneifolia*	Clark VR, Coombs G 330
Fabaceae	*Indigofera disticha* Eckl. & Zeyh. (possibly a new variety; Schrire, pers. comm.)	Clark VR, Coombs G 433
Fabaceae	*Indigofera heterophylla* Thunb.	Clark VR, Te Water Naudé T 375
Fabaceae	*Indigofera leptocarpa* Eckl. & Zeyh.	Clark VR, Ramdhani S 401
Fabaceae	*Indigofera meyeriana* Eckl. & Zeyh.	Clark VR, Te Water Naudé T 360
Fabaceae	*Indigofera mollis* Eckl. & Zeyh.	Clark VR, Coombs G 395
Fabaceae	*Indigofera sessilifolia* DC.	Clark VR, Ngcobo L, Pienaar C 324
Fabaceae	*Indigofera* sp. nov. 1 (Schrire, pers. comm.)	Clark VR, Te Water Naudé T 335
Fabaceae	*Indigofera* sp. nov. 2 (Schrire, pers. comm.)	Clark VR, Coombs G 208
Fabaceae	*Indigofera zeyheri* Spreng. ex Eckl. & Zeyh.	Clark VR, Te Water Naudé T 80
Fabaceae	*Lessertia annularis* Burch.	Bolus H s.n.
Fabaceae	*Lessertia depressa* Harv.	MacOwan P 1362
Fabaceae	*Lessertia perennans* var. *sericea* L.Bol.	Clark VR, Rose M 59
Fabaceae	*Lessertia sneeuwbergensis* Germish.	Germishuizen (1992)
Fabaceae	*Lotononis caerulescens* (E.Mey.) B.-E.Van Wyk	Clark VR, Coombs G 15
Fabaceae	*Lotononis* cf. *galpinii* Dummer	McKenzie RJ, Weston P, Clark VR 112
Fabaceae	*Lotononis decumbens* (Thunb.) B.-E.Van Wyk subsp. *decumbens*	Clark VR, Te Water Naudé T 178
Fabaceae	*Lotononis fruticoides* B.-E.Van Wyk	Van Wyk (1991)
Fabaceae	*Lotononis laxa* Eckl. & Zeyh.	Clark VR, Coombs G 50
Fabaceae	*Lotononis lenticula* (E.Mey.) Benth.	Van Wyk (1991)
Fabaceae	*Lotononis pulchella* (E.Mey.) B.-E.Van Wyk	Van Wyk (1991)
Fabaceae	*Lotononis pungens* Eckl. & Zeyh.	McKenzie RJ, Weston P, Clark VR 35
Fabaceae	*Lotononis pusilla* Dummer	Van Wyk (1991)
Fabaceae	*Lotononis sericophylla* Benth.	Clark VR, Devos N, McKenzie RJ 128
Fabaceae	*Medicago laciniata* (L.) Mill. var. *laciniata**	MacOwan P 1650
Fabaceae	*Medicago polymorpha* L.*	Clark VR, Ramdhani S 126
Fabaceae	*Melolobium adenodes* Eckl. & Zeyh.	Clark VR, Barker NP, Devos N 45
Fabaceae	*Melolobium calycinum* Benth.	Moteetee and Van Wyk (2006)
Fabaceae	*Melolobium candicans* (E.Mey.) Eckl. & Zeyh.	Clark VR, Barker NP, Devos N 32
Fabaceae	*Melolobium microphyllum* (L.f.) Eckl. & Zeyh.	Barker NP 1457
Fabaceae	*Melolobium obcordatum* Harv.	Clark VR, Te Water Naudé T 35
Fabaceae	*Otholobium candicans* (Eckl. & Zeyh.) C.H.Stirt.	Forbes (1930)
Fabaceae	*Otholobium macradenium* (Harv.) C.H.Stirt.	Clark VR, Barker NP, Devos N 30
Fabaceae	*Prosopis glandulosa* var. *torreyana* (Benson) Johnst.*	Henderson (2001)
Fabaceae	*Psoralea glabra* E.Mey.	Clark VR, Coombs G 101
Fabaceae	*Rhynchosia minima* var. *prostrata* (Harv.) Meikle	Clark VR, Ramdhani S 3
Fabaceae	*Rhynchosia totta* (Thunb.) DC. var. *totta*	Clark VR, Te Water Naudé T 81
Fabaceae	*Robinia pseudacacia* L.*	Clark VR, Coombs G 575
Fabaceae	*Sutherlandia frutescens* (L.) R.Br.	Clark VR, Barker NP, Devos N 23
Fabaceae	*Trifolium africanum* Ser. var. *africanum*	Clark VR, Ngcobo L, Pienaar C 124
Fabaceae	*Trifolium burchellianum* Ser. subsp. *burchellianum*	Clark VR, Coombs G 244
Fabaceae	*Trifolium repens* L.*	Clark VR, Rose M 131
Fabaceae	*Vicia sativa* L. subsp. *sativa**	Clark VR, Coombs G 501
Flacourtiaceae	*Dovyalis zeyheri* (Sond.) Warb.	MacOwan P 1324
Flacourtiaceae	*Kiggelaria africana* L.	McKenzie RJ, Weston P, Clark VR 104
Flacourtiaceae	*Scolopia zeyheri* (Nees) Harv.	MacOwan P 1324
Fumariaceae	*Cysticapnos pruinosa* (Bernh.) Lidén	Clark VR, Coombs G 351
Gentianaceae	*Chironia krebsii* Griseb.	Marais and Verdoorn (1963)
Gentianaceae	*Sebaea macrophylla* Gilg	Clark VR, Coombs G 293
Gentianaceae	*Sebaea pentrandra* E.Mey. var. *pentandra*	Marais and Verdoorn (1963)
Gentianaceae	*Sebaea thomasii* (S.Moore) Schinz	Clark VR, Te Water Naudé T 228
Geraniaceae	*Erodium cicutarium* (L.) L'Hér.	Clark VR, Coombs G 431
Geraniaceae	*Geranium baurianum* R.Knuth	Hilliard and Burtt (1985a)
Geraniaceae	*Geranium caffrum* Eckl. & Zeyh.	Clark VR, Coombs G 43
Geraniaceae	*Geranium* cf. *brycei* N.E.Br. (Dreyer, pers. comm.)	McKenzie RJ, Weston P, Clark VR 144
Geraniaceae	*Geranium dregei* Hilliard & B.L.Burtt	Hilliard and Burtt (1985a)
Geraniaceae	*Geranium harveyi* Briq.	Clark VR, Coombs G 163

Geraniaceae	*Geranium incanum* var. *multifidum* (Sweet) Hilliard & B.L.Burtt	Clark VR, Te Water Naudé T 194
Geraniaceae	*Geranium magniflorum* R.Knuth	Hilliard and Burtt (1985a)
Geraniaceae	*Geranium multisectum* N.E.Br.	Clark VR, McKenzie RJ 327
Geraniaceae	*Monsonia angustifolia* E.Mey. ex A.Rich.	Venter (1979)
Geraniaceae	*Monsonia emarginata* (L.f.) L'Hér.	Venter (1979)
Geraniaceae	*Pelargonium abrotanifolium* (L.f.) Jacq.	Barker NP 1438
Geraniaceae	*Pelargonium alchemilloides* (L.) L'Hér.	Clark VR, Barker NP, Devos N 15
Geraniaceae	*Pelargonium aridum* R.A.Dyer	Clark VR, Pienaar C, Lochner EJ 14
Geraniaceae	*Pelargonium carnosum* (L.) L'Hér.	Palmer AR 1453
Geraniaceae	*Pelargonium dichondrifolium* DC.	Van der Walt et al. (1988)
Geraniaceae	*Pelargonium exhibens* Vorster	Van der Walt et al. (1988)
Geraniaceae	*Pelargonium glutinosum* (Jacq.) L'Hér.	Clark VR, Barker NP, Devos N 9
Geraniaceae	*Pelargonium griseum* R.Knuth	Van der Walt et al. (1981)
Geraniaceae	*Pelargonium grossularioides* (L.) L'Hér. ex Aiton	Clark VR, Coombs G 238
Geraniaceae	*Pelargonium ionodiflorum* (Eckl. & Zeyh.) Steud.	Van der Walt et al. (1981)
Geraniaceae	*Pelargonium laevigatum* (L.f.) Willd.	Clark VR, Crause I 194
Geraniaceae	*Pelargonium laxum* (Sweet) G.Don	Van der Walt et al. (1988)
Geraniaceae	*Pelargonium leucophyllum* Turcz.	Van der Walt et al. (1981)
Geraniaceae	*Pelargonium luridum* (Andrews) Sweet	Clark VR, Te Water Naudé T 336
Geraniaceae	*Pelargonium minimum* (Cav.) Willd.	Van der Walt et al. (1988)
Geraniaceae	*Pelargonium multicaule* Jacq. subsp. *multicaule*	Clark VR, Coombs G 209
Geraniaceae	*Pelargonium odoratissimum* (L.) L'Hér.	Van der Walt and Ward-Hilhorst (1977)
Geraniaceae	*Pelargonium peltatum* (L.) L'Hér.	Barker NP 1447
Geraniaceae	*Pelargonium ranunculophyllum* (Eckl. & Zeyh.) Baker	Clark VR, Devos N, McKenzie RJ 57
Geraniaceae	*Pelargonium reniforme* Curtis subsp. *reniforme*	Van der Walt and Ward-Hilhorst (1977)
Geraniaceae	*Pelargonium sidoides* DC.	Clark VR, Coombs G 371
Geraniaceae	*Pelargonium tetragonum* (L.f.)L'Hér.	Van der Walt and Ward-Hilhorst (1977)
Geraniaceae	*Pelargonium tragacanthoides* Burch.	Clark VR, Devos N, McKenzie RJ 17
Geraniaceae	*Pelargonium zonale* (L.)L'Hér.	Clark VR, Coombs G 299
Geraniaceae	*Sarcocaulon camdeboense* Moffett	Barker NP 1451
Gesneriaceae	*Streptocarpus meyeri* B.L.Burtt	Clark VR, Ramdhani S 344
Haloragaceae	*Gunnera perpensa* L.	Clark VR, Coombs G 29
Hypericaceae	*Hypericum aethiopicum* Thunb. subsp. *aethiopicum*	Clark VR, Coombs G 159
Illecebraceae	*Pollichia campestris* Aiton	McKenzie RJ, Weston P, Clark VR 80
Lamiaceae	*Ajuga ophrydis* Burch. ex Benth.	Clark VR, Coombs G 289
Lamiaceae	*Ballota africana* (L.) Benth.	Clark VR, Pienaar C, Lochner EJ 190
Lamiaceae	*Leonotis ocymifolia* (Burm.f.) Iwarsson var. *ocymifolia*	Clark VR, Coombs G 258
Lamiaceae	*Leucas capensis* (Benth.) Engl.	Barker NP 1433
Lamiaceae	*Mentha longifolia* subsp. *capensis* (Thunb.) Briq.	Clark VR, Coombs G 20
Lamiaceae	*Ocimum burchellianum* Benth.	Clark VR, Te Water Naudé T 364
Lamiaceae	*Salvia repens* Burch. ex Benth. var. *repens*	Clark VR, Coombs G 317
Lamiaceae	*Salvia stenophylla* Burch. ex Benth.	Archibald EEA 3017
Lamiaceae	*Salvia verbenaca* L.	Archibald EEA 2903
Lamiaceae	*Stachys aethiopica* L.	Clark VR, Coombs G 318
Lamiaceae	*Stachys cymbalaria* Briq.	Codd (1985)
Lamiaceae	*Stachys dregeana* Benth.	Clark VR, Coombs G 151
Lamiaceae	*Stachys grandifolia* E.Mey. ex Benth.	MacOwan P 1494
Lamiaceae	*Stachys linearis* Burch. ex Benth.	Clark VR, Ngcobo L, Pienaar C 279
Lamiaceae	*Stachys rugosa* Aiton	Drège JF 3584
Lamiaceae	*Teucrium africanum* Thunb.	Clark VR, Ngcobo L, Pienaar C 277
Lamiaceae	*Teucrium trifidum* Retz.	MacOwan P s.n.
Lentibulariaceae	*Utricularia capensis* Streng.	Clark VR, Pienaar C 294
Lentibulariaceae	*Utricularia livida* E.Mey.	Clark VR, Pienaar C 93
Linaceae	*Linum thunbergii* Eckl. & Zeyh.	Clark VR, Coombs G 49
Lobeliaceae	*Cyphia assimilis* Sond.	Phillipson P 5624
Lobeliaceae	*Lobelia dregeana* (C.Presl) A.DC.	Clark VR, Te Water Naudé T 248
Lobeliaceae	*Lobelia flaccida* (C.Presl) A.DC. subsp. *flaccida*	Clark VR, Coombs G 149
Lobeliaceae	*Lobelia preslii* A.DC.	Clark VR, Coombs G 169
Lobeliaceae	*Lobelia quadrisepala* (R.Good.) E.Wimm.	Clark VR, Pienaar C 297
Lobeliaceae	*Lobelia thermalis* Thunb.	Clark VR, Coombs G 558
Loranthaceae	*Moquiniella rubra* (A.Spreng.) Balle	Clark VR, Ngcobo L, Pienaar C 337
Malvaceae	*Abutilon sonneratianum* (Cav.) Sweet	Clark VR, Rose M 42
Malvaceae	*Anisodontea malvastroides* (Baker f.) Bates	Bolus H 390
Malvaceae	*Anisodontea procumbens* (Harv.) Bates	Clark VR, Devos N, McKenzie RJ 126

Malvaceae	*Hibiscus pusillus* Thunb.	Clark VR, Coombs G 423
Malvaceae	*Hibiscus trionum* L.*	Clark VR, Ngcobo L, Pienaar C 85
Malvaceae	*Malva parviflora* L. var. *parviflora**	Tyson W 369
Malvaceae	*Radyera urens* (L.f.) Bullock	Bolus H 603
Malvaceae	*Sida ternata* L.f.	Clark VR, Rose M 97
Meliaceae	*Nymania capensis* (Thunb.) Lindb.	Clark VR, Ramdhani S 324
Melianthaceae	*Melianthus comosus* Vahl	Barker NP 1500
Melianthaceae	*Melianthus major* L.	Clark VR, Ramdhani S 59
Menispermaceae	*Cissampelos capensis* L.f.	Barker NP 1522
Mesembryanthemaceae	*Aloinopsis rubrolineata* (N.E.Br.) Schwantes	Brown et al. (1931)
Mesembryanthemaceae	*Aptenia cordifolia* (L.f.) Schwantes	Rogers FA 170
Mesembryanthemaceae	*Aridaria noctiflora* subsp. *straminea* (Haw.) Gerbaulet	Bolus H 546
Mesembryanthemaceae	*Bergeranthus nanus* A.P.Dold & S.A.Hammer	Clark VR, Rose M 390
Mesembryanthemaceae	*Bergeranthus vespertinus* (A.Berger) Schwantes	MacOwan P 1587
Mesembryanthemaceae	*Chasmatophyllum musculinum* (Haw.) Dinter & Schwantes	McKenzie RJ, Weston P, Clark VR 132
Mesembryanthemaceae	*Delosperma brevisepalum* L.Bolus var. *brevisepalum*	Clark VR, Rose M 284
Mesembryanthemaceae	*Delosperma concavum* L.Bolus	Clark VR, Coombs G 442
Mesembryanthemaceae	*Delosperma frutescens* L.Bolus	Pond et al. (2002)
Mesembryanthemaceae	*Delosperma incomptum* (Haw.) L.Bolus	Bolus H 547
Mesembryanthemaceae	*Delosperma karrooicum* L.Bolus	Clark VR, Coombs G 183
Mesembryanthemaceae	*Delosperma lootsbergense* Lavis	Clark VR, Coombs G 226
Mesembryanthemaceae	*Delosperma luckhoffii* L.Bolus	Clark VR, Rose M 242
Mesembryanthemaceae	*Delosperma* sp. nov. 1 aff. *dyeri* L.Bolus (Burgoyne, pers. comm.)	Burgoyne, pers. comm.
Mesembryanthemaceae	*Drosanthemum hispidum* (L.) Schwantes	Barker NP 1435
Mesembryanthemaceae	*Drosanthemum lique* (N.E.Br.) Schwantes	MacOwan P 2040
Mesembryanthemaceae	*Faucaria bosscheana* (A.Berger) Schwantes	Rattray G 72
Mesembryanthemaceae	*Mestoklema copiosum* N.E.Br. ex Glen	Clark VR, Pienaar C, Lochner EJ 299
Mesembryanthemaceae	*Pleiospilos bolusii* (Hook.f.) N.E.Br.	Brown et al. (1931)
Mesembryanthemaceae	*Prenia radicans* (L.Bolus) Gerbaulet	Gerbaulet (1996)
Mesembryanthemaceae	*Psilocaulon articulatum* (Thunb.) N.E.Br.	Klak and Linder (1998)
Mesembryanthemaceae	*Psilocaulon coriarium* (Burch. ex N.E.Br.) N.E.Br.	Klak and Linder (1998)
Mesembryanthemaceae	*Psilocaulon junceum* (Haw.) Schwantes	Klak and Linder (1998)
Mesembryanthemaceae	*Rabiea albipuncta* (Haw.) N.E.Br.	Clark VR, Pienaar C, Lochner EJ 341
Mesembryanthemaceae	*Rhombophyllum dolabriforme* (L.) Schwantes	Bolus H 2044
Mesembryanthemaceae	*Ruschia complanata* L.Bolus	Clark VR, Te Water Naudé T 279
Mesembryanthemaceae	*Ruschia cradockensis* (Kuntze) H.E.K.Hartmann & Stüber subsp. *cradockensis*	Clark VR, Pienaar C 321
Mesembryanthemaceae	*Ruschia hamata* (L.Bolus) Schwantes	Clark VR, Ngcobo L, Pienaar C 357
Mesembryanthemaceae	*Ruschia intricata* (N.E.Br.) H.E.K.Hartmann & Stüber	Clark VR, Coombs G 214
Mesembryanthemaceae	*Ruschia putterillii* (L.Bolus) L.Bolus	Clark VR, Te Water Naudé T 251
Mesembryanthemaceae	*Sceletium emarcidum* (Thunb.) L.Bolus ex H.J.J.Jacobssen	Tyson W 376
Mesembryanthemaceae	*Stomatium duthiae* L.Bolus	Clark VR, Coombs G 454
Mesembryanthemaceae	*Trichodiadema olivaceum* L.Bolus	Mucina and Rutherford (2006)
Mesembryanthemaceae	*Trichodiadema pomeridianum* L.Bolus	Clark VR, McKenzie RJ 66B
Molluginaceae	*Corbichonia decumbens* (Forssk.) Exell	Adamson (1958)
Molluginaceae	*Hypertelis bowkeriana* Sond.	Adamson (1958)
Molluginaceae	*Hypertelis salsoloides* (Burch.) Adamson var. *salsoloides*	Adamson (1958)
Molluginaceae	*Limeum argute-carinatum* Wawra ex Wawra & Peyr. var. *argute-carinatum*	Clark VR, McKenzie RJ 448
Molluginaceae	*Limeum humifusum* Friedrich	Clark VR, Te Water Naudé T 357
Molluginaceae	*Mollugo cerviana* (L.) Ser.	Adamson (1958)
Molluginaceae	*Pharnaceum detonsum* Fenzl	Clark VR, Coombs G 315
Molluginaceae	*Pharnaceum dichotomum* L.f.	Adamson (1958)
Molluginaceae	*Pharnaceum trigonum* Eckl. & Zeyh.	Adamson (1958)
Molluginaceae	*Psammotropha mucronata* (Thunb.) Fenzl var. *mucronata*	Clark VR, Pienaar C 483
Moraceae	*Ficus burtt-davyi* Hutch.	Burrows and Burrows (2003)
Myricaceae	*Morella serrata* (Lam.) Killick	Clark VR, Pienaar C 496
Myrsinaceae	*Myrsine africana* L.	Clark VR, Barker NP, Devos N 60
Myrtaceae	*Eucalyptus camaldulensis* Dehnh.*	Henderson (2001)
Oleaceae	*Olea europaea* subsp. *africana* (Mill.) P.S.Green	Clark VR, Barker NP, Devos N 57
Oliniaceae	*Olinia emarginata* Burtt Davy	Clark VR, Crause I 78
Onagraceae	*Epilobium capense* Buch. ex Hochst	Tyson W 175
Onagraceae	*Epilobium tetragonum* L. subsp. *tetragonum**	Tyson W 419
Onagraceae	*Oenothera indecora* Cambess. subsp. *indecora**	Clark VR, Coombs G 456
Onagraceae	*Oenothera rosea* L.Hér. ex Aiton*	Clark VR, Rose M 428

Orobanchaceae	*Alectra capensis* Thunb.	Clark VR, Coombs G 295
Orobanchaceae	*Alectra orobanchoides* Benth.	Bolus H 406
Orobanchaceae	*Harveya huttonii* Hiern.	Clark VR, Devos N, McKenzie RJ 52
Oxalidaceae	*Oxalis bifurca* var. *angustiloba* Sond.	Clark VR, Coombs G 357
Oxalidaceae	*Oxalis bifurca* Lodd. var. *bifurca*	MacOwan P 1869
Oxalidaceae	*Oxalis depressa* Eckl. & Zeyh.	Clark VR, Coombs G 448
Oxalidaceae	*Oxalis imbricata* var. *violacea* R.Knuth	Clark VR, Te Water Naudé T 186
Oxalidaceae	*Oxalis pes-caprae* L. var. *pes-caprae*	Francis M 26
Oxalidaceae	*Oxalis smithiana* Eckl. & Zeyh.	Clark VR, Coombs G 230
Papaveraceae	*Argemone ochroleuca* Sweet subsp. *ochroleuca**	Clark VR, Pienaar C 281
Papaveraceae	*Papaver aculeatum* Thunb.	Clark VR, Coombs G 420
Pedaliaceae	*Pterodiscus luridus* Hook.f.	Pond et al. (2002)
Pedaliaceae	*Sesamum capense* Burm.f.	Bolus H s.n.
Piperaceae	*Peperomia retusa* var. *bachmannii* (C.DC.) Düll	Rogers FA 165
Pittosporaceae	*Pittosporum viridiflorum* Sims	Clark VR, Coombs G 74
Plantaginaceae	*Plantago lanceolata* L.*	Clark VR, Coombs G 89
Polygalaceae	*Muraltia alopecuroides* (L.) DC.	Levyns (1954)
Polygalaceae	*Muraltia alticola* Schltr.	Clark VR, Barker NP, Devos N 18
Polygalaceae	*Muraltia macrocarpa* Eckl. & Zeyh.	Levyns (1954)
Polygalaceae	*Muraltia saxicola* Chodat	Levyns (1954)
Polygalaceae	*Polygala asbestina* Burch.	Bolus H 494
Polygalaceae	*Polygala ephedroides* Burch.	Clark VR, Pienaar C 336
Polygalaceae	*Polygala gracilenta* Burtt Davy	Clark VR, Pienaar C 417
Polygalaceae	*Polygala hottentotta* C.Presl	Clark VR, Pienaar C 13
Polygalaceae	*Polygala microlopha* DC.	Clark VR, Pienaar C 390
Polygalaceae	*Polygala sphenoptera* Fresen.	Clark VR, Pienaar C 413
Polygalaceae	*Polygala virgata* Thunb. var. *virgata*	Clark VR, Ngcobo L, Pienaar C 239
Polygonaceae	*Rumex acetosella* subsp. *angiocarpus* (Murb.) Murb.*	Clark VR, Coombs G 152
Polygonaceae	*Rumex cordatus* Poir.	Clark VR, Ramdhani S 332
Polygonaceae	*Rumex crispus* L.*	Clark VR, McKenzie RJ 334
Polygonaceae	*Rumex lanceolatus* Thunb.	Clark VR, Coombs G 405
Polygonaceae	*Rumex sagittatus* Thunb.	Clark VR, Te Water Naudé T 240
Polygonaceae	*Rumex steudelii* Hochst. ex A.Rich.	Clark VR, Coombs G 554
Polygonaceae	*Rumex woodii* N.E.Br.	Rechinger (1954)
Portulacaceae	*Anacampseros* cf. *rufescens* (Haw.) Sweet	Clark VR, Pienaar C, Lochner EJ 106
Portulacaceae	*Avonia ustulata* (E.Mey. ex Fenzl) G.D.Rowley	Gerbaulet (1992)
Portulacaceae	*Portulaca oleracea* L. subsp. *oleracea**	Clark VR, Pienaar C, Lochner EJ 44
Portulacaceae	*Portulacaria afra* Jacq.	Clark VR, Coombs G 563
Potamogetonaceae	*Potamogeton pusillus* L.	Clark VR, Coombs G 273
Primulaceae	*Anagallis huttonii* Harv.	Clark VR, Pienaar C 491
Proteaceae	*Faurea* sp. nov. 1 (Rourke, pers. comm.)	Clark VR, Crause I 106
Proteaceae	*Protea lorifolia* (Salisb. ex Knight) Fourc.	Rebelo (2001)
Ranunculaceae	*Clematis brachiata* Thunb.	Clark VR, Coombs G 393
Ranunculaceae	*Ranunculus aquatilis* L.	Barker NP 1495
Ranunculaceae	*Ranunculus meyeri* Harv.	Clark VR, Te Water Naudé T 321
Ranunculaceae	*Ranunculus multifidus* Forssk.	Clark VR, Coombs G 42
Ranunculaceae	*Thalictrum minus* L.	Bolus H 1808
Resedaceae	*Oligomeris dregeana* (Müll.Arg.) Müll.Arg.	Leistner (1970)
Rhamnaceae	*Phylica paniculata* Willd.	Clark VR, Te Water Naudé T 261
Rhamnaceae	*Rhamnus prinoides* L'Hér.	Clark VR, Barker NP, Devos N 63
Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz	MacOwan P 278
Rhamnaceae	*Ziziphus mucronata* Willd. subsp. *mucronata*	MacOwan P 477
Rosaceae	*Alchemilla capensis* Thunb.	Clark VR, Te Water Naudé T 355
Rosaceae	*Alchemilla elongata* Eckl. & Zeyh. var. *elongata*	Clark VR, Te Water Naudé T 354
Rosaceae	*Cliffortia bolusii* Diels ex C.Whitehouse	Whitehouse and Fellingham (2007)
Rosaceae	*Cliffortia eriocephalina* Cham.	Clark VR, Coombs G 278
Rosaceae	*Cliffortia montana* Weim.	Clark VR, Pienaar C 475
Rosaceae	*Cliffortia ramosissima* Schltr.	Clark VR, Coombs G 354
Rosaceae	*Cotoneaster hupehensis* Rehd.Wils.*	Clark VR, Ngcobo L, Pienaar C 236
Rosaceae	*Crataegus monogyna* Jacq.*	Clark VR, McKenzie RJ 185
Rosaceae	*Cydonia oblonga* Mill.*	Clark VR, Te Water Naudé T 207
Rosaceae	*Geum capense* Thunb.	Clark VR, Te Water Naudé T 67
Rosaceae	*Leucosidea sericea* Eckl. & Zeyh.	Clark VR, Barker NP, Devos N 64
Rosaceae	*Pyracantha angustifolia* (Franch.) C.K.Schneid.*	Henderson (2001)

Rosaceae	*Rosa rubiginosa* L.*	Clark VR, McKenzie RJ 190
Rosaceae	*Rubus ludwigii* Eckl. & Zeyh. subsp. *ludwigii*	Clark VR, Coombs G 225
Rosaceae	*Rubus pinnatus* Willd	MacOwan P 1903
Rosaceae	*Rubus rigidus* Sm.	Clark VR, Ramdhani S 259
Rubiaceae	*Anthospermum herbaceum* L.f.	Clark VR, Ramdhani S 360
Rubiaceae	*Anthospermum monticola* Puff	Clark VR, Coombs G 437
Rubiaceae	*Anthospermum paniculatum* Cruse	Clark VR, Coombs G 310
Rubiaceae	*Anthospermum pumilum* subsp. *rigidum* (Eckl. & Zeyh.) Puff	Clark VR, Pienaar C, Lochner EJ 308
Rubiaceae	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *rigidum*	Clark VR, Pienaar C, Lochner EJ 10
Rubiaceae	*Galium capense* subsp. *garipense* (Sond.) Puff	Clark VR, McKenzie RJ 133
Rubiaceae	*Galium capense* Thunb. subsp. *capense*	Clark VR, Coombs G 140
Rubiaceae	*Galium spurium* subsp. *africanum* Verdc.	Clark VR, Coombs G 45
Rubiaceae	*Galium thunbergianum* var. *hirsutum* (Sond.) Verdc.	McKenzie RJ, Weston P, Clark VR 139
Rubiaceae	*Galium tomentosum* Thunb.	Bolus H 144
Rubiaceae	*Nenax microphylla* (Sond.) T.M.Salter	McKenzie RJ, Weston P, Clark VR 66
Rubiaceae	*Rubia petiolaris* DC.	Clark VR, Coombs G 22
Rubiaceae	*Sherardia arvensis* L.*	Clark VR, Coombs G 571
Rutaceae	*Acmadenia* sp. nov. 1 aff. *sheilae* I. Williams (Trinder-Smith, pers. comm.)	Clark VR, Crause I 130
Rutaceae	*Agathosma* cf. *capensis* (L.) Dummer (Trinder-Smith, pers. comm.)	Clark VR, Crause I 229
Rutaceae	*Agathosma venusta* (Eckl. & Zeyh.) Pillans	Clark VR, Te Water Naudé T 280
Rutaceae	*Vepris lanceolata* (Lam.) G.Don	MacOwan P 410
Salicaceae	*Populus alba* L.*	Pond et al. (2002)
Salicaceae	*Populus deltoides* Marshall subsp. *deltoides**	Jordaan (2005)
Salicaceae	*Populus nigra* var. *italica* (Moench) Koehne*	Jordaan (2005)
Salicaceae	*Populus x canescens* (Aiton) Sm.*	Henderson (2001)
Salicaceae	*Salix babylonica* L. var. *babylonica**	Henderson (2001)
Salicaceae	*Salix fragilis* L. var. *fragilis**	Jordaan (2005)
Salicaceae	*Salix mucronata* Thunb. subsp. *mucronata*	Clark VR, Pienaar C 331
Santalaceae	*Osyris lanceolata* Hochst. & Steud.	Clark VR, Barker NP, Devos N 61
Santalaceae	*Thesium acutissimum* A.DC.	MacOwan P 2218
Santalaceae	*Thesium disciflorum* A.W.Hill	Clark VR, Te Water Naudé T 153
Santalaceae	*Thesium gnidiaceum* A.DC.	Clark VR, Coombs G 109
Santalaceae	*Thesium hirsutum* A.W.Hill	MacOwan P 1618
Santalaceae	*Thesium imbricatum* Thunb.	Hill (1925)
Santalaceae	*Thesium impeditum* A.W.Hill	Clark VR, Barker NP, Devos N 34
Santalaceae	*Thesium orientale* A.W.Hill	Hill (1925)
Santalaceae	*Thesium paniculatum* L.	Hill (1925)
Santalaceae	*Thesium triflorum* Thunb. ex L.f.	Hill (1925)
Sapindaceae	*Dodonaea viscosa* var. *angustifolia* (L.f.) Benth.	Barker NP 1506
Sapindaceae	*Pappea capensis* Eckl. & Zeyh.	Clark VR, Ramdhani S 423
Scrophulariaceae	*Aptosimum procumbens* (Lehm.) Steud.	Barker NP 1432
Scrophulariaceae	*Bartsia trixago* L.	Clark VR, Coombs G 603
Scrophulariaceae	*Cromidon austerum* Hilliard	Clark VR, Te Water Naudé T 231A
Scrophulariaceae	*Cromidon corrigioloides* (Rolfe) Compton	Hilliard (1990)
Scrophulariaceae	*Cromidon decumbens* (Thunb.) Hilliard	Clark VR, Te Water Naudé T 184
Scrophulariaceae	*Diascia alsinooides* Benth.	Drège JF 2322
Scrophulariaceae	*Diascia capsularis* Benth.	Clark VR, Coombs G 204
Scrophulariaceae	*Diascia ramosa* Scott-Elliot	Hilliard and Burtt (1984)
Scrophulariaceae	*Glekia krebsiana* (Benth.) Hilliard	Clark VR, Coombs G 341
Scrophulariaceae	*Halleria lucida* L.	Clark VR, Ramdhani S 329
Scrophulariaceae	*Hebenstretia dura* Choisy	Clark VR, Coombs G 170
Scrophulariaceae	*Hyobanche rubra* N.E.Br.	Clark VR, Barker NP, Devos N 41
Scrophulariaceae	*Jamesbrittenia atropurpurea* (Benth.) Hilliard subsp. *atropurpurea*	Hilliard (1994)
Scrophulariaceae	*Jamesbrittenia crassicaulis* (Benth.) Hilliard	Clark VR, Coombs G 281
Scrophulariaceae	*Jamesbrittenia filicaulis* (Benth.) Hilliard	Barker NP 1497
Scrophulariaceae	*Jamesbrittenia foliolosa* (Benth.) Hilliard	Clark VR, Coombs G 573
Scrophulariaceae	*Jamesbrittenia tysonii* (Hiern) Hilliard	Hilliard (1994)
Scrophulariaceae	*Limosella* sp. (possibly several spp.)	Clark VR, Coombs G 302
Scrophulariaceae	*Lindernia conferta* (Hiern) Philcox	Clark VR, Ngcobo L, Pienaar C 261
Scrophulariaceae	*Manulea crassifolia* Benth. subsp. *crassifolia*	Clark VR, Coombs G 375
Scrophulariaceae	*Nemesia albiflora* N.E.Br.	Clark VR, Ramdhani S 62
Scrophulariaceae	*Nemesia cynanchifolia* Benth.	Drège JF 7880a
Scrophulariaceae	*Nemesia floribunda* Lehm.	Clark VR, Devos N, McKenzie RJ 149

Scrophulariaceae	*Nemesia fruticans* (Thunb.) Benth.	Clark VR, Coombs G 479
Scrophulariaceae	*Nemesia melissifolia* Benth.	MacOwan P 330
Scrophulariaceae	*Nemesia umbonata* (Hiern) Hilliard & B.L.Burtt	Clark VR, Coombs G 196
Scrophulariaceae	*Peliostomum origanoides* E.Mey. ex Benth.	Bolus H 356
Scrophulariaceae	*Phygelius capensis* E.Mey. ex Benth.	Clark VR, Coombs G 280
Scrophulariaceae	*Phyllopodium rustii* (Rolfe) Hilliard	Hilliard (1994)
Scrophulariaceae	*Selago albida* Choisy	Clark VR, McKenzie RJ 423
Scrophulariaceae	*Selago bolusii* Rolfe	Hilliard (1999)
Scrophulariaceae	*Selago centralis* Hilliard	Hilliard (1999)
Scrophulariaceae	*Selago crassifolia* (Rolfe) Hilliard	Hilliard (1999)
Scrophulariaceae	*Selago divaricata* L.f.	Clark VR, Coombs G 283
Scrophulariaceae	*Selago dolosa* Hilliard	Clark VR, Coombs G 300
Scrophulariaceae	*Selago geniculata* L.f.	Clark VR, Coombs G 469
Scrophulariaceae	*Selago magnakarooica* Hilliard	Clark VR, Pienaar C, Lochner EJ 143
Scrophulariaceae	*Selago paniculata* Thunb.	Bolus H 293
Scrophulariaceae	*Selago retropilosa* Hilliard	Clark VR, Te Water Naudé T 100
Scrophulariaceae	*Selago rotundifolia* L.f.	Bolus H 446
Scrophulariaceae	*Selago saxatilis* E.Mey.	Clark VR, Coombs G 134
Scrophulariaceae	*Sutera halimifolia* (Benth.) Kuntze	Clark VR, Coombs G 194
Scrophulariaceae	*Sutera macrosiphon* (Schltr.) Hiern	Clark VR, Devos N, McKenzie RJ 56
Scrophulariaceae	*Sutera rotundifolia* (Benth.) Kuntze	McKenzie RJ, Weston P, Clark VR 143
Scrophulariaceae	*Veronica anagallis-aquatica* L.	Clark VR, Coombs G 27
Scrophulariaceae	*Zaluzianskya angustifolia* Hilliard & B.L.Burtt	Hilliard (1994)
Scrophulariaceae	*Zaluzianskya capensis* (L.) Welp.	Clark VR, Coombs G 236
Scrophulariaceae	*Zaluzianskya glareosa* Hilliard & B.L.Burtt	Hilliard (1994)
Scrophulariaceae	*Zaluzianskya karooica* Hilliard	Drège JF 584
Scrophulariaceae	*Zaluzianskya ovata* (Benth.) Walp.	Barker NP 1475
Scrophulariaceae	*Zaluzianskya peduncularis* (Benth.) Walp.	Clark VR, Te Water Naudé T 189
Scrophulariaceae	*Zaluzianskya schmitziae* Hilliard & B.L.Burtt	Hilliard (1994)
Scrophulariaceae	*Zaluzianskya spathacea* (Benth.) Walp.	MacOwan P 1632
Scrophulariaceae	*Zaluzianskya synaptica* Hilliard	Hilliard (1994)
Simaroubaceae	*Ailanthus altissima* Swingle*	Henderson (2001)
Solanaceae	*Datura ferox* L.*	Henderson (2001)
Solanaceae	*Datura stramonium* L. var. *stramonium**	McKenzie RJ, Weston P, Clark VR 168
Solanaceae	*Lycium arenicolum* Miers	Bolus H 282
Solanaceae	*Lycium cinereum* Thunb.	Clark VR, Ramdhani S 198
Solanaceae	*Lycium horridum* Thunb.	Clark VR, Coombs G 671a
Solanaceae	*Lycium oxycarpum* Dunal	Bolus H 45
Solanaceae	*Lycium schizocalyx* C.H.Wright	Clark VR, Coombs G 432
Solanaceae	*Nicotiana glauca* Graham*	Henderson (2001)
Solanaceae	*Physalis peruviana* L.*	MacOwan P s.n.
Solanaceae	*Solanum pseudocapsicum* L.*	Clark VR, Te Water Naudé T 374
Solanaceae	*Solanum retroflexum* Dunal	Clark VR, Coombs G 397
Solanaceae	*Solanum supinum* Dunal	MacOwan P 1606
Solanaceae	*Solanum tomentosum* var. *coccineum* (Jacq.) Willd.	Clark VR, Coombs G 85
Solanaceae	*Withania somnifera* (L.) Dunal	Clark VR, Coombs G 277
Sterculiaceae	*Hermannia althaeifolia* L.	Clark VR, McKenzie RJ 40
Sterculiaceae	*Hermannia althaeoides* Link	Clark VR, Devos N, McKenzie RJ 70
Sterculiaceae	*Hermannia coccocarpa* (Eckl. & Zeyh.) Kuntze	Barker NP 1436
Sterculiaceae	*Hermannia cuneifolia* var. *glabrescens* (Harv.) I.Verd.	Clark VR, Ramdhani S 166
Sterculiaceae	*Hermannia erodioides* (Burch. ex DC.) Kuntze	Barker NP 1516
Sterculiaceae	*Hermannia filifolia* L.f. var. *filifolia*	Tyson W 32
Sterculiaceae	*Hermannia filifolia* var. *robusta* I.Verd.	Clark VR, Coombs G 408
Sterculiaceae	*Hermannia flammea* Jacq.	MacOwan P 246
Sterculiaceae	*Hermannia glabrata* L.f.	Barker NP 1458
Sterculiaceae	*Hermannia gracilis* Eckl. & Zeyh.	MacOwan P 935
Sterculiaceae	*Hermannia holosericea* Jacq.	Clark VR, Ramdhani S 351
Sterculiaceae	*Hermannia lacera* (E.Mey. ex Harv.) Fourc.	Bolus H 500
Sterculiaceae	*Hermannia linearis* (Harv.) Hochr.	Barker NP 1458
Sterculiaceae	*Hermannia pulverata* Andrews	Barker NP 1524
Sterculiaceae	*Hermannia* sp. nov. 1 (Gwynne-Evans, pers. comm.)	Clark VR, Barker NP, Devos N 7
Sterculiaceae	*Hermannia* sp. nov. 2 (Gwynne-Evans, pers. comm.)	Gwynne-Evans, pers. comm.
Sterculiaceae	*Hermannia vestita* Thunb.	Barker NP 1503
Sterculiaceae	*Hermannia violacea* (Burch. ex DC.) K.Schum.	Gwynne-Evans, pers. comm.

Thymelaeaceae	*Gnidia burchellii* (Meisn.) Gilg.	Clark VR, Te Water Naudé T 256
Thymelaeaceae	*Gnidia microphylla* Meisn.	Tyson W 168
Thymelaeaceae	*Gnidia polyantha* Gilg.	Clark VR, Te Water Naudé T 256
Thymelaeaceae	*Gnidia polycephala* (C.A.Mey.) Gilg ex Engl.	Barker NP 1456
Thymelaeaceae	*Gnidia wikstroemiana* (Thunb.) Meisn.	Clark VR, Ramdhani S 432
Thymelaeaceae	*Passerina corymbosa* Eckl. ex C.H.Wright	Bredenkamp and Van Wyk (2003)
Thymelaeaceae	*Passerina falcifolia* (Meisn.) C.H.Wright	Bredenkamp and Van Wyk (2003)
Thymelaeaceae	*Passerina montana* Thoday	Clark VR, Coombs G 231
Thymelaeaceae	*Passerina obtusifolia* Thoday	Bredenkamp and Van Wyk (2003)
Tiliaceae	*Grewia occidentalis* L. var. *occidentalis*	Clark VR, Crause I 110
Tiliaceae	*Grewia robusta* Burch.	Clark VR, Coombs G 7
Ulmaceae	*Celtis africana* Burm.f.	Clark VR, Te Water Naudé T 206
Urticaceae	*Didymodoxa caffra* (Thunb.) Friis & Wilmot-Dear	Clark VR, Rose M 73
Urticaceae	*Forsskaolea candida* L.f.	Bolus H 474
Urticaceae	*Laportea grossa* (Wedd.) Chew	Bolus H 1809
Urticaceae	*Laportea peduncularis* (Wedd.) Chew subsp. *peduncularis*	MacOwan P s.n.
Urticaceae	*Urtica dioica* L.*	Clark VR, Coombs G 464
Urticaceae	*Urtica lobulata* Blume	Clark VR, Coombs G 158
Urticaceae	*Urtica urens* L.*	Clark VR, Ramdhani S 237
Valerianaceae	*Valeriana capensis* Thunb. var. *capensis*	Clark VR, Pienaar C 478
Verbenaceae	*Chascanum pinnatifidum* (L.f.) E.Mey. var. *pinnatifidum*	Bolus H 193
Verbenaceae	*Lantana rugosa* Thunb.	Clark VR, Coombs G 41
Verbenaceae	*Verbena bonariensis* L.*	Clark VR, Pienaar C 364
Verbenaceae	*Verbena brasiliensis* Vell.*	Clark VR, Ramdhani S 98
Violaceae	*Viola tricolor* L.*	Clark VR, Rose M 494
Viscaceae	*Viscum continuum* E.Mey. ex Sprague	Polhill and Wiens (1998)
Viscaceae	*Viscum crassulae* Eckl. & Zeyh.	Polhill and Wiens (1998)
Viscaceae	*Viscum hoolei* (Wiens) Polhill & Wiens	Clark VR, Coombs G 78
Viscaceae	*Viscum obscurum* Thunb.	Polhill and Wiens (1998)
Viscaceae	*Viscum rotundifolium* L.f.	Clark VR, Ramdhani S 409
Vitaceae	*Rhoicissus tridentata* subsp. *cuneifolia* (Eckl. & Zeyh.) Urton	Clark VR, Rose M 28
Vitaceae	*Rhoicissus tridentata* (L.f.) Wild & R.B.Drumm. subsp. *tridentata*	Bolus H 291
Zygophyllaceae	*Roepera foetida* (Schrad. & J.C.Wendl.) Beier & Thulin	Clark VR, Ramdhani S 325
Zygophyllaceae	*Roepera incrustata* (E.Mey. ex Sond.) Beier & Thulin	MacOwan P 362
Zygophyllaceae	*Roepera lichtensteiniana* (Cham. & Schltdl.) Beier & Thulin	Bolus H 279
Zygophyllaceae	*Tetraena microcarpa* (Licht. ex Cham.) Beier & Thulin	Bolus H 212
Zygophyllaceae	*Tribulus zeyheri* Sond.	Bolus H 83b

* Denotes alien species.

Chapter 3: The Boschberg and Groot-Bruintjieshoogde.

3.1. Introduction

The Boschberg and Groot-Bruintjieshoogde are located in the Somerset East District of the Eastern Cape Province in South Africa and together comprise the south-eastern end of the Sneeuberg mountain complex (hereafter referred to as the Sneeuberg) in the Sneeuberg Centre of Plant Endemism (Clark et al., 2009; see Chapter 2). The Boschberg is a ridge that extends roughly from Antoniekop in the west (immediately east of the Little Fish River) to Slagtersnek behind Cookhouse (Fig. 3.1). Although the whole ridge is technically the “Boschberg” (Van der Walt, 1972), in connotation the name mostly refers to the heavily wooded section of the ridge behind Somerset East. The Groot-Bruintjieshoogde is situated between the Boschberg and the Coetzeesberg–Aasvoëlkrans section of the Sneeuberg. It is separated from the Boschberg by the Little Fish River valley and from Aasvoëlkrans by Buffelshoek-se-Pas (Fig. 3.1).

The Boschberg and Groot-Bruintjieshoogde differ significantly from the rest of the Sneeuberg in a number of ways. The most obvious difference is that they are much wetter (see later) than the rest of the Sneeuberg, and consequently host many species not found further west along the southern Great Escarpment. Consequently they also host vegetation units different from the rest of the Sneeuberg. So thus, although they are geomorphologically part of the Sneeuberg, they are climatically and phytogeographically closer to the Great Winterberg–Amatolas (Story, 1952a; Mucina and Rutherford, 2006; Clark et al., 2009). For this reason, although the Boschberg and Groot-Bruintjieshoogde were considered in the detailed overview of the Sneeuberg in Chapter 2 (also Clark et al., 2009), their uniqueness in the Sneeuberg warrants a separate detailed overview, particularly given their links with the Great Winterberg–Amatolas (thus bringing the significance of the Great Fish River Interval into question; see Chapters 1 and 6). The Boschberg and Groot-Bruintjieshoogde are also possible key components in Weimarck's (1941) SE connection between the CFR (via the Zuurberg 60 km to the south) and the Great Escarpment (see Chapter 6), and as such would be possibly one of the most important biogeographical connections in southern Africa, as pertaining to the CFR and DAC, and perhaps the Afromontane centre in general (for instance White, 1983; Galley et al., 2007).

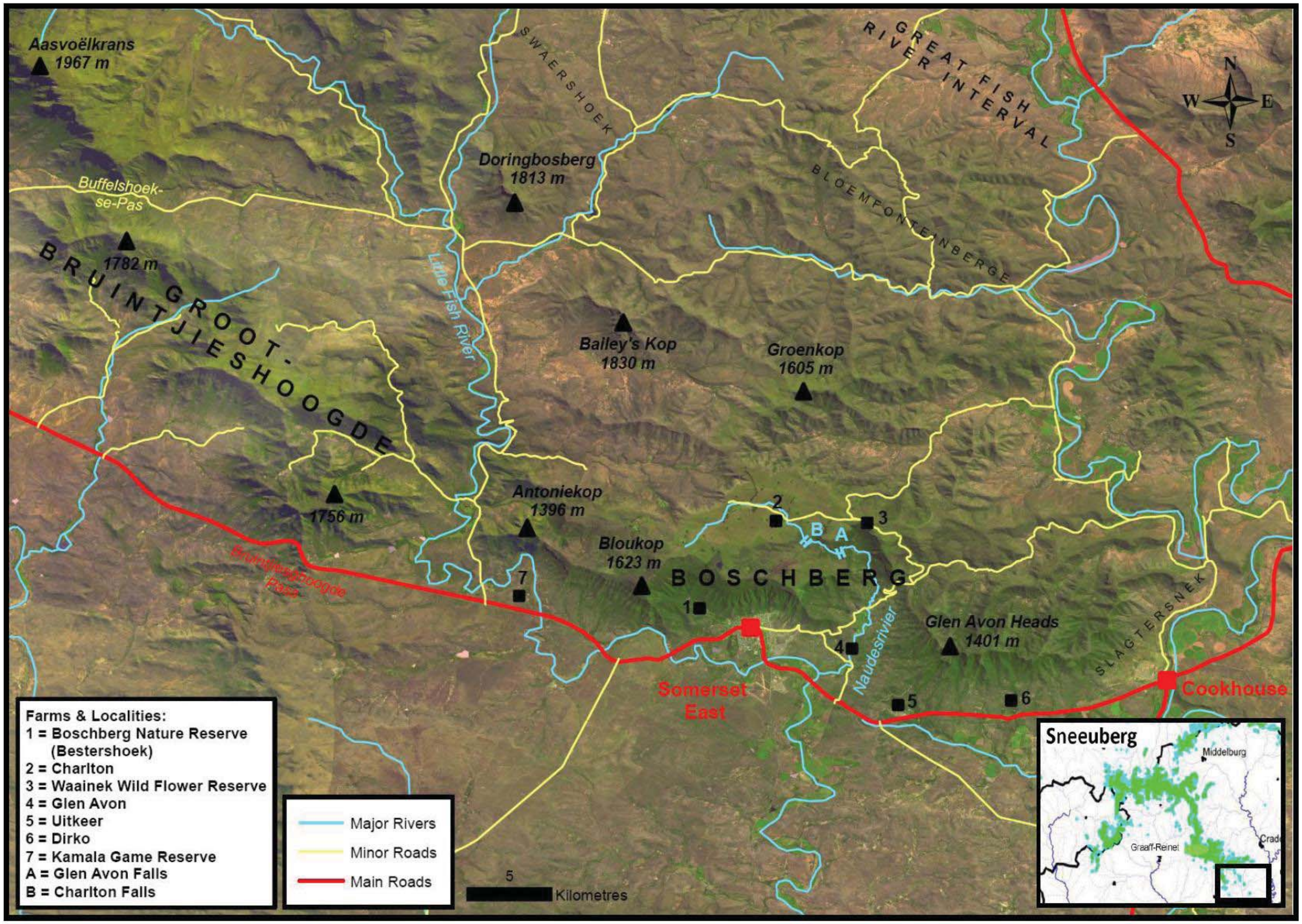


Figure 3.1: The Boschberg and Groot-Bruintjieshoogde, in the Sneeuberg mountain complex, indicating the highest points, farms used as bases for fieldwork, and localities mentioned in the text. Satellite imagery sourced from the CSIR (2009).

The presence of several taxa that are endemic and near-endemic (McMaster, 2007a, 2009; Clark et al., 2009) or "lost" (e.g. *Protea lorifolia* and *Diascia ramosa*; Rebelo, 2001; Hilliard and Burtt, 1984; see also Chapter 2) is a further motivation for a detailed floristic analysis of these mountains. An additional motivation rests on the fact that although plant collecting in the area has been ongoing since the second half of the 1800s, the flora has never been comprehensively documented. This is always a worthwhile endeavour in itself, particularly from a conservation perspective and in terms of the public interest in the Boschberg.

3.2. The Physical and Historical Environment of the Boschberg and Groot-Bruintjieshoogde

3.2.1. Geology and geomorphology

The geology of the Boschberg is dominated by Beaufort Group sediments (sandstones and shales) inconspicuously capped with dolerite (Clark et al., 2009). In terms of altitude, the Boschberg is the lowest section of the Sneeuberg, only reaching 1 623 m above sea level at its highest point (Bloukop; Figs 3.1 and 3.2F). The general plateau altitude is between 1 300 and 1 550 m above sea level, and the summit plateau is gently undulating with occasional outcrops (small "tors") of dolerite boulders. The southern slopes are steep to precipitous and form a low altitude section of the Great Escarpment complimentary to the Kagaberg behind Bedford on the opposite side of the Great Fish River Interval.

The geology and geomorphology of the Groot-Bruintjieshoogde is more typical of the rest of the Sneeuberg, comprising Beaufort Group sediments intruded by massive dolerites and forming an imposing Great Escarpment front (Clark et al., 2009). The Groot-Bruintjieshoogde has a dramatic scarp on its western and southern sides (Fig. 3.2C), but generally drops away more gently to the east and north. The summit plateau is between 1 600 m and 1 750 m above sea level with a highest point of 1 782 m, near Buffelshoek-se-Pas (Fig. 3.1). Although not much higher than the Boschberg in terms of absolute elevation, the Groot-Bruintjieshoogde is nevertheless more dramatic in terms of relative elevation.

3.2.2. Soils

The Boschberg summit plateau hosts very rich, black-brown clay turf soil derived from dolerite (Van der Walt, 1972). This soil is relatively acidic and has a low status of dissolved minerals (Van der Walt, 1972). Elsewhere, the soil consists of shallow *in situ* lithosols or colluvium, with deep (1–3 m) alluvial deposits along the Naudesrivier and the Little Fish River. As for the Boschberg summit, the Groot-Bruintjieshoogde summit also has dolerite-derived clayey soils. Generally in the area,

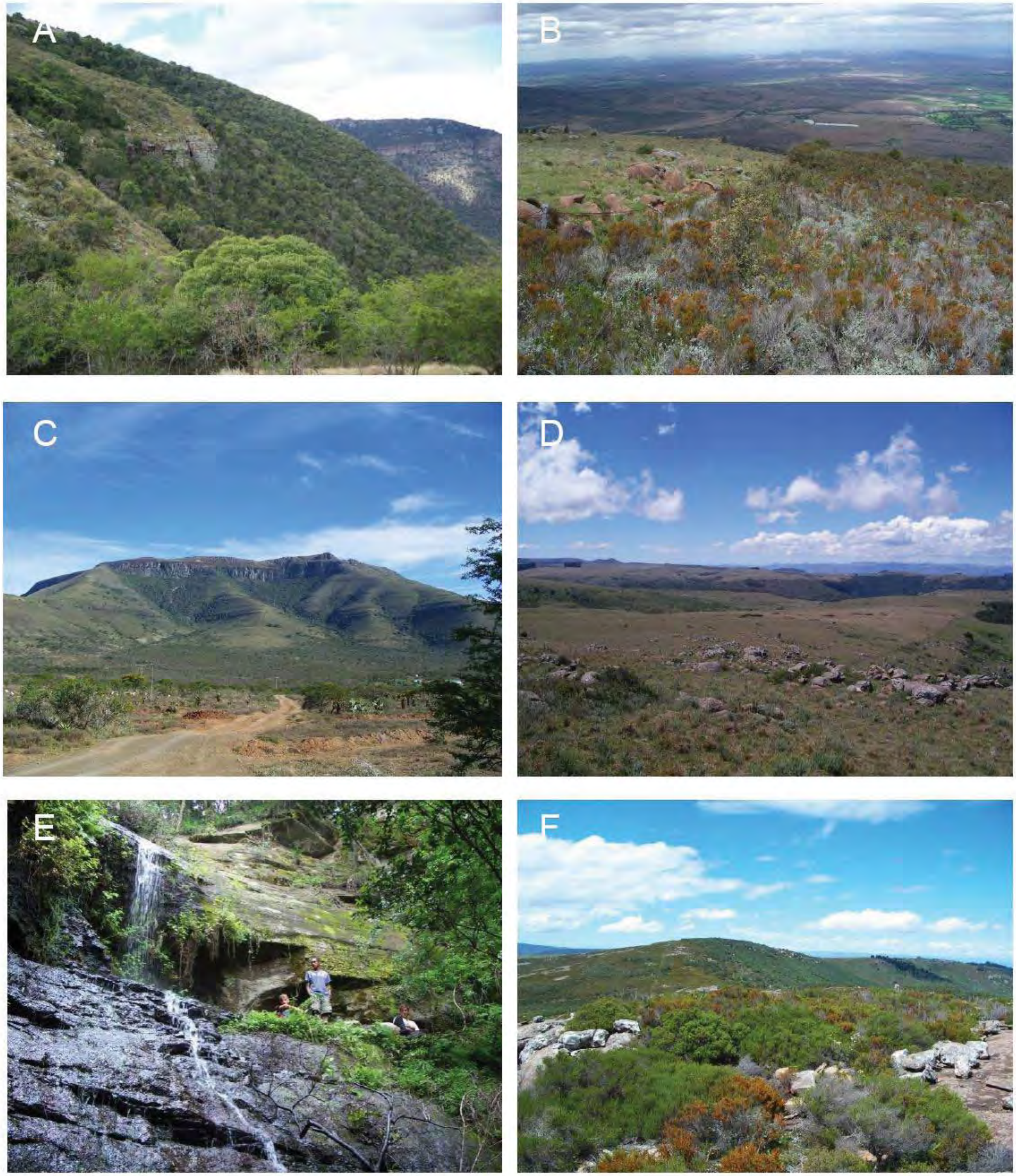


Figure 3.2: A selection of photographs from the Boschberg and Groot-Bruintjieshoogde: (A) The wooded nature of the Boschberg (summit 1 300 m), Farm Glen Avon; (B) Contrast between culturally-maintained grassland and moribund fynbos, Boschberg summit plateau (1 400 m); (C) The Groot-Bruintjieshoogde as viewed from the Farm Rietfontein (1 000 m on road); (D) The rolling Boschberg summit plateau, dominated by Amathole Montane Grassland (1 300–1 500 m); (E) Remote waterfall in the Boschberg Nature Reserve; (F) Fynbos near Bloukop (1 600 m), Boschberg Nature Reserve.

sandstone soils are shallower, nutrient-deficient and stony, while dolerite soils are deeper and more fertile and have a very high clay fraction (Van der Walt, 1972; Clark et al., 2009).

3.2.3. Climate

The Boschberg has a steep rainfall gradient from south to north. Bestershoek, at the base of the Boschberg in the Boschberg Nature Reserve, receives 699 mm per annum (Van der Walt, 1972), while the south and south-east-facing sections of the Boschberg Nature Reserve receive about ca. 800 mm (Somerset East Municipality, sine anno; Somerset East Transitional Council, sine anno). The upper slopes and crest receive between 900 to 1 000 mm per annum (G. and B. Brown, pers. comm.; Wilkins, pers. comm.). This is the highest rainfall in the Sneeuberg, and is comparable to the wet, south-facing slopes of the Great Winterberg (Scott, pers. comm.). Northwards, rainfall drops off quickly away from the Great Escarpment edge, for instance the Farm Charlton, approximately four kilometres inland from the Great Escarpment edge, receives 579 mm (Van der Walt, 1972). The Boschberg receives most of its rain in the summer (Van der Walt, 1972). March is the wettest month and June the driest, with May–August receiving less than 30 mm (Van der Walt, 1972). Summer thunderstorms originate in the north and north-east, while gentle rains (which can occur any time of the year) come from the south and south-east (Van der Walt, 1972). Orographic rain from the south-east is no doubt responsible for the higher rainfall along the Great Escarpment crest (Van der Walt, 1972). During fieldtrips in November and December 2008 (a drought summer), work was often hampered by such rain, and mist was frequent. Mist and rain can thus be taken as regular features of the Boschberg, with mist a significant contributor to effective moisture. Snow occurs annually on the summit plateau, mostly in June (Van der Walt, 1972).

No temperature data is available for the summit, but as for the rest of the Sneeuberg the effect of altitude on the Boschberg is clearly evident. Somerset East itself has average daily maximum temperatures of just under 20^{o}C in July to ca. 28^{o}C in January, and average daily minimum temperatures of ca. 6^{o}C in July to 15^{o}C in January (Van der Walt, 1972). Relative humidity is very high at the base of the Boschberg (pers. obs.), Van der Walt (1972) indicating average December values at 254 mm as measured from a Class A pan. In general, the Boschberg can be classified as having a sub-humid warm climate surrounded by a semi-arid warm climate (Van der Walt, 1972).

Although little climatic data are available for the Groot-Bruintjieshoogde, it is evident that a similar regime as on the Boschberg is present. The south and south-east-facing slopes, Great Escarpment crests and summits are very wet (ca. 800 mm; Staples, pers. comm.) and much cooler than the north-facing and west-facing slopes (ca. 400–500 mm). This is evident from the vegetation transitions from moist thicket-forest on the southern slopes to rich Afromontane grassland on the summit plateaux, to dry karroid grassland and thicket on the northern and western slopes. The Groot-Bruintjieshoogde is a climatic transition zone between the Boschberg and the rest of the Sneeuberg.

3.2.4. Hydrology

The Boschberg is drained entirely by the Little Fish and Great Fish Rivers. Of special interest is the 80 m-high Glen Avon Falls – at the head of the Naudesrivier Valley – and Charlton Falls, further upstream on the Boschberg plateau (Fig. 3.1). The Groot-Bruintjieshoogde forms part of the watershed between the Sundays River (the Voëlrivier, a main tributary of the Sundays, rises behind Pearston; Fig. 3.1) and Little–Great Fish River systems. Most rivers and streams in the area are episodic or non-perennial, with those on the wetter, southern slopes more likely to have reliable flow than those on the drier, northern slopes. The precipitous southern slopes of the Boschberg above Somerset East are renowned for the numerous cascades and waterfalls evident in the summer rainfall season (Fig. 3.2E).

3.2.5. Historical land-use and vegetation

One of the first European settlers in the area was Willem Prinsloo, who was farming at the base of the Boschberg in 1771 (Walker, 1936; Bergh and Visagie, 1985; Raper and Boucher, 1988), predating the settlement of Somerset East. Somerset East (originally called Somerset) was initiated in about 1817 as a British government farming scheme to provide fodder for the British border troops, and was declared a town in 1825 (Van der Walt, 1972). The Boschberg was heavily exploited for its timber in the latter 1700s and in the 1800s, supplying Outeniqua Yellow-wood *Afrocarpus falcatus* for the building industry, Sneezewood *Pteroxylon obliquum* for the farming industry, and as an informal source of firewood for Somerset East itself (Raper and Boucher, 1988; Le Vaillant, 1790; Van der Walt, 1972). The Somerset East area is currently a major agricultural area, with irrigation agriculture (e.g. lucern) along the Little Fish River, sheep and cattle farming both on the Boschberg and Groot-Bruintjieshoogde and on the plains below, game farming and eco-tourism (e.g. Kamala Game Reserve, fly-fishing at Glen Avon, Glen Avon Falls, farm holidays etc.). Cultivation in some of the Groot-Bruintjieshoogde valleys has apparently long been abandoned and those areas are now very badly eroded. The Boschberg Nature Reserve (ca. 2 050 Ha; Somerset East Transitional Council, sine anno) was established in 1937 (Van der Walt, 1972) and is owned by the Somerset East Municipality. It has a two-day hiking trail and overnight hut, otherwise it has been a declared water catchment for Somerset East since 1885, with reservoirs such as Mountain Reservoir and Bestershoek Dam (Van der

Walt, 1972). The Fish–Sundays water transfer scheme exits the Boschberg at Uitkeer, between Somerset East and Cookhouse.

With human activity comes the inherent infestation of undesirable plant species. *Nassella trichotoma*, a South American grass species (Henderson, 2001) – is a scourge on the Boschberg and Groot-Bruintjieshoogde. It now covers large tracts of summit plateau. This situation requires emergency measures in order to combat this very serious invader (Bromilow, 1996). The overall impact on biodiversity and rangeland value is very high and very negative (Boerdery in S.A., 1965), particularly as infestations have been present since at least the 1970s and currently run into the hundreds of hectares. Given the ease by which *Nassella* is wind-distributed (Bromilow, 1996), the *Nassella* infestations are probably feeding seed westwards onto the main Sneeuberg and possibly also eastwards onto the Great Winterberg–Amatolas where the species is also locally problematic. The species is encouraged through overgrazing and soil disturbance, and eventually out-competes indigenous grasses to form pure, unpalatable stands (Boerdery in S.A., 1965; Bromilow, 1996).

Acacia mearnsii is an invader of watercourses and grassland on the Boschberg plateau. A bio-control agent (the weevil *Melanterius maculatus*; Agricultural Research Council, 2006) was released on the Boschberg in November 2008 and will hopefully assist in curbing this species. *Pinus patula*, planted once as wind-rows on the Boschberg plateau, has become a serious invader of these plateau grasslands and fynbos. It requires attention, especially below Mountain Reservoir. *Rosa rubiginosa*, prevalent in the Aasvoëlkrans and Bankberg section of the Sneeuberg (Clark et al., 2009), is also potentially problematic in the Boschberg and Groot-Bruintjieshoogde and it forms dense thickets if left untreated. *Sambucus nigra*, widespread and occasional at the base of moist cliffs in the Sneeuberg (Clark et al., 2009), is also problematic on at least the Farm Glen Avon at the base of cliffs in forest. *Solanum pseudocapsicum* is a widespread problem in Boschberg forest understory (as well as in kloofs west along the lower Sneeuberg along the Graaff-Reinet–Murraysburg road). Typical invaders of the drier plains and lower slopes in the area are *Nicotiana glauca*, *Opuntia* spp. and *Agave americana*.

There has been an increase in conservation awareness in the region since the publication of Sim's (1907) work on the forests of the then Cape Colony. Apart from the Boschberg Nature Reserve (discussed above), the Waainek Wild Flower Reserve has been established by local farmer Philip Erasmus to protect a section of the Boschberg summit grassland (McMaster, 2007a, b, 2009). The Glen Avon Falls and valley have been designated as a Natural Heritage Site, and most recently several private game reserves have become established in the area. The main issues requiring urgent attention are alien invaders (*Nassella trichotoma*, *Pinus patula* and *Acacia mearnsii*), soil erosion in parts of the

Groot-Bruintjieshoogde, and protection for some of the rarer endemic and near-endemic species (e.g. *Dierama grandiflorum* and *Kniphofia acraea*). There is also probably a high local demand for plant material for traditional uses.

3.2.6. Pioneer botanical work

Chapter 2 (Clark et al., 2009) provides an overview of historical plant collectors in the Sneeuberg region. It would appear that most pioneer botanical work in the Boschberg and Groot-Bruintjieshoogde was undertaken by Peter MacOwan and Harry Bolus, as most historical specimens from the Boschberg and Groot-Bruintjieshoogde in Selmar Schönland Herbarium (GRA) are from these gentlemen (Clark et al., 2009), although lesser amounts have been undertaken by others (Gunn and Codd, 1981). A phyto-ecological study of the Boschberg – concentrating on the impacts of grazing – was undertaken by Van der Walt (1972). His work remains the most comprehensive survey of the vegetation of the Boschberg to date. More recent work on the Boschberg has been done by the Cameron McMaster, particularly relating to local endemics and the establishment of the Waainek Wild Flower Reserve (McMaster, 2007a, b, 2009; Dold and McMaster, 2005). The surveys conducted for this thesis however represent the first known comprehensive floristic survey of the Boschberg and Groot-Bruintjieshoogde.

3.3. The botanical environment of the Boschberg and Groot-Bruintjieshoogde

Four biomes occur in the region, namely Grassland, Afrotemperate Forest, Albany Thickets and Nama-Karoo (Mucina and Rutherford, 2006). The relatively low altitude of the Boschberg and Groot-Bruintjieshoogde, the dissected topography, and the relatively higher rainfall than the rest of the Sneeuberg, has resulted in these biomes inter-digitating with each other, especially Afrotemperate Forest and Thicket. Nama-Karoo, being peripheral to this area – and having been well-documented for the Sneeuberg region by Clark et al. (2009; see Chapter 2) – is not considered here.

3.3.1. Grassland

The summit grassland of the Boschberg is described by Mucina and Rutherford (2006) as Amathole Montane Grassland. This vegetation unit occurs along the southern Great Escarpment from the Groot-Bruintjieshoogde in the west to the Stutterheim and Komga in the Great Winterberg–Amatolas in the east (Mucina and Rutherford, 2006). On the Boschberg it is confined to the wetter summit crests and summit plateau, and with loss of altitude and northerly aspect quickly gives way to Karoo Escarpment Grassland (Mucina and Rutherford, 2006; detailed in Clark et al., 2009, and not considered further here), *Acacia karroo* woodland, and dry Great Fish Thicket (Mucina and Rutherford, 2006; see below). Amathole Montane Grassland differs significantly from Karoo Escarpment Grassland (which is typical of the rest of the Sneeuberg; Mucina and Rutherford, 2006; Clark et al., 2009) by an absence of *Merxmuellera disticha* and a dominance of *Themeda triandra* and a greater presence of other moister montane grasses such as *Andropogon appendiculatus*, *Brachiaria serrata*, *Brachypodium flexum*, *Cymbopogon nardus*, *Eragrostis capensis*, *Eustachys paspaloides*, *Festuca scabra*, *Harpochloa falx*, *Koeleria capensis* and *Tristachya leucothrix*. Many forbs and geophytes that are only found at higher altitudes on the Sneeuberg are common on the wetter, lower altitude Boschberg (see also Chapter 6). Typical forb, geophyte and suffrutex species are *Alchemilla bicarpellata*, *Cyrtanthus macowanii*, *C. tuckii*, *Geranium harveyi*, *Geum capense*, *Haplocarpha nervosa*, *H. scaposa*, *Indigofera cuneifolia*, *I. mollis*, *Lachenalia campanulata*, *Moraea elliotii*, *Nemesia umbonata*, *Wahlenbergia krebsii* subsp. *krebsii*, etc.. *Helichrysum* species are particularly abundant (Mucina and Rutherford, 2006) and include *H. anomalum*, *H. appendiculatum*, *H. aureonitens*, *H. aureum*, *H. ecklonis*, *H. felinum*, *H. microniifolium*, *H. montanum*, *H. nudifolium* var. *nudifolium* and var. *pilosellum*, *H. odoratissimum*, *H. petiolare*, and *H. splendidum*, *H. trilineatum*, *H. umbraculigerum* and *H. xerochrysum*. This habitat also hosts numerous regionally endemic and rare species such as *Dierama grandiflorum*, *Disa lugens* var. *lugens*, *Haemanthus carneus* and *Kniphofia acraea* (Dold and McMaster, 2005; McMaster, 2007a, b, 2009; Clark et al., 2009).

The summit of the Groot-Bruintjieshoogde can also be classified as Amathole Montane Grassland. It is transitional however, and is not as rich in species as the Boschberg summit grassland. The summit of the southern section of the Groot-Bruintjieshoogde (Fig. 3.1) is interesting in that it hosts massive colonies of *Watsonia pillansii*, a species not found elsewhere in the Sneeuberg but is common eastwards onto the Great Winterberg–Amatolas. The upper slopes, seeps and areas near cliff-lines are swathed in massive colonies of *Agapanthus praecox*, these colonies petering out on the Sneeuberg on the Farm Buffelshoek behind Pearston.

The very prominent fynbos component evident on the Boschberg and sections of the Groot-Bruintjieshoogde can possibly be assigned to Mucina and Rutherford's (2006) Drakensberg–Amathole Afromontane Fynbos vegetation unit, although on the Boschberg and Groot-Bruintjieshoogde it is more typical of the Great Escarpment crest and forest margins than river valleys as stated by Mucina and Rutherford (2006). Drakensberg–Amathole Afromontane Fynbos occurs from the Boschberg along the southern Great Escarpment into the DAC with outliers in northern KZN (Mucina and Rutherford, 2006). Story (1952a) notes the close similarity of the fynbos on the Boschberg with that on the Amatolas.

There are strong indications that, together with *Leucosidea sericea, Buddleja salviifolia* and *Rubus rigidus*, this fynbos invades grassland where fire and grazing are excluded on the Boschberg and Groot-Bruintjieshoogde (e.g. Story, 1952a, b). In the Boschberg Nature Reserve, this vegetation unit occurs as a dense *Erica simulans–E. cafforum–Passerina montana* “climax” fynbos up to 2 m tall, and as extensive, dense, and virtually pure/species-poor stands of both *Protea subvestita* and *Leucosidea sericea*. Areas that had been recently burnt at the time of the fieldwork suggest a typical fybos regeneration/successional process, with many herbaceous and suffrutex species evident. The regenerating *Protea subvestita* fynbos in the burnt area near Bloukop in the Boschberg Nature Reserve included species such as *Centella graminifolia* var. *graminifolia, Hebenstretia dura, Helichrysum felinum, Ischyrolepis* sp. aff. *constipata, I. distracta, Metalasia muricata, Morella brevifolia, Muraltia alopecuroides, M. saxicola, Pelargonium glutinosum, P. laevigatum* var. *laevigatum, Polygala microlopha*, *Osteospermum caulescens, Phylica paniculata* and *Senecio tanacetopsis.* A comparable fynbos patch on the Groot-Bruintjieshoogde contained additional species such as *Anthospermum herbaceum*, *Erica caespitosa*, *Ficinia ramossisima*, *Harveya bolusii*, *Merxmuellera stricta*, *Muraltia alticola* and *Schizaea pectinata*. Other typical species, apart from the ones mentioned already, are *Anthospermum monticola*, *Cliffortia eriocephalina*, *C. paucistaminea*, *Erica leucopelta*, *Merxmuellera macowanii*, *Psoralea glabra* and *Restio sejunctus*. *Protea lorifolia*, a CFR species recorded historically on the Boschberg (Rebelo, 2001), is apparently still present (Wilkins, pers. comm.).

As adjacent commercial farms are characterised by fire- and grazing-maintained grassland, the fynbos can be considered possibly invasive to grassland and indicative of a moribund veld condition (e.g. Story, 1952a, b). If not burnt, it may even give way to forest in suitable circumstances (Story, 1952a). There has probably been a continual interplay between grassland and woody vegetation on the Boschberg and Groot-Bruintjieshoogde, driven mostly by fire (from lightning; e.g. Staples, pers. comm. for the Groot-Bruintjieshoogde burn in spring 2008), decadel climate fluctuations (wetter periods favouring woody vegetation), and large herbivores (cattle and sheep replacing wild game in the past 250 years). Grassland was present on the Boschberg just after the first European settlers began farming in the area in the 1770s (Raper and Boucher, 1988), and this together with the numerous grassland endemics and near-endemics indicates that grassland is a natural vegetation type in the area and not an anthropogenically produced one (compare Story, 1952a, b) – although today grassland is anthropogenically maintained as dominant through burning and high livestock density (a good example is the boundary between the Boschberg Nature Reserve and adjacent private land; Fig. 3.2B).

Bedford Dry Grassland (Mucina and Rutherford, 2006), characterised by *Acacia karroo* parkland-savannah, dominates the plains below the Boschberg and Groot-Bruintjieshoogde (Clark et al., 2009). This vegetation unit extends from the Bruintjiesghoogde Pass in the west to Fort Beaufort in the east, occupying the flats along the base of the Great Escarpment (Mucina and Rutherford, 2006).

3.3.2. Afrotemperate Forest

Mucina and Rutherford (2006) have included the Boschberg forests (Fig. 3.2A) in their Southern Misbelt Forest vegetation unit (Clark et al., 2006). Southern Misbelt Forest occurs from the Boschberg and Baviaanskloofberge in the Eastern Cape to Ulundi in KZN (Mucina and Rutherford, 2006). The Boschberg is the western limit of Great Escarpment forest in southern Africa, and is the only section of the Sneeuberg to host a yellow-wood species (*Afrocarpus falcatus*), some remnant specimens of which are substantial in size. However the more typical eastern Great Escarpment yellow-wood species (*Podocarpus latifolius* (Thunb.) R. Br. ex Mirb.) does not occur on the Boschberg, its western limit apparently being Fenella Gorge in the Great Winterberg.

Forest on the Boschberg is fragmented and is largely confined to the deeper ravines on south and south-east-facing slopes. It occurs in a matrix of, and intergrades with, Eastern Cape Escarpment Thicket (Mucina and Rutherford, 2006) as well as woodland types dominated by *Celtis africana*, *Kiggelaria africana* and *Olea europeae* subsp. *africana*. Substantial forest patches occur on the Boschberg Nature Reserve, above the Farm Glen Avon (where groves of large *Afrocarpus falcatus* of ca. 15–20 m tall still occur and are perhaps indicative of the original Boschberg forest prior to disturbance), and in the ravines above Uitkeer and the Farm Dirko (these warrant further exploration).

Van der Walt (1972) motivates for a historically more continuous Boschberg forest in which trees up to 30 m tall were common (probably emergent canopy *Afrocarpus falcatus*, such as in the Amatola forests today), while R.J. Gordon (in Raper and Boucher, 1988) estimated an *Afrocarpus falcatus* tree on the Boschberg in 1777 to have a height of 15 m and a circumference of 4.6 m, and the forest in general to be typically characterised by very tall trees. Hilliard and Burtt (1984) and Van der Walt (1972) concur that the Boschberg forests have been badly disturbed. The current fragmented nature of the forest has been attributed to fire from human activity (Van der Walt, 1972), large-scale harvesting of commercial timber in the late 1700s and the 1800s (Van der Walt, 1972), and possibly general aridification since European colonisation (e.g. Sim, 1907; Sugden, 1989), favouring thicket rather than forest regeneration. Forest fragmentation may also have been encouraged by the use of the Boschberg forests behind Somerset East as commonage for cattle grazing (Wilkins, pers. comm.), although the effect of historical large game such as *Syncerus caffer* (Cape Buffalo; Raper and

Boucher, 1988) may have been no different. *Poicephalus robustus* (Cape Parrots) which rely primarily on yellow-wood fruits (Hockey et al., 2005), were known from the Boschberg in the late 1700s (Raper and Boucher, 1988). They are now extinct on the Boschberg (G. Brown, pers. comm.) but are still present in the Amatola forests to the east. This suggests a richer yellow-wood forest on the Boschberg in times past, although historical persecution by farmers is also a possible cause of local extinction of these parrots.

Although both R.J. Gordon (in Raper and Boucher, 1988) and Le Vaillant (1790) noted the presence of valuable *Ocotea bullata* (Burch.) Baill. on the Boschberg, it was not mentioned by Sim (1907) as occurring in the area except for a few trees in the higher elevations of the Amatola Forests. (Sim, 1907, in fact did not mention the Boschberg in particular in his overview of the forests of the then Cape Colony). Even if *Ocotea bullata* occurred on the Boschberg prior to European settlement its existence on the Boschberg today is doubtful.

Today the slopes of the Boschberg are probably in a state of regeneration, with young to medium-sized *Afrocarpus falcatus* common in the dense ravine forests. The intervening spurs are currently dominated by dense *Olea europaea* subsp. *africana* woodland-thicket, and this may be a pre-climax woodland-forest community to be replaced in time with *Afrocarpus falcatus* and other typical forest species, or represents a stable woodland community as is typical elsewhere in the Sneeuberg (Clark et al., 2009; see Chapter 2). It is possible, however, given the protection received since 1937, that the Boschberg Nature Reserve forests are in their best condition since ca. 1900 but are a far cry from the purported 15–30 m tall yellow-wood climax forest of times past.

Typical woody species in the Boschberg forests include *Afrocarpus falcatus*, *Apodytes dimidiata*, *Calodendrum capense*, *Canthium ciliatum*, *C. mundianum*, *Carissa bispinosa*, *Cassinopsis illicifolia*, *Celtis africana*, *Cussonia spicata*, *Dovyalis zeyheri*, *Ficus burtt-davyii*, *Grewia occidentalis*, *Halleria lucida*, *Heteromorpha arborescens* var. *arborescens* (interior form), *Maytenus acuminata*, *M. undata*, *Mimusops obovata*, *Mystroxylon aethiopicum*, *Olinia emarginata* (often in pure stands on both the Boschberg and Groot-Bruintjieshoogde), *Pittosporum viridiflorum*, *Pterocelastrus tricuspidatus*, *Rapanea melanophloeos*, *Rhamnus prinoides*, *Rhoicissus revoili*, *R. tridentata*, *Scolopia mundii*, *Searsia chiridensis*, *S. dentata*, *S. pyroides* and *Xanthoxylem capense.* The understory comprises species such as *Asparagus declinatus*, *Behnia reticulate*, *Dietes grandiflora*, *Disperis lindleyana*, *Lauridia tetragona*, *Oplismenus hirtellus* and *Plectranthus laxiflorus*. Ferns are abundant, particularly along watercourses, and include *Asplenium aethiopicum*, *A. monanthes*, *Blechnum attenuatum* var. *attenuatum*, *Cystopteris fragilis*, *Dryopteris inaeqaulis*, *Thelypterus guienziana* and *T. pozoi*. *Freesia* *laxa* and *Hermannia violacea* (Great Winterberg–Amatola and Boschberg endemic) are common on forest margins.

3.3.3. Albany Thickets

Eastern Cape Escarpment Thicket (Mucina and Rutherford, 2006) dominates much of the Boschberg, intergrading with Southern Mistbelt Forest as mentioned above. This vegetation unit occurs patchily along the southern Great Escarpment from Somerset East to Hogsback (Mucina and Rutherford, 2006). Typical species are *Acacia karroo*, *Azima tetracantha*, *Capparis sepiaria*, *Ehretia rigida*, *Euclea crispa* subsp. *crispa*, *E. undulate*, *Euphorbia tetragona*, *Gymnosporia buxifolia*, *Hippobromus pauciflorus*, *Pappea capensis*, *Portulacaria afra*, *Pteroxylon obliquum*, *Schotia latifolia*, *Scutia myrtina*, *Searsia pallens*, *Vepris lanceolata* and *Ziziphus mucronata*. In some places *Acacia karroo* is almost completely dominant (such as at the base of the Boschberg in the Boschberg Nature Reserve) while in other places *Euphorbia tetragona* is more typically dominant (such on the east-facing slopes of the Glen Avon Falls valley).

Great Fish Thicket occurs along the Little Fish River between the Boschberg and the Groot-Bruintjieshoogde, as well as along the Great Fish River (Mucina and Rutherford, 2006; Clark et al., 2009). This is a much more arid thicket vegetation unit and is characteristic of much of the Albany Centre of Plant Endemism (Mucina and Rutherford, 2006). Typical trees include *Acacia karroo*, *Boschia oleoides*, *Euclea undulate* and *Olea europaea* subsp. *africana*, while the bulb *Drimia altissima* is abundant and very conspicuous in early summer after rains. The invasive shrub *Nicotiana glauca* is common and is a potential problem in this vegetation type along watercourses. Camdeboo Escarpment Thicket, the typical Sneeuberg thicket vegetation unit, occurs on the western slopes of the Groot-Bruintjieshoogde (Mucina and Rutherford, 2006) and is detailed by Clark et al. (2009).

3.3.4. Noteworthy localised vegetation types

Although not common on the Boschberg, *Pteridium aquilinum* subsp. *aquilinum–Rubus rigidus* ("bracken-briar") thickets are worthy of mention simply because it is a typical Afromontane community characteristic of the moister eastern Great Escarpment in southern Africa but absent from the Sneeuberg except on the Boschberg. A bracken-brier patch of about 1 Ha occurs on the Farm Glen Avon and consists of a dense community of *Clutia pulchella*, *Euclea coriacea*, *Garuleum tanacetifolium*, *Hermannia violacea*, *Indigofera cuneifolia*, *Lauridia tetragona*, *Pelargonium grossulariodes*, *Phylica paniculata*, *Printzia pyrifolia*, *Psoralea glabra*, *Pteridium aquilinum* subsp. *aquilinum*, *Rubus rigidus* and *Searsia tomentosa*. It is situated in a south-east-facing bowl on the

Boschberg crest and probably receives an abundant supply of moisture from groundwater seepage and from mist and rain.

Wetland vegetation is confined to the edges of local dams, natural pools along rivers, and stream- and river-lines. Species typical of open habitats (dam fringes and summit streams) include *Cliffortia paucistaminea*, *Denekia capensis*, *Merxmuellera macowanii*, *Paspalum dilatatum* (alien), *Senecio polyodon* subsp. *polyodon*, and numerous Cyperaceae and Juncaceae. The riparian vegetation of the Naudesrivier downstream of Glen Avon Falls is characterised by *Cliffortia strobolifera*, *Cotula nigellifolia*, *Cyperus textilis*, *Moraea huttonii*, *Salix mucronata*, and the grasses *Holcus lanatus* and *Panicum deustum*.

Another important type of community is found on south- and south-east-facing cliffs. These moist cliff-lines host cushions of *Anthospermum pumilum* subsp. *rigidum*, *Asplenium adiantum-nigrum* var. *adiantum-nigrum*, *A. trichomanes* subsp. *quadrivalens*, *Crassula cultrata*, *C. montana* subsp. *quadrivalens*, *C. setulosa* var. *setulosa*, *Delosperma lootsbergense*, *Galium thunbergianum* subsp. *hirsutum*, *Lepisourus schraderi*, *Nemesia* cf. *rupicola* (specimens sent to K. Steiner), *Othonna carnosa*, *Pentaschistis airoides* subsp. *jugorum*, *Pleopeltis macrocarpa*, *Polypodium vulgare*, *Streptocarpus meyeri* and *Troglophyton capillaceum* subsp. *diffusum*. Cliff-bases host *Cineraria erodioides* var. *erodioides*, *Conium* sp. no. 3, *Polystichum monticola*, *Stachys grandifolia* and *Rumex cordatus*, and various wooded communities such as *Buddleja salviifolia–Kiggelaria africana* thicket or more mesic thicket and forest types as discussed above.

3.4. Flora of the Boschberg and Groot-Bruintjieshoogde

Two comprehensive collecting trips were undertaken in November and December 2008 to the Boschberg and Groot-Bruintjieshoogde (Table 3.1), resulting in a collection of 939 specimens. This data has been augmented with data collected by Cameron McMaster since 1973 (mostly photographic) and historical collections by Harry Bolus and Peter MacOwan housed in GRA. The identification of the collected specimens was undertaken as for the Sneeuberg in Chapter 2. Photographic specimens are to be lodged in GRA. The flora of the Boschberg is contained in Appendix 3.

Table 3.1: Collecting trips to the Boschberg and Groot-Bruintjieshoogde (2008).

Localities	Dates	Collectors	Grids
1. Boschberg Nature Reserve, Boschberg (Somerset East District).	November 2008.	Clark VR, Andrews A; Clark VR, Coombs G.	3225DA
2. Boschberg Nature Reserve, Boschberg, Groot-Bruintjieshoogde (Somerset East District).	December 2008.	Clark VR, Daniels RJ, Le Roux JA, Fabricius M.	3225AD, CB, DA

3.5. Phytogeographical Considerations

Although considered by Clark et al. (2009) to be part of the Sneeuberg mountain complex, the vegetation of the Boschberg and Groot-Bruintjieshoogde (but particularly of the Boschberg) differs significantly from the rest of the Sneeuberg in terms of species composition and vegetation units. Of the rest of the Sneeuberg, only the Kamdebooberge approaches the Boschberg and Groot-Bruintjieshoogde in this regard, and all three of these montane components host species not found elsewhere in the Sneeuberg. This may be due to their orientation, which is well-situated to harvest moisture from south-easterlies, compared to the more arid interior Sneeuberg (Clark et al., 2009). This moisture availability perhaps compensates for their relatively low-altitude. Thus the Boschberg and Kamdebooberge are wetter "tail-ends" spurs off the eastern and western ends of the Sneeuberg respectively, providing high local endemism and diversity in the Sneeuberg Centre.

3.5.1. Flora and significant findings

A flora of 630 taxa has been compiled (Appendix 3), and although this probably only represents ca. 60–70% of the absolute total for the Boschberg and Groot-Bruintjieshoogde, it nevertheless adds 240 species not recorded previously in the Sneeuberg mountain complex (i.e. additional to Appendix 2). Not many significant finds were forthcoming, but do include *Aspalathus* cf. *katbergensis* from the Boschberg Nature Reserve, a species previously considered endemic to the Great Winterberg and Katberg (Dahlgren, 1988). Additional collections of the poorly known near-endemic *Garuleum tanacetifolium* were made. Additional material of the recently discovered Boschberg endemic *Hermannia crassifolia* (Gwynne-Evans, pers. comm.; see Tables 2.3 and 2.4 in Chapter 2) were also made. Despite an intensive search, *Diascia ramosa*, endemic to the forests on the Boschberg and only known from two specimens collected in the later 1800s (see Table 2.2 in Chapter 2), was not rediscovered.

3.5.2. The Boschberg and Groot-Bruintjieshoogde: floristic "hub" of the southern Great Escarpment

The species composition and vegetation units of Boschberg and Groot-Bruintjieshoogde are more typical of the Great Winterberg–Amatolas than of the Sneeuberg (Mucina and Rutherford, 2006), although there is a clear gradation along the Groot-Bruintjieshoogde from typical Boschberg vegetation to typical Sneeuberg vegetation (e.g. Mucina and Rutherford, 2006). These differences can be attributed to a climate gradient, suggesting that the vegetation units and species distributions on the southern Great Escarpment are largely climate-driven, as southern Great Escarpment geology is consistent from the Great Winterberg across to the Roggeveld (i.e. Beaufort Group sediments intruded by dolerites). The Great Winterberg has a MAP of at least 1 000 mm per annum on the windward Great Escarpment crest (Scott, pers. comm.), as does the Boschberg (G. Brown, pers. comm; Wilkins, pers. comm.), whereas the wettest components of the Sneeuberg only have a MAP of about 700 mm (Clark et al., 2009; see Chapters 2 and 6).

Of particular interest are the several plant species endemic to the Great Winterberg–Amatolas and which also occur on the Boschberg (Clark et al., 2009; see Table 2.3 in Chapter 2). The reverse is true, with the recent discovery of previously-considered Sneeuberg endemic *Bergeranthus nanus* (Clark et al., 2009) being recently found on the Great Winterberg (pers. obs., January, 2009). Similarly, the Great Fish River Interval does not appear to have been a serious barrier to a host of moist eastern species (e.g. *Peperomia retusa*, *Deneckia capensis*, *Cyrtanthus tuckii*, to name a few). Connectivity between the Sneeuberg-proper and Great Winterberg–Amatolas is supported by *Erica* aff. *reenensis* on the Nardousberg (Clark et al. 2009), and recently recorded on the Great Winterberg (pers. obs., January, 2009), and *Delosperma* sp. nov. aff. *dyeri* from the Nardousberg (Clark et al. 2009; see Table 2.2 in Chapter 2) either being sympatric the Great Winterberg-endemic *D. dyeri* (Dold and Hammer, 2001), or conspecific with it (Burgoyne, pers. comm.). *Garuleum tanacetifolium*, previously only known from the Kagaberg (behind Bedford) and the Boschberg, is now known from the Sneeuberg as far west as the Nardousberg where it is very common on south-facing mountain slopes above 1 800 m (see Tables 2.3 and 2.4 in Chapter 2). This suggests that the Great Fish River Interval of Clark et al. (2009; see Chapter 2) is not a major hindrance to connectivity along this region of the Great Escarpment, and lends support to Nordenstam (1969) and Hilliard's (1994) "Sneeuwbergen" phytogeographical centre. This centre circumscribes the Sneeuberg together with the Great Winterberg–Amatolas and Stormberg (Clark et al., 2009), and brings into question the validity of a separate Sneeuberg Centre of Endemism as proposed by Clark et al. (2009). An alternative is to simply lump all these fragmented sections of Great Escarpment into an extended DAC as proposed by Mucina and Rutherford (2006) and contemplated by Clark et al. (2009). The difficulty in this regard is that despite many similarities between these sections of the Great Escarpment, there is enough local endemism (at least 1.5% in each) to tempt delimitation of separate Sneeuberg, Great Winterberg–Amatola and Stormberg Centres of Endemism (the Stormberg still requires a detailed floristic study, but available evidence indicates significant local endemism). It will probably never be possible to completely resolve this biogeographically complicated montane scenario, but nevertheless it should be acknowledged that these (still poorly known) sections of Great Escarpment are rich in localised endemics – even the well-connected Boschberg has some local endemics and local variants of more widespread eastern species – and therefore warrant further detailed botanical investigation and appropriate conservation measures.

3.5.3. The Boschberg and Groot-Bruintjieshoogde: floristic "hub" between the southern Great Escarpment and the CFR

The possibility exists that the Boschberg is a significant link between the CFR and the Great Escarpment in southern Africa. The 60 km of relatively high ground between the Zuurberg and the Boschberg could easily account for the presence of numerous fynbos species found on the Boschberg, and perhaps account for the current disjunction of several others known from the DAC and CFR (Weimarck, 1941). This connection, representing Weimarck's (1941) SE connection, may thus account for a high proportion of the genetic traffic between the CFR and eastern Great Escarpment. It may also be the route that was used for the now sympatric species of *Pseudochloroptila* (Siskens), *Chaetops* (Rockjumpers) and *Promerops* (Sugarbirds) endemic to the CFR and DAC/eastern Great Escarpment (Hockey et al., 2005; Clark et al., 2009; see Chapter 2), as well as for the host of species that occur from the CFR up through the eastern Great Escarpment (and for some, northwards into the tropical African mountains; see Chapters 1 and 6).

3.6. Conclusion

The Boschberg and Groot-Bruintjieshoogde have a rich flora and are floristically closely related to the Great Winterberg–Amatolas, sharing four endemics and a large number of moist eastern taxa not found on the main Sneeuberg. Such evidence of connectivity suggests that the Great Fish River Interval is a minor phytogeographical interval. The presence of such species on the Boschberg and Groot-Bruintjieshoogde – but not further west on the same (continuous) Sneeuberg – suggests that the distribution of species on the southern Great Escarpment is also due to climate filtering and not simply disjunction. Disjunction thus plays a minor role in the distribution of many Great Escarpment species.

The Boschberg is a key component in the SE connection between the CFR (via the Zuurberg) and the eastern Great Escarpment, and is the main link between the CFR and the Afromontane region on the eastern Great Escarpment in southern Africa. Thus the Boschberg is the key node in the hub between the drier west, the Great Winterberg–Amatolas to the east, and the CFR to the south. Detailed floristic analyses to test this further are undertaken in Chapter 6.

Appendix 3: Flora of the Boschberg and Groot-Bruintjieshoogde (Sneeuberg mountain complex).

Family	**Genus and species**	**Collectors/References**
Pteridophytes		
Anemiaceae	*Mohria nudiuscula* J.P.Roux	Clark VR, Daniels R, Le Roux J, Fabricius M 289
Aspidiaceae	*Dryopteris inequalis* (Schltdl.) Kuntze	Clark VR, Daniels R, Le Roux J, Fabricius M 439
Aspidiaceae	*Polystichum monticola* N.C.Anthony & Schelpe	Clark VR, Andrews A 88
Aspidiaceae	*Rumohra adiantiformis* (G.Forst) Ching	Clark VR, Andrews A 243
Aspleniaceae	*Asplenium adiantum-nigrum* L. var. *adiantum-nigrum*	Clark VR, Daniels R, Le Roux J, Fabricius M 378
Aspleniaceae	*Asplenium aethiopicum* (Burm.f.) Bech.	Clark VR, Andrews A 245
Aspleniaceae	*Asplenium monanthes* L.	Clark VR, Daniels R, Le Roux J, Fabricius M 436
Aspleniaceae	*Asplenium platyneuron* (L.) Britton, Sterns & Poggenb.	Clark VR, Daniels R, Le Roux J, Fabricius M 272
Aspleniaceae	*Asplenium trichomanes* subsp. *quadrivalens* D.E.Mey.	Clark VR, Daniels R, Le Roux J, Fabricius M 339
Behniaceae	*Behnia reticulata* (Thunb.) Didr.	Clark VR, Daniels R, Le Roux J, Fabricius M 425
Blechnaceae	*Blechnum attenuatum* (Sw.) Mett.	Clark VR, Daniels R, Le Roux J, Fabricius M 437
Blechnaceae	*Blechnum australe* L. subsp. *australe*	Clark VR, Daniels R, Le Roux J, Fabricius M 90
Dennstaedtiaceae	*Pteridium aquilinum* (L.) Kuhn subsp. *aquilinum*	Clark VR, Andrews A 313
Equisetaceae	*Equisetum ramosissimum* Desf. subsp. *ramosissimum*	Clark VR, Andrews A 73
Polypodiaceae	*Lepisorus schraderi* (Mett.) Ching	Clark VR, Daniels R, Le Roux J, Fabricius M 230
Polypodiaceae	*Pleopeltis macrocarpa* (Bory ex Willd.) Kaulf. var. *macrocarpa*	Clark VR, Andrews A 277
Polypodiaceae	*Polypodium vulgare* L.	Clark VR, Daniels R, Le Roux J, Fabricius M 47
Pteridaceae	*Adiantum poiretii* Wikstr.	Clark VR, Andrews A 91
Pteridaceae	*Cheilanthes eckloniana* (Kunze) Mett.	Clark VR, Daniels R, Le Roux J, Fabricius M 19
Pteridaceae	*Cheilanthes hirta* Sw.	Clark VR, Andrews A 151
Pteridaceae	*Cheilanthes quadripinnata* (Forssk.) Kuhn	Clark VR, Daniels R, Le Roux J, Fabricius M 94
Pteridaceae	*Cheilanthes viridis* (Forssk.) Sw.	Clark VR, Andrews A 120
Pteridaceae	*Pellaea calomelanos* (Sw.) Link var. *calomelanos*	Clark VR, Daniels R, Le Roux J, Fabricius M 114
Pteridaceae	*Pteris cretica* L.	Clark VR, Daniels R, Le Roux J, Fabricius M 105
Pteridaceae	*Pteris dentata* Forssk.	Clark VR, Andrews A 124
Schizaeaceae	*Schizaea pectinata* (L.) Sw.	Clark VR, Daniels R, Le Roux J, Fabricius M 161
Thelypteridaceae	*Stegnogramma pozoi* (Lag.) K.lwats	Clark VR, Daniels R, Le Roux J, Fabricius M 435
Thelypteridaceae	*Thelypteris bergiana* (Schltdl.) Ching	Clark VR, Andrews A 307
Thelypteridaceae	*Thelypteris guienziana* (Mett.) Schelpe	Clark VR, Daniels R, Le Roux J, Fabricius M 331
Woodsiaceae	*Cystopteris fragilis* (L.) Bernh.	Clark VR, Daniels R, Le Roux J, Fabricius M 329
Gymnosperms		
Podocarpaceae	*Afrocarpus falcatus* (Thunb.) C.N.Page	Clark VR, Andrews A 49
Monocotyledons		
Agapanthaceae	*Agapanthus praecox* Willd.	Clark VR, Andrews A 37
Alliaceae	*Tulbaghia acutiloba* Harv.	McMaster C 2 December 2005 No. 1
Alliaceae	*Tulbaghia cernua* Avé-Lall.	Clark VR, Andrews A 210
Amaryllidaceae	*Boophone disticha* (L.f.) Herb.	Clark VR, Daniels R, Le Roux J, Fabricius M 404
Amaryllidaceae	*Brunsvigia grandiflora* Lindl.	McMaster C 6 March 2009 No. 1
Amaryllidaceae	*Cyrtanthus macowanii* Baker	Clark VR, Andrews A 366
Amaryllidaceae	*Cyrtanthus smithiae* Watt ex Harv.	MacOwan P 1580
Amaryllidaceae	*Haemanthus albiflos* Jacq.	McMaster C 24 January 2009 No. 1
Amaryllidaceae	*Haemanthus carneus* Ker Gawl.	McMaster C 6 February 2004 No. 1
Amaryllidaceae	*Nerine angustifolia* (Baker) Baker	MacOwan P 1889
Amaryllidaceae	*Scadoxus puniceus* (L.) Friis & Nordal	Clark VR, Daniels R, Le Roux J, Fabricius M 420
Anthericaceae	*Chlorophytum comosum* (Thunb.) Jacq.	Clark VR, Andrews A 38
Araceae	*Zantedeschia aethiopica* (L.) Spreng.	Clark VR, Andrews A 39

Asparagaceae	*Asparagus aethiopicus* L.	Clark VR, Andrews A 10
Asparagaceae	*Asparagus asparagoides* (L.) Druce	Clark VR, Daniels R, Le Roux J, Frabricius M 61
Asparagaceae	*Asparagus burchellii* Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 216
Asparagaceae	*Asparagus concinnus* (Baker) Kies	Clark VR, Daniels R, Le Roux J, Frabricius M 217
Asparagaceae	*Asparagus declinatus* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 319
Asparagaceae	*Asparagus denudatus* (Kunth) Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 215
Asparagaceae	*Asparagus macrocarpa* MS S.M.Burrows	Clark VR, Daniels R, Le Roux J, Frabricius M 210
Asparagaceae	*Asparagus mollis* (Oberm.) Fellingham & N.L.Mey.	Clark VR, Daniels R, Le Roux J, Frabricius M 338
Asparagaceae	*Asparagus setaceus* (Kunth) Jessop	Clark VR, Andrews A 65
Asparagaceae	*Asparagus striatus* (L.f.) Thunb.	Clark VR, Andrews A 3
Asparagaceae	*Asparagus suaveolens* Burch.	Clark VR, Daniels R, Le Roux J, Frabricius M 214
Asparagaceae	*Asparagus virgatus* Baker	Clark VR, Andrews A 16
Asphodelaceae	*Aloe broomii* Schönland	Clark VR, Daniels R, Le Roux J, Frabricius M 423B
Asphodelaceae	*Aloe pluridens* Haw.	McMaster C 7 January 2008 No. 1
Asphodelaceae	*Aloe striatula* Haw.	Clark VR, Daniels R, Le Roux J, Frabricius M 163
Asphodelaceae	*Bulbine frutescens* (L.) Willd.	Clark VR, Andrews A 69
Asphodelaceae	*Bulbine narcissifolia* Salm-Dyck	Clark VR, Andrews A 256
Asphodelaceae	*Haworthia bolusii* var. *blackbeardiana* (Poelln.) M.B.Bayer	Clark VR, Coombs G 1070
Asphodelaceae	*Kniphofia acraea* Codd	McMaster C 24 February 2008 No. 1
Asphodelaceae	*Kniphofia triangularis* Kunth subsp. *triangularis*	McMaster C 24 February 2008 No. 2
Colchicaceae	*Androcymbium longipes* Baker	McMaster C sine anno No. 1
Commelinaceae	*Commelina africana* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 257
Cyperaceae	*Carex glomerabilis* Krecz.	Clark VR, Daniels R, Le Roux J, Frabricius M 204
Cyperaceae	*Cyperus albostriatus* Schrad.	Clark VR, Andrews A 159
Cyperaceae	*Cyperus marginatus* Thunb.	Clark VR, Andrews A 134
Cyperaceae	*Cyperus obtusiflorus* Vahl var. *flavissimus* (Schrad.) Boeck.	Sonnenberg, 1993
Cyperaceae	*Cyperus rupestris* Kunth var. *rupestris*	Sonnenberg, 1993
Cyperaceae	*Cyperus semitrifidus* Schrad.	Sonnenberg, 1993
Cyperaceae	*Cyperus textilis* Thunb.	Field Obs.
Cyperaceae	*Cyperus usitatus* Burch.	Clark VR, Daniels R, Le Roux J, Frabricius M 317
Cyperaceae	*Eleocharis dregeana* Steud.	Sonnenberg, 1993
Cyperaceae	*Ficinia compasbergensis* Drège	Clark VR, Daniels R, Le Roux J, Frabricius M 350
Cyperaceae	*Ficinia fascicularis* Nees	Sonnenberg, 1993
Cyperaceae	*Ficinia ramosissima* Kunth	Clark VR, Daniels R, Le Roux J, Frabricius M 69
Cyperaceae	*Ficinia stolonifera* Boeck.	Sonnenberg, 1993
Cyperaceae	*Fuirena coerulescens* Steud.	Clark VR, Daniels R, Le Roux J, Frabricius M 496
Cyperaceae	*Isolepis costata* A.Rich.	Clark VR, Daniels R, Le Roux J, Frabricius M 27
Cyperaceae	*Isolepis diabolica* (Steud.) Schrad.	Clark VR, Andrews A 330
Cyperaceae	*Isolepis ludwigii* (Steud.) Kunth	Sonnenberg, 1993
Cyperaceae	*Isolepis natans* (Thunb.) A.Dietr.	Sonnenberg, 1993
Cyperaceae	*Schoenoxiphium lanceum* (Thunb.) Kük.	Clark VR, Daniels R, Le Roux J, Frabricius M 18
Cyperaceae	*Schoenoxiphium rufum* Nees	Sonnenberg, 1993
Cyperaceae	*Schoenoxiphium sparteum* (Wahlenb.) C.B.Clarke	Clark VR, Andrews A 85
Cyperaceae	*Scirpoides dioecus* (Kunth) Browning	Sonnenberg, 1993
Cyperaceae	*Tetraria cuspidata* (Rottb.) C.B.Clarke var. *cuspidata*	MacOwan P 1954
Hyacinthaceae	*Albuca nelsonii* N.E.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 231
Hyacinthaceae	*Albuca shawii* Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 498
Hyacinthaceae	*Drimia altissima* (L.f.) Ker Gawl.	Clark VR, Daniels R, Le Roux J, Frabricius M 1
Hyacinthaceae	*Drimia anomala* (Baker) Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 491
Hyacinthaceae	*Drimia calcarata* (Baker) Stedje	Clark VR, Daniels R, Le Roux J, Frabricius M 294
Hyacinthaceae	*Drimia elata* Jacq.	McMaster C 2 February 2008 No. 1
Hyacinthaceae	*Drimia uniflora* J.C.Manning & Goldblatt	McMaster C 7 January 2008 No. 2
Hyacinthaceae	*Lachenalia campanulata* Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 384

Hyacinthaceae	*Ledebouria ensifolia* (Eckl.) S.Venter & T.J.Edwards	Clark VR, Daniels R, Le Roux J, Frabricius M 254
Hyacinthaceae	*Ornithogalum* cf. *capillare* J.M.Wood & M.S.Evans (Snijman, pers. comm.)	Clark VR, Daniels R, Le Roux J, Frabricius M 288
Hyacinthaceae	*Ornithogalum dubium* Houtt.	Clark VR, Andrews A 164
Hyacinthaceae	*Ornithogalum graminifolium* Thunb.	Clark VR, Andrews A 94
Hyacinthaceae	*Ornithogalum longibracteatum* Jacq.	Clark VR, Andrews A 89
Hyacinthaceae	*Ornithogalum tenuifolium* F.Delaroche subsp. *tenuifolium*	McMaster C 17 November 2008 No. 1
Hyacinthaceae	*Thuranthos noctiflorum* (Batt. & Trab.) Speta	McMaster C 15 January 2007 No. 1
Hypoxidaceae	*Empodium elongatum* (Nel) B.L.Burtt	Clark VR, Daniels R, Le Roux J, Frabricius M 145
Hypoxidaceae	*Hypoxis argentea* var. *sericea* (Baker) Baker	Clark VR, Andrews A 355
Hypoxidaceae	*Hypoxis filiformis* Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 312
Hypoxidaceae	*Hypoxis obliqua* Jacq.	Clark VR, Daniels R, Le Roux J, Frabricius M 372
Hypoxidaceae	*Hypoxis* cf. *zeyheri* Baker (Singh, pers. comm.)	Clark VR, Daniels R, Le Roux J, Frabricius M 239
Hypoxidaceae	*Spiloxene trifurcillata* (Nel) Fourc.	Clark VR, Andrews A 250
Iridaceae	*Aristea abyssinica* Pax	McMaster C 7 January 2008
Iridaceae	*Aristea schizolaena* Harv. ex Baker	McMaster C 7 January 2008
Iridaceae	*Dierama grandiflorum* G.J.Lewis	Clark VR, Daniels R, Le Roux J, Frabricius M 287
Iridaceae	*Dietes grandiflora* N.E.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 197
Iridaceae	*Freesia laxa* (Thunb.) Goldblatt & J.C.Manning subsp. *laxa*	Clark VR, Daniels R, Le Roux J, Frabricius M 256
Iridaceae	*Gladiolus mortonius* Herb.	Goldblatt & Manning, 1998
Iridaceae	*Hesperantha bulbifera* Baker	Clark VR, Andrews A 83
Iridaceae	*Hesperantha longituba* (Klatt) Baker	Goldblatt, 1984
Iridaceae	*Hesperantha radiata* (Jacq.) Ker Gawl.	Goldblatt, 1984
Iridaceae	*Moraea cookii* (L.Bolus) Goldblatt	Clark VR, Andrews A 122
Iridaceae	*Moraea elliotii* Baker	Clark VR, Coombs G 1030
Iridaceae	*Moraea huttonii* (Baker) Oberm.	Clark VR, Andrews A 36
Iridaceae	*Moraea spathulata* (L.f.) Klatt	Clark VR, Daniels R, Le Roux J, Frabricius M 400
Iridaceae	*Moraea unguiculata* Ker Gawl.	Clark VR, Andrews A 87
Iridaceae	*Tritonia gladiolaris* (Lam.) Goldblatt & J.C.Manning	Clark VR, Coombs G 1034
Iridaceae	*Tritonia laxifolia* (Klatt) Benth. & Hook.f.	McMaster C 2 February 2008
Iridaceae	*Watsonia pillansii* L.Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 399
Juncaceae	*Juncus exsertus* Buchenau subsp. *exsertus*	Clark VR, Andrews A 333
Juncaceae	*Juncus inflexus* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 39
Juncaceae	*Juncus oxycarpus* E.Mey. ex Kunth	Clark VR, Coombs G 1007
Juncaceae	*Luzula africana* Drège ex Steud.	Clark VR, Daniels R, Le Roux J, Frabricius M 375
Orchidaceae	*Disa lugens* Bolus var. *lugens*	McMaster, 2007b
Orchidaceae	*Disperis lindleyana* Rchb.f.	Clark VR, Daniels R, Le Roux J, Frabricius M 327
Orchidaceae	*Satyrium membranaceum* Sw.	Clark VR, Daniels R, Le Roux J, Frabricius M 290
Poaceae	*Agrostis eriantha* Hack.	Clark VR, Andrews A 221
Poaceae	*Agrostis lachnantha* Nees	Clark VR, Andrews A 96
Poaceae	*Andropogon appendiculatus* Nees	MacOwan P 116
Poaceae	*Brachiaria serrata* (Thunb.) Stapf.	Clark VR, Andrews A 276
Poaceae	*Brachypodium bolusii* Stapf	Clark VR, Daniels R, Le Roux J, Frabricius M 450
Poaceae	*Brachypodium distachyum* (L.) P.Beauv. var. *distachyum**	Clark VR, Andrews A 215
Poaceae	*Brachypodium flexum* Nees	MacOwan P 1495
Poaceae	*Briza subaristatum* Lam.*	Clark VR, Andrews A 267
Poaceae	*Bromus catharticus* Vahl*	Clark VR, Daniels R, Le Roux J, Frabricius M 116
Poaceae	*Cynodon incompletus* Nees	Clark VR, Daniels R, Le Roux J, Frabricius M 461
Poaceae	*Ehrharta calycina* J.E.Sm.	Clark VR, Daniels R, Le Roux J, Frabricius M 110
Poaceae	*Ehrharta erecta* Lam. var. *erecta*	Clark VR, Daniels R, Le Roux J, Frabricius M 109
Poaceae	*Ehrharta longigluma* C.E.Hubb.	Clark VR, Daniels R, Le Roux J, Frabricius M 468
Poaceae	*Elionurus muticus* (Spreng.) Kunth	Clark VR, Daniels R, Le Roux J, Frabricius M 479
Poaceae	*Eragrostis capensis* (Thunb.) Trin.	Clark VR, Daniels R, Le Roux J, Frabricius M 253
Poaceae	*Eustachys paspaloides* (Vahl) Lanza & Mattei subsp.	Clark VR, Daniels R, Le Roux J, Frabricius M 476

	paspaloides	
Poaceae	*Festuca scabra* Vahl	Clark VR, Andrews A 101
Poaceae	*Harpochloa falx* (L.f.) Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 11
Poaceae	*Helictotrichon turgidulum* (Stapf) Schweick.	Clark VR, Daniels R, Le Roux J, Frabricius M 99
Poaceae	*Hemarthria altissima* (Poir.) Stapf & C.E.Hubb	Clark VR, Andrews A 100
Poaceae	*Heteropogon contortus* (L.) Beauverd ex Roem. & Schult.	Clark VR, Coombs G 1041
Poaceae	*Holcus lanatus* L.*	Clark VR, Daniels R, Le Roux J, Frabricius M 421
Poaceae	*Hordeum murinum* subsp. *leporinum* (Link) Arcang.*	Clark VR, Daniels R, Le Roux J, Frabricius M 120
Poaceae	*Hyparrhenia hirta* (L.) Stapf.	Clark VR, Daniels R, Le Roux J, Frabricius M 410
Poaceae	*Karroochloa curva* (Nees) Conert & Tuerpe	Clark VR, Daniels R, Le Roux J, Frabricius M 127
Poaceae	*Koeleria capensis* (Steud.) Nees	Clark VR, Daniels R, Le Roux J, Frabricius M 306
Poaceae	*Melica decumbens* Thunb.	Clark VR, Andrews A 229
Poaceae	*Melinis nerviglumis* (Franch.) Zizka	Clark VR, Coombs G 1038
Poaceae	*Merxmuellera disticha* (Nees) Conert	Clark VR, Daniels R, Le Roux J, Frabricius M 79
Poaceae	*Merxmuellera macowanii* (Stapf) Conert	Clark VR, Daniels R, Le Roux J, Frabricius M 263
Poaceae	*Merxmuellera stricta* (Schrad.) Conert	Clark VR, Daniels R, Le Roux J, Frabricius M 38
Poaceae	*Nassella neesiana* (Trin. & Rupr.) Barkworth*	Clark VR, Andrews A 125
Poaceae	*Nassella trichotoma* (Nees) Hack. ex Arechav.*	Clark VR, Daniels R, Le Roux J, Frabricius M 122
Poaceae	*Oplismenus hirtellus* (L.) Beauverd subsp. *hirtellus*	Clark VR, Daniels R, Le Roux J, Frabricius M 325
Poaceae	*Panicum deustum* Thunb.	Clark VR, Coombs G 1010
Poaceae	*Paspalum dilatatum* Poir.*	Clark VR, Daniels R, Le Roux J, Frabricius M 424
Poaceae	*Pennisetum clandestinum* Hochst. ex Chiov.*	Clark VR, Andrews A 329
Poaceae	*Pennisetum thunbergii* Kunth	Clark VR, Andrews A 283
Poaceae	*Pentaschistis airoides*subsp. *jugorum* (Stapf) H.P.Linder	Clark VR, Daniels R, Le Roux J, Frabricius M 12
Poaceae	*Pentaschistis setifolia* (Thunb.) McClean	Clark VR, Daniels R, Le Roux J, Frabricius M 10
Poaceae	*Poa binata* Nees	Clark VR, Andrews A 262
Poaceae	*Sporobolus africanus* (Poir.) Robyns & Tournay	Clark VR, Andrews A 303
Poaceae	*Stipa dregeana* Steud. var. *dregeana*	Clark VR, Daniels R, Le Roux J, Frabricius M 106
Poaceae	*Stipa dregeana* Steud. var. *elongata* (Nees) Stapf	MacOwan P 1520
Poaceae	*Themeda triandra* Forssk.	Clark VR, Andrews A 228
Poaceae	*Tribolium hispidum* (Thunb.) Desv.	Clark VR, Daniels R, Le Roux J, Frabricius M 220
Poaceae	*Tristachya leucothrix* Trin. ex Nees	Clark VR, Coombs G 1042
Poaceae	*Vulpia bromoides* (L.) S.F.Gray*	Clark VR, Andrews A 214
Potamogetonaceae	*Potamogeton pusillus* L.	Clark VR, Andrews A 280
Restionaceae	*Ischyrolepis* sp. aff. *constipata* H.P.Linder (det. H.P. Linder)	Clark VR, Daniels R, Le Roux J, Frabricius M 92
Restionaceae	*Restio sejunctus* Mast.	Clark VR, Daniels R, Le Roux J, Frabricius M 247
Dicotyledons		
Acanthaceae	*Justicia protracta* (Nees) T.Anderson subsp. *protracta*	McMaster C 7 January 2008
Acanthaceae	*Sclerochiton odoratissimus* Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 418
Adoxaceae	*Sambucus nigra* L.*	Clark VR, Andrews A 236
Amaranthaceae	*Achyranthes aspera* L. var. *aspera**	Clark VR, Andrews A 235
Anacardiaceae	*Searsia chirindensis* (Baker f.) Moffett	Clark VR, Andrews A 77
Anacardiaceae	*Searsia dentata* (Thunb.) F.A.Barkley	Clark VR, Andrews A 104
Anacardiaceae	*Searsia divaricata* (Eckl. & Zeyh.) Moffett	Clark VR, Daniels R, Le Roux J, Frabricius M 62
Anacardiaceae	*Searsia dregeana* (Sond.) Moffett	Clark VR, Daniels R, Le Roux J, Frabricius M 173
Anacardiaceae	*Searsia krebsiana* (C.Presl ex Engl.) Moffett	Clark VR, Andrews A 227
Anacardiaceae	*Searsia lancea* (L.f.) F.A.Barkley	Clark VR, Daniels R, Le Roux J, Frabricius M 405
Anacardiaceae	*Searsia longispina* (Eckl. & Zeyh.) Moffett	Clark VR, Andrews A 5
Anacardiaceae	*Searsia pallens* (Eckl. & Zeyh.) Moffett	Clark VR, Andrews A 11
Anacardiaceae	*Searsia pyroides* (Burch.) Moffett var. *pyroides*	Clark VR, Andrews A 61
Anacardiaceae	*Searsia refracta* (Eckl. & Zeyh.) Moffett	Clark VR, Coombs G 1018
Anacardiaceae	*Searsia rehmanniana* var. *glabrata* (Sond.) Moffett	Clark VR, Andrews A 80

Anacardiaceae	*Searsia tomentosa* (L.) F.A.Barkley	Clark VR, Andrews A 354
Apiaceae	*Alepidea delicatula* Weim.	MacOwan P 139
Apiaceae	*Alepidea macowani* Dummer	Clark et al., 2009
Apiaceae	*Berula erecta* subsp. *thunbergii* (DC.) B.L.Burtt	Clark VR, Andrews A 247
Apiaceae	*Bupleurum mundii* Cham. & Schltdl.	Clark VR, Daniels R, Le Roux J, Frabricius M 264
Apiaceae	*Centella asiatica* (L.) Urb.	Clark VR, Andrews A 172
Apiaceae	*Centella graminifolia* Adamson	Clark VR, Daniels R, Le Roux J, Frabricius M 308
Apiaceae	*Conium* sp. no. 3 (Hilliard & Burtt, 1985)	Clark VR, Daniels R, Le Roux J, Frabricius M 337
Apiaceae	*Cyclospermum leptophyllum* (Pers.) Sprague*	Clark VR, Andrews A 216
Apiaceae	*Dasispermum humile* (Meisn.) Magee & B.-E.van Wyk	Clark VR, Andrews A 233
Apiaceae	*Heteromorpha arborescens* (Spreng.) Cham. & Schltdl. var. *arborescens* (interior form)	Clark VR, Andrews A 204
Apiaceae	*Notobubon laevigatum* (Aiton) A.R.Magee	Clark VR, Daniels R, Le Roux J, Frabricius M 54
Apiaceae	*Sanicula elata* Buch.-Ham. ex D.Don	Clark VR, Andrews A 84
Apocynaceae	*Asclepias gibba* (E.Mey.) Schltr. var. *gibba*	MacOwan P 2028
Apocynaceae	*Carissa bispinosa* (L.) Desf. ex Brenan	Clark VR, Andrews A 56
Apocynaceae	*Carissa haematocarpa* (Eckl.) A.DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 188
Apocynaceae	*Duvalia caespitosa* (Masson) Haw. subsp. *caespitosa*	McMaster C sine anno
Apocynaceae	*Gomphocarpus fruticosus* (L.) W.T.Aiton subsp. *fruticosus*	Clark VR, Coombs G 1004
Apocynaceae	*Sarcostemma viminale* (L.) R.Br.	MacOwan P s.n.
Apocynaceae	*Schizoglossum hamatum* E.Mey.	MacOwan P 1637
Apocynaceae	*Secamone gerrardii* Harv. ex Benth.	Clark VR, Andrews A 128
Araliaceae	*Cussonia paniculata* Eckl. & Zeyh. subsp. *paniculata*	Clark VR, Daniels R, Le Roux J, Frabricius M 97
Araliaceae	*Cussonia spicata* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 232
Asteraceae	*Arctotis arctotoides* (L.f.) O.Hoffm.	Clark VR, Daniels R, Le Roux J, Frabricius M 235
Asteraceae	*Artemisia afra* Jacq. ex Willd. var. *afra*	Clark VR, Andrews A 234
Asteraceae	*Aster bakerianus* Burtt Davy ex C.A.Sm.	Clark VR, Daniels R, Le Roux J, Frabricius M 492
Asteraceae	*Athrixia angustissima* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 28
Asteraceae	*Athrixia crinita* (L.) Druce	Clark VR, Andrews A 351
Asteraceae	*Athrixia fontana* MacOwan	MacOwan P 1995
Asteraceae	*Berkheya buphthalmoides* (DC.) Schltr.	Clark VR, Andrews A 116
Asteraceae	*Berkheya carduoides* (Less.) Hutch.	Clark VR, Daniels R, Le Roux J, Frabricius M 444
Asteraceae	*Berkheya heterophylla* var. *radiata* (DC.) Roessler	Clark VR, Daniels R, Le Roux J, Frabricius M 480
Asteraceae	*Chrysocoma ciliata* L.	Clark VR, Andrews A 188
Asteraceae	*Cineraria aspera* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 112
Asteraceae	*Cineraria erodioides* DC. var. *erodioides*	Clark VR, Daniels R, Le Roux J, Frabricius M 342
Asteraceae	*Cineraria geraniifolia* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 144
Asteraceae	*Conyza scabrida* DC.	Clark VR, Andrews A 72
Asteraceae	*Conyza ulmifolia* (Burm.f.) Kuntze	Clark VR, Andrews A 41
Asteraceae	*Cotula microglossa* (DC.) O.Hoffm. & Kuntze ex Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 125
Asteraceae	*Cotula nigellifolia* (DC.) Bremer & Humphries	Clark VR, Daniels R, Le Roux J, Frabricius M 419
Asteraceae	*Denekia capensis* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 284
Asteraceae	*Dicerothamnus rhinocerotis* (L.f.) Koekemoer	Clark VR, Daniels R, Le Roux J, Frabricius M 72
Asteraceae	*Dichrocephala integrifolia* (L.f.) Kuntze subsp. *integrifolia*	MacOwan P s.n.
Asteraceae	*Dimorphotheca caulescens* Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 310
Asteraceae	*Eriocephalus ericoides* (L.f.) Druce subsp. *ericoides*	Clark VR, Daniels R, Le Roux J, Frabricius M 206
Asteraceae	*Euryops galpinii* Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 35
Asteraceae	*Euryops spathaceus* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 101
Asteraceae	*Euryops trilobus* Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 85
Asteraceae	*Felicia burkei* (Harv.) L.Bolus	MacOwan P 1629
Asteraceae	*Felicia fascicularis* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 77
Asteraceae	*Felicia filifolia* (Vent.) Burtt Davy	Clark VR, Daniels R, Le Roux J, Frabricius M 73
Asteraceae	*Felicia hirsuta* DC.	Clark VR, Andrews A 184
Asteraceae	*Felicia rosulata* Yeo	Clark VR, Daniels R, Le Roux J, Frabricius M 377

Asteraceae	*Garuleum tanacetifolium* (MacOwan) Norl.	Clark VR, Daniels R, Le Roux J, Frabricius M 243
Asteraceae	*Gazania krebsiana* Less.	Clark VR, Daniels R, Le Roux J, Frabricius M 373
Asteraceae	*Gerbera piloselloides* (L.) Cass.	Clark VR, Daniels R, Le Roux J, Frabricius M 74
Asteraceae	*Gnaphalium capense* Hilliard	Hilliard, 1983
Asteraceae	*Gnaphalium pensylvanicum* Willd.*	Clark VR, Andrews A 156
Asteraceae	*Gnaphalium vestitum* Thunb.	Hilliard, 1983
Asteraceae	*Gymnopentzia bifurcata* Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 445
Asteraceae	*Haplocarpha nervosa* (Thunb.) Beauverd	Clark VR, Andrews A 337
Asteraceae	*Haplocarpha scaposa* Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 303
Asteraceae	*Helichrysum anomalum* Less.	Clark VR, Daniels R, Le Roux J, Frabricius M 307
Asteraceae	*Helichrysum appendiculatum* (L.f.) Less	Clark VR, Daniels R, Le Roux J, Frabricius M 283
Asteraceae	*Helichrysum asperum* var. *appressifolium* (Moeser) Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 174
Asteraceae	*Helichrysum aureonitens* Sch.Bip.	MacOwan P 1693
Asteraceae	*Helichrysum aureum* (Houtt.) Merr.	Clark VR, Daniels R, Le Roux J, Frabricius M 273
Asteraceae	*Helichrysum ecklonis* Sond.	Clark VR, Daniels R, Le Roux J, Frabricius M 402
Asteraceae	*Helichrysum felinum* Less.	Clark VR, Daniels R, Le Roux J, Frabricius M 270
Asteraceae	*Helichrysum grandibracteatum* M.D.Hend.	Hilliard, 1983
Asteraceae	*Helichrysum hamulosum* E.Mey. ex DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 165
Asteraceae	*Helichrysum miconiifolium* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 280
Asteraceae	*Helichrysum montanum* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 50
Asteraceae	*Helichrysum mundtii* Harv.	MacOwan P 1472
Asteraceae	*Helichrysum nanum* Klatt	MacOwan P 1472
Asteraceae	*Helichrysum nudifolium* (L.) Less. var. *nudifolium*	Clark VR, Daniels R, Le Roux J, Frabricius M 251
Asteraceae	*Helichrysum nudifolium* var. *oxyphyllum* (DC.) Beentje	MacOwan P s.n.
Asteraceae	*Helichrysum nudifolium* var. *pilosellum* (L.f.) Beentje	Clark VR, Daniels R, Le Roux J, Frabricius M 295
Asteraceae	*Helichrysum odoratissimum* (L.) Sweet	Clark VR, Daniels R, Le Roux J, Frabricius M 423
Asteraceae	*Helichrysum pallidum* DC.	Hilliard, 1983
Asteraceae	*Helichrysum petiolare* Hilliard & B.L.Burtt	Clark VR, Daniels R, Le Roux J, Frabricius M 108
Asteraceae	*Helichrysum rosum* var. *arcuatum* Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 76
Asteraceae	*Helichrysum rosum* (P.J.Bergius) Less. var. *rosum*	Clark VR, Andrews A 269
Asteraceae	*Helichrysum rugulosum* Less.	Clark VR, Andrews A 316
Asteraceae	*Helichrysum sessile* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 293
Asteraceae	*Helichrysum splendidum* (Thunb.) Less.	Clark VR, Daniels R, Le Roux J, Frabricius M 8
Asteraceae	*Helichrysum subglomeratum* Less.	Bolus H s.n.
Asteraceae	*Helichrysum tenuiculum* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 248
Asteraceae	*Helichrysum trilineatum* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 353
Asteraceae	*Helichrysum umbraculigerum* Less.	Clark VR, Andrews A 324
Asteraceae	*Helichrysum xerochrysum* DC.	MacOwan P 568
Asteraceae	*Hypochaeris radicata* L.*	Clark VR, Andrews A 326
Asteraceae	*Lactuca inermis* Forssk.	Clark VR, Andrews A 361
Asteraceae	*Lasiospermum bipinnatum* (Thunb.) Druce	Clark VR, Daniels R, Le Roux J, Frabricius M 124
Asteraceae	*Lasiospermum pedunculare* Lag.	Clark VR, Andrews A 127
Asteraceae	*Leysera gnaphalodes* (L.) L.	Clark VR, Daniels R, Le Roux J, Frabricius M 170
Asteraceae	*Metalasia muricata* (L.) D.Don	Clark VR, Daniels R, Le Roux J, Frabricius M 301
Asteraceae	*Microglossa mespilifolia* (Less.) B.L.Rob.	Clark VR, Daniels R, Le Roux J, Frabricius M 433
Asteraceae	*Osteospermum imbricatum* var. *nervatum* (DC.) Norl.	MacOwan P 1909
Asteraceae	*Tripteris aghillana* DC. var. *aghillana*	MacOwan P 1954
Asteraceae	*Pentzia cooperi* Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 63
Asteraceae	*Pentzia incana* (Thunb.) Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 102
Asteraceae	*Printzia pyrifolia* Less.	Clark VR, Coombs G 1058
Asteraceae	*Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt subsp. *luteo-album*	Clark VR, Andrews A 152
Asteraceae	*Pseudognaphalium undulatum* (L.) Hilliard & B.L.Burtt	Clark VR, Andrews A 33
Asteraceae	*Rosenia humilis* (Less.) K.Bremer	MacOwan P 1736

Asteraceae	*Senecio asperulus* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 53
Asteraceae	*Senecio deltoideus* Less.	Clark VR, Andrews A 308
Asteraceae	*Senecio digitalifolius* DC.	MacOwan P 628
Asteraceae	*Senecio erubescens* var. *crepidifolius* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 286
Asteraceae	*Senecio glanduloso-pilosus* Volkens & Muschl.	MacOwan P 8659
Asteraceae	*Senecio hastatus* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 49
Asteraceae	*Senecio hypochoerideus* DC.	MacOwan P 1711
Asteraceae	*Senecio inaequidens* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 67
Asteraceae	*Senecio juniperinus* L.f. var. *juniperinus*	Clark VR, Daniels R, Le Roux J, Frabricius M 261
Asteraceae	*Senecio napifolius* MacOwan	Hilliard, 1977
Asteraceae	*Senecio othonniflorus* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 292
Asteraceae	*Senecio parvifolius* DC.	Clark VR, Andrews A 153
Asteraceae	*Senecio polyodon* var. *subglaber* (O.Hoffm. ex Kuntze) Hilliard & B.L.Burtt	Clark VR, Andrews A 322
Asteraceae	*Senecio retrorsus* DC.	MacOwan P 655
Asteraceae	*Senecio ruwenzoriensis* S.Moore	MacOwan P 907
Asteraceae	*Senecio tanacetopsis* Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 278
Asteraceae	*Silybum marianum* (L.) Gaertn.*	Clark VR, Daniels R, Le Roux J, Frabricius M 475
Asteraceae	*Sonchus dregeanus* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 60
Asteraceae	*Sonchus integrifolius* Harv. var. *integrifolius*	Clark VR, Daniels R, Le Roux J, Frabricius M 449
Asteraceae	*Tarchonanthus minor* Less.	Clark VR, Daniels R, Le Roux J, Frabricius M 460
Asteraceae	*Tolpis capensis* (L.) Sch.Bip.	Clark VR, Daniels R, Le Roux J, Frabricius M 358
Asteraceae	*Troglophyton capillaceum* subsp. *diffusum* (DC.) Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 334
Asteraceae	*Vernonia capensis* (Houtt.) Druce	Clark VR, Daniels R, Le Roux J, Frabricius M 427
Balanophoraceae	*Sarcophyte sanguinea* Sparrm. subsp. *sanguinea*	Clark VR, Daniels R, Le Roux J, Frabricius M 320
Boraginaceae	*Anchusa capensis* Thunb.	Wright, 1904
Boraginaceae	*Anchusa riparia* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 414
Boraginaceae	*Cynoglossum geometricum* Baker & C.H.Wright	Wright, 1904
Boraginaceae	*Cynoglossum hispidum* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 456
Boraginaceae	*Cynoglossum lanceolatum* Forssk.	Wright, 1904
Boraginaceae	*Echium plantagineum* L.*	Clark VR, Daniels R, Le Roux J, Frabricius M 123
Boraginaceae	*Ehretia rigida* (Thunb.) Druce subsp. *rigida*	Clark VR, Andrews A 21
Boraginaceae	*Lappula squarrosa* (Retz.) Dumort.	Wright, 1904
Boraginaceae	*Lithospermum papillosum* Thunb.	Clark VR, Andrews A 266
Boraginaceae	*Myosotis arvensis* (L.) Hill*	Wright, 1904
Boraginaceae	*Myosotis sylvatica* Hoffm.*	Clark VR, Daniels R, Le Roux J, Frabricius M 32
Brassicaceae	*Cardamine africana* L.	MacOwan P 210
Brassicaceae	*Nasturtium officinale* R.Br.	Clark VR, Coombs G 1011
Brassicaceae	*Rorippa nudiuscula* Thell.	MacOwan P 1592
Brassicaceae	*Turritis glabra* L.*	Marais, 1970
Buddlejaceae	*Buddleja auriculata* Benth.	Clark VR, Andrews A 28
Buddlejaceae	*Buddleja salviifolia* (L.) Lam.	Clark VR, Daniels R, Le Roux J, Frabricius M 91
Buddlejaceae	*Gomphostigma virgatum* (L.f.) Baill.	Clark VR, Andrews A 76
Campanulaceae	*Craterocapsa montana* (A.DC.) Hilliard & B.L.Burtt	Clark VR, Daniels R, Le Roux J, Frabricius M 282
Campanulaceae	*Wahlenbergia albens* (Spreng. ex A.DC.) Lammers	Clark VR, Daniels R, Le Roux J, Frabricius M 237
Campanulaceae	*Wahlenbergia krebsii* Cham. subsp. *krebsii*	Clark VR, Daniels R, Le Roux J, Frabricius M 9
Campanulaceae	*Wahlenbergia laxiflora* (Sond.) Lammers	Adamson, 1955b
Campanulaceae	*Wahlenbergia stellarioides* Cham. & Schltdl.	Clark VR, Coombs G 1040
Campanulaceae	*Wahlenbergia undulata* (L.f.) A.DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 356
Capparaceae	*Boscia oleoides* (Burch. ex DC.) Tölken	Clark VR, Daniels R, Le Roux J, Frabricius M 2
Capparaceae	*Cadaba aphylla* (Thunb.) Wild	Clark VR, Daniels R, Le Roux J, Frabricius M 3
Capparaceae	*Capparis sepiaria* var. *citrifolia* (Lam.) Tölken	Clark VR, Andrews A 22
Caryophyllaceae	*Cerastium capense* Sond.	Clark VR, Andrews A 160
Caryophyllaceae	*Cerastium glomeratum* Thuill.	MacOwan P 773

Caryophyllaceae	*Dianthus micropetalus* Ser.	Clark VR, Andrews A 271
Caryophyllaceae	*Silene undulata* Aiton	Clark VR, Andrews A 282
Caryophyllaceae	*Stellaria media* (L.) Vill.*	Clark VR, Andrews A 252
Celastraceae	*Gymnosporia buxifolia* (L.) Szyszyl.	Clark VR, Andrews A 7
Celastraceae	*Lauridia tetragona* (L.f.) R.H.Archer	Clark VR, Andrews A 359
Celastraceae	*Maytenus acuminata* (L.f.) Loes. var. *acuminata*	Clark VR, Daniels R, Le Roux J, Frabricius M 31
Celastraceae	*Maytenus undata* (Thunb.) Blakelock	Clark VR, Daniels R, Le Roux J, Frabricius M 86
Celastraceae	*Mystroxylon aethiopicum* (Thunb.) Loes. subsp. *aethiopicum*	Clark VR, Andrews A 24
Celastraceae	*Pterocelastrus tricuspidatus* (Lam.) Walp.	Clark VR, Coombs G 1020
Celastraceae	*Putterlickia pyracantha* (L.) Szyszyl.	Clark VR, Andrews A 194
Chenopodiaceae	*Chenopodium murale* L. var. *murale**	MacOwan P s.n.
Convolvulaceae	*Convolvulus farinosus* L.	Clark VR, Coombs G 1000
Convolvulaceae	*Convolvulus galpinii* C.H.Wright	Clark VR, Daniels R, Le Roux J, Frabricius M 423A
Convolvulaceae	*Falkia repens* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 366
Crassulaceae	*Cotyledon campanulata* Marloth	Clark VR, Andrews A 192
Crassulaceae	*Cotyledon orbiculata* L.	Clark VR, Andrews A 143
Crassulaceae	*Cotyledon velutina* Hook.f.	Clark VR, Andrews A 25
Crassulaceae	*Crassula cultrata* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 274
Crassulaceae	*Crassula dependens* Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 159
Crassulaceae	*Crassula ericoides* Haw. subsp. *ericoides*	Tölken, 1977
Crassulaceae	*Crassula lanceolata* (Eckl. & Zeyh.) Endl. ex Walp. subsp. *lanceolata*	Clark VR, Daniels R, Le Roux J, Frabricius M 157
Crassulaceae	*Crassula montana* subsp. *triangularis* (Schönland.) Tölken	Clark VR, Andrews A 217
Crassulaceae	*Crassula muscosa* L.	Clark VR, Andrews A 133
Crassulaceae	*Crassula natans* Thunb. var. *natans*	Clark VR, Andrews A 285
Crassulaceae	*Crassula nemorosa* (Eckl. & Zeyh.) Endl. ex Walp.	Clark VR, Andrews A 296
Crassulaceae	*Crassula pellucida* subsp. *brachypetala* (Drège ex Harv.) Tölken	Clark VR, Andrews A 15
Crassulaceae	*Crassula pellucida* subsp. *marginalis* (Dryand.) Tölken	Tölken, 1977
Crassulaceae	*Crassula perforata* Thunb.	Clark VR, Andrews A 30
Crassulaceae	*Crassula sarcocaulis* Eckl. & Zeyh. subsp. *sarcocaulis*	Clark VR, Andrews A 26
Crassulaceae	*Crassula setulosa* Harv. var. *setulosa*	Clark VR, Daniels R, Le Roux J, Frabricius M 344
Crassulaceae	*Crassula vaginata* Eckl. & Zeyh. subsp. *vaginata*	Clark VR, Andrews A 312
Dipsacaceae	*Cephalaria pungens* Szabó	McMaster C 24 January 2009
Dipsacaceae	*Scabiosa columbaria* L.	Clark VR, Andrews A 270
Ebenaceae	*Diospyros austro-africana* var. *microphylla* (Burch.) De Winter	Clark VR, Daniels R, Le Roux J, Frabricius M 190
Ebenaceae	*Diospyros lycioides* Desf.	Clark VR, Andrews A 12
Ebenaceae	*Diospyros scabrida* var. *cordata* (E.Mey. ex A.DC.) De Winter	Clark VR, Andrews A 32
Ebenaceae	*Euclea coriacea* A.DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 463
Ebenaceae	*Euclea crispa* (Thunb.) Gürke subsp. *crispa*	Clark VR, Daniels R, Le Roux J, Frabricius M 55
Ebenaceae	*Euclea undulata* Thunb.	Clark VR, Coombs G 1015
Ericaceae	*Erica alopecurus* Harv. var. *alopecurus*	Baker and Oliver, 1967
Ericaceae	*Erica brownleeae* Bolus	Baker and Oliver, 1967
Ericaceae	*Erica caespitosa* Hilliard & B.L.Burtt	Clark VR, Daniels R, Le Roux J, Frabricius M 13
Ericaceae	*Erica caffrorum* Bolus var. *caffrorum*	Clark VR, Daniels R, Le Roux J, Frabricius M 315
Ericaceae	*Erica leucopelta* Tausch	Clark VR, Daniels R, Le Roux J, Frabricius M 385
Ericaceae	*Erica simulans* Dulfer	Clark VR, Daniels R, Le Roux J, Frabricius M 42
Euphorbiaceae	*Adenocline pauciflora* Turcz.	Clark VR, Daniels R, Le Roux J, Frabricius M 381
Euphorbiaceae	*Clutia alaternoides* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 89
Euphorbiaceae	*Clutia hirsuta* (Sond.) Müll.Arg. var. *hirsuta*	Clark VR, Daniels R, Le Roux J, Frabricius M 396
Euphorbiaceae	*Clutia impedita* Prain	Clark VR, Daniels R, Le Roux J, Frabricius M 349
Euphorbiaceae	*Clutia monticola* S.Moore var. *monticola*	Clark VR, Daniels R, Le Roux J, Frabricius M 357
Euphorbiaceae	*Clutia pulchella* L. var. *pulchella*	Clark VR, Andrews A 183
Euphorbiaceae	*Euphorbia caterviflora* N.E.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 175
Euphorbiaceae	*Euphorbia clavarioides* Boiss. var. *clavarioides*	Clark VR, Daniels R, Le Roux J, Frabricius M 311

Euphorbiaceae	*Euphorbia epicyparissias* E.Mey. ex Boiss.	Clark VR, Daniels R, Le Roux J, Frabricius M 246
Euphorbiaceae	*Euphorbia mauritanica* L. var. *mauritanica*	Clark VR, Daniels R, Le Roux J, Frabricius M 147
Euphorbiaceae	*Euphorbia tetragona* Haw.	Clark VR, Andrews A 242
Euphorbiaceae	*Ricinus communis* L. var. *communis**	Clark VR, Andrews A 302
Fabaceae	*Acacia karroo* Hayne	Clark VR, Andrews A 14
Fabaceae	*Acacia mearnsii* De Wild.*	Clark VR, Andrews A 126
Fabaceae	*Argyrolobium tomentosum* (Andrews) Druce	Clark VR, Daniels R, Le Roux J, Frabricius M 133
Fabaceae	*Aspalathus* cf. *katbergensis* (R.Dahlgren) R.Dahlgren	Clark VR, Daniels R, Le Roux J, Frabricius M 275
Fabaceae	*Calpurnia aurea* (Aiton) Benth. subsp. *aurea*	Clark VR, Andrews A 305
Fabaceae	*Indigofera cuneifolia* Eckl. & Zeyh.	Clark VR, Andrews A 258
Fabaceae	*Indigofera mollis* Eckl. & Zeyh.	Clark VR, Andrews A 206
Fabaceae	*Indigofera monostachya* Eckl. & Zeyh.	Clark VR, Andrews A 273
Fabaceae	*Indigofera verrucosa* Eckl. & Zeyh.	Clark VR, Andrews A 108
Fabaceae	*Indigofera zeyheri* Spreng. ex Eckl. & Zeyh.	Clark VR, Andrews A 356
Fabaceae	*Lessertia depressa* Harv.	MacOwan P 1362
Fabaceae	*Lessertia perennans* var. *sericea* L.Bol.	MacOwan P 1701
Fabaceae	*Lotononis laxa* Eckl. & Zeyh.	Clark VR, Daniels R, Le Roux J, Frabricius M 351
Fabaceae	*Lotononis pulchella* (E.Mey.) B.-E.van Wyk	Van Wyk, 1991
Fabaceae	*Lotononis pungens* Eckl. & Zeyh.	Clark VR, Daniels R, Le Roux J, Frabricius M 179
Fabaceae	*Lotononis pusilla* Dummer	Van Wyk, 1991
Fabaceae	*Medicago laciniata* (L.) Mill. var. *laciniata**	MacOwan P 1650
Fabaceae	*Otholobium candicans* (Eckl. & Zeyh.) C.H.Stirt.	MacOwan P 1856
Fabaceae	*Otholobium stachyerum* (Eckl. & Zeyh.) C.H.Stirt.	Clark VR, Coombs G 1064
Fabaceae	*Rhynchosia minima* var. *prostrata* (Harv.) Meikle	Clark VR, Daniels R, Le Roux J, Frabricius M 422
Fabaceae	*Rhynchosia totta* (Thunb.) DC. var. *totta*	Clark VR, Andrews A 274
Fabaceae	*Schotia latifolia* Jacq.	Clark VR, Andrews A 20
Fabaceae	*Sutherlandia frutescens* (L.) R.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 208
Fabaceae	*Trifolium africanum* Ser. var. *africanum*	Clark VR, Daniels R, Le Roux J, Frabricius M 482
Fabaceae	*Trifolium burchellianum* Ser. subsp. *burchellianum*	Clark VR, Daniels R, Le Roux J, Frabricius M 136
Flacourtiaceae	*Dovyalis zeyheri* (Sond.) Warb.	Clark VR, Andrews A 198
Flacourtiaceae	*Kiggelaria africana* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 83
Flacourtiaceae	*Scolopia mundii* (Eckl. & Zeyh.) Warb.	Clark VR, Andrews A 50
Flacourtiaceae	*Scolopia zeyheri* (Nees) Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 98
Gentianaceae	*Chironia krebsii* Griseb.	Marias & Verdoorn, 1963
Geraniaceae	*Geranium caffrum* Eckl. & Zeyh.	Clark VR, Daniels R, Le Roux J, Frabricius M 34
Geraniaceae	*Geranium* cf. *brycei* N.E.Br. (Dreyer, pers. comm.)	Clark VR, Daniels R, Le Roux J, Frabricius M 268
Geraniaceae	*Geranium harveyi* Briq.	Clark VR, Daniels R, Le Roux J, Frabricius M 58
Geraniaceae	*Geranium multisectum* N.E.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 269
Geraniaceae	*Pelargonium abrotanifolium* (L.f.) Jacq.	Clark VR, Daniels R, Le Roux J, Frabricius M 171
Geraniaceae	*Pelargonium alchemilloides* (L.) L'Hér.	Clark VR, Daniels R, Le Roux J, Frabricius M 494
Geraniaceae	*Pelargonium glutinosum* (Jacq.) L'Hér.	Clark VR, Daniels R, Le Roux J, Frabricius M 57
Geraniaceae	*Pelargonium grossularioides* (L.) L'Hér. ex Aiton	Clark VR, Coombs G 1049
Geraniaceae	*Pelargonium laevigatum* (L.f.) Willd.	Clark VR, Daniels R, Le Roux J, Frabricius M 298
Geraniaceae	*Pelargonium multicaule* Jacq. subsp. *multicaule*	Clark VR, Coombs G 1050
Geraniaceae	*Pelargonium odoratissimum* (L.) L'Hér.	Clark VR, Andrews A 174
Geraniaceae	*Pelargonium peltatum* (L.) L'Hér.	Clark VR, Andrews A 166
Geraniaceae	*Pelargonium pulverulentum* Colvill ex Sweet	Clark VR, Coombs G 1033
Geraniaceae	*Pelargonium ranunculophyllum* (Eckl. & Zeyh.) Baker	Clark VR, Daniels R, Le Roux J, Frabricius M 59
Geraniaceae	*Pelargonium schizopetalum*Sweet	Van der Walt and Ward-Hillhorst, 1977
Geraniaceae	*Pelargonium sidoides* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 181
Geraniaceae	*Pelargonium tetragonum* (L.f.)L'Hér.	MacOwan P s.n.
Geraniaceae	*Pelargonium zonale* (L.)L'Hér.	Clark VR, Daniels R, Le Roux J, Frabricius M 46
Gesneriaceae	*Streptocarpus meyeri* B.L.Burtt	Clark VR, Daniels R, Le Roux J, Frabricius M 379

Haloragaceae	*Gunnera perpensa* L.	Clark VR, Andrews A 299
Hypericaceae	*Hypericum aethiopicum* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 225
Icacinaceae	*Apodytes dimidiata* E.Mey. ex Arn. var. *dimidiata*	Clark VR, Coombs G 1068
Icacinaceae	*Cassinopsis ilicifolia* (Hochst.) Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 202
Lamiaceae	*Ajuga ophrydis* Burch. ex Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 128
Lamiaceae	*Isoglossa macowanii* C.B.Clarke	MacOwan P 933
Lamiaceae	*Mentha longifolia* subsp. *capensis* (Thunb.) Briq.	Clark VR, Daniels R, Le Roux J, Frabricius M 107
Lamiaceae	*Plectranthus laxiflorus* Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 438
Lamiaceae	*Salvia repens* Burch. ex Benth. var. *repens*	Clark VR, Daniels R, Le Roux J, Frabricius M 478
Lamiaceae	*Stachys aethiopica* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 142
Lamiaceae	*Stachys grandifolia* E.Mey. ex Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 146
Lamiaceae	*Teucrium africanum* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 407
Lamiaceae	*Teucrium trifidum* Retz.	MacOwan P s.n.
Linaceae	*Linum thunbergii* Eckl. & Zeyh.	Clark VR, Daniels R, Le Roux J, Frabricius M 177
Lobeliaceae	*Cyphia assimilis* Sond.	Phillipson P 5624
Lobeliaceae	*Lobelia flaccida* (C.Presl) A.DC. subsp. *flaccida*	Clark VR, Daniels R, Le Roux J, Frabricius M 25
Lobeliaceae	*Lobelia preslii* A.DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 152
Lobeliaceae	*Monopsis stellarioides* (C.Presl) Urb. subsp. *stellarioides*	Clark VR, Andrews A 181
Malvaceae	*Abutilon sonneratianum* (Cav.) Sweet	MacOwan P 83
Malvaceae	*Sida dregei* Burtt Davy	Clark VR, Andrews A 191
Malvaceae	*Sida ternata* L.f.	Clark VR, Andrews A 177
Melianthaceae	*Melianthus major* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 82
Mesembryanthemaceae	*Aptenia cordifolia* (L.f.) Schwantes	Clark VR, Andrews A 130
Mesembryanthemaceae	*Bergeranthus vespertinus* (A.Berger) Schwantes	MacOwan P 1587
Mesembryanthemaceae	*Chasmatophyllum musculinum* (Haw.) Dinter & Schwantes	Clark VR, Andrews A 194
Mesembryanthemaceae	*Delosperma brevisepalum* L.Bolus	Clark VR, Andrews A 317
Mesembryanthemaceae	*Delosperma karrooicum* L.Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 313
Mesembryanthemaceae	*Delosperma lootsbergense* Lavis	Clark VR, Daniels R, Le Roux J, Frabricius M 387
Mesembryanthemaceae	*Drosanthemum lique* (N.E.Br.) Schwantes	MacOwan P 2040
Mesembryanthemaceae	*Ruschia complanata* L.Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 223
Mesembryanthemaceae	*Ruschia cradockensis* subsp. *tricticiformis* (L.Bolus) H.E.K.Hartmann	Clark VR, Daniels R, Le Roux J, Frabricius M 221
Mesembryanthemaceae	*Ruschia putterillii* (L.Bolus) L.Bolus	Clark VR, Daniels R, Le Roux J, Frabricius M 224
Mesembryanthemaceae	*Trichodiadema olivaceum* L.Bolus	Mucina & Rutherford, 2006
Molluginaceae	*Psammotropha myriantha* Sond.	Clark VR, Daniels R, Le Roux J, Frabricius M 309
Moraceae	*Ficus burtt-davyi* Hutch.	Clark VR, Andrews A 71
Myricaceae	*Morella brevifolia* (E.Mey. ex C.DC.) Killick	Clark VR, Daniels R, Le Roux J, Frabricius M 240
Myrsinaceae	*Myrsine africana* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 209
Myrsinaceae	*Rapanea melanophloeos* (L.) Mez	Clark VR, Andrews A 78
Oleaceae	*Jasminum angulare* Vahl	Clark VR, Daniels R, Le Roux J, Frabricius M 503
Oleaceae	*Olea europaea* subsp. *africana* (Mill.) P.S.Green	Clark VR, Daniels R, Le Roux J, Frabricius M 33
Oliniaceae	*Olinia emarginata* Burtt Davy	Clark VR, Coombs G 1063
Onagraceae	*Epilobium capense* Buch. ex Hochst	MacOwan P 729
Onagraceae	*Oenothera rosea* L.Hér. ex Aiton*	Clark VR, Andrews A 80
Oxalidaceae	*Oxalis bifurca* Lodd. var. *bifurca*	MacOwan P 1689
Oxalidaceae	*Oxalis depressa* Eckl. & Zeyh.	Clark VR, Daniels R, Le Roux J, Frabricius M 411
Papaveraceae	*Papaver aculeatum* Thunb.	Clark VR, Andrews A 34
Piperaceae	*Peperomia retusa* (L.f.) Dietr.	Clark VR, Andrews A 253
Pittosporaceae	*Pittosporum viridiflorum* Sims	Clark VR, Andrews A 320
Plantaginaceae	*Plantago lanceolata* L.*	Clark VR, Daniels R, Le Roux J, Frabricius M 129
Plumbaginaceae	*Plumbago auriculata* Lam.	Clark VR, Andrews A 19
Polygalaceae	*Muraltia alopecuroides* (L.) DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 302
Polygalaceae	*Muraltia alticola* Schltr.	Clark VR, Daniels R, Le Roux J, Frabricius M 266
Polygalaceae	*Muraltia saxicola* Chodat	Clark VR, Daniels R, Le Roux J, Frabricius M 241

Polygalaceae	*Polygala fruticosa* P.J.Bergius	Clark VR, Andrews A 142
Polygalaceae	*Polygala gracilenta* Burtt Davy	Clark VR, Daniels R, Le Roux J, Frabricius M 281
Polygalaceae	*Polygala hispida* Burch. ex DC.	Clark VR, Coombs G 1046
Polygalaceae	*Polygala microlopha* DC.	Clark VR, Daniels R, Le Roux J, Frabricius M 244
Polygalaceae	*Polygala virgata* Thunb. var. *virgata*	Clark VR, Andrews A 264
Polygonaceae	*Rumex acetosella* subsp. *angiocarpus* (Murb.) Murb.*	Clark VR, Andrews A 318
Polygonaceae	*Rumex cordatus* Poir.	Clark VR, Daniels R, Le Roux J, Frabricius M 336
Polygonaceae	*Rumex woodii* N.E.Br.	Rechinger, 1954
Portulacaceae	*Portulacaria afra* Jacq.	Clark VR, Coombs G 1016
Proteaceae	*Protea lorifolia* (Salisb. ex Knight) Fourc.	Rebelo, 2001
Proteaceae	*Protea subvestita* N.E.Br.	Clark VR, Daniels R, Le Roux J, Frabricius M 318
Ptaeroxylaceae	*Ptaeroxylon obliquum* (Thunb.) Radlk.	Clark VR, Andrews A 6
Ranunculaceae	*Clematis brachiata* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 51
Ranunculaceae	*Ranunculus meyeri* Harv.	Clark VR, Daniels R, Le Roux J, Frabricius M 26
Ranunculaceae	*Ranunculus multifidus* Forssk.	Clark VR, Daniels R, Le Roux J, Frabricius M 23
Resedaceae	*Oligomeris dregeana* (Müll.Arg.) Müll.Arg.	Leistner, 1970
Rhamnaceae	*Phylica paniculata* Willd.	Clark VR, Daniels R, Le Roux J, Frabricius M 88
Rhamnaceae	*Rhamnus prinoides* L'Hér.	Clark VR, Daniels R, Le Roux J, Frabricius M 64
Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz	Clark VR, Andrews A 8
Rhamnaceae	*Ziziphus mucronata* Willd. subsp. *mucronata*	Clark VR, Andrews A 9
Rosaceae	*Alchemilla bicarpellata* Rothm.	Clark VR, Andrews A 208
Rosaceae	*Alchemilla elongata* Eckl. & Zeyh. var. *elongata*	Clark VR, Daniels R, Le Roux J, Frabricius M 29
Rosaceae	*Cliffortia eriocephalina* Cham.	Clark VR, Daniels R, Le Roux J, Frabricius M 305
Rosaceae	*Cliffortia linearifolia* Eckl. & Zeyh.	Clark VR, Andrews A 325
Rosaceae	*Cliffortia paucistaminea* Weim.	Clark VR, Andrews A 107
Rosaceae	*Cliffortia strobilifera* L.	Clark VR, Andrews A 74
Rosaceae	*Duchesnea indica* (Andrews) Focke*	Clark VR, Andrews A 121
Rosaceae	*Geum capense* Thunb.	Clark VR, Andrews A 201
Rosaceae	*Leucosidea sericea* Eckl. & Zeyh.	Clark VR, Andrews A 112
Rosaceae	*Rosa rubiginosa* L.*	Clark VR, Daniels R, Le Roux J, Frabricius M 115
Rosaceae	*Rubus ludwigii* Eckl. & Zeyh. subsp. *ludwigii*	Clark VR, Daniels R, Le Roux J, Frabricius M 409
Rosaceae	*Rubus pinnatus* Willd	MacOwan P 1903
Rosaceae	*Rubus rigidus* Sm.	Clark VR, Daniels R, Le Roux J, Frabricius M 84
Rubiaceae	*Anthospermum herbaceum* L.f.	Clark VR, Daniels R, Le Roux J, Frabricius M 95
Rubiaceae	*Anthospermum monticola* Puff	Clark VR, Daniels R, Le Roux J, Frabricius M 41
Rubiaceae	*Anthospermum rigidum* Eckl. & Zeyh. subsp. *rigidum*	Clark VR, Andrews A 353
Rubiaceae	*Anthospermum rigidum* subsp. *pumilum* (Sond.) Puff	Clark VR, Daniels R, Le Roux J, Frabricius M 382
Rubiaceae	*Anthospermum spathulatum* Spreng. subsp. *spathulatum*	Clark VR, Andrews A 352
Rubiaceae	*Canthium ciliatum* (Klotzsch ex Eckl. & Zeyh.) Kuntze	Clark VR, Andrews A 60
Rubiaceae	*Canthium mundianum* Cham. & Schltdl.	Clark VR, Daniels R, Le Roux J, Frabricius M 430
Rubiaceae	*Galium capense* Thunb. subsp. *capense*	Clark VR, Daniels R, Le Roux J, Frabricius M 167
Rubiaceae	*Galium capense*subsp. *garipense* (Sond.) Puff	MacOwan P 1627
Rubiaceae	*Galium spurium* subsp. *africanum* Verdc.	Clark VR, Andrews A 249
Rubiaceae	*Galium thunbergianum* var. *hirsutum* (Sond.) Verdc.	Clark VR, Daniels R, Le Roux J, Frabricius M 333
Rubiaceae	*Kohautia amatymbica* Eckl. & Zeyh.	Clark VR, Coombs G 1051
Rubiaceae	*Nenax microphylla* (Sond.) T.M.Salter	Clark VR, Daniels R, Le Roux J, Frabricius M 184
Rubiaceae	*Rubia petiolaris* DC.	Clark VR, Andrews A 344
Rutaceae	*Calodendrum capense* (L.f.) Thunb.	Clark VR, Coombs G 1031
Rutaceae	*Vepris lanceolata* (Lam.) G.Don	Clark VR, Andrews A 31
Rutaceae	*Zanthoxylum capense* (Thunb.) Harv.	Clark VR, Andrews A 47
Salicaceae	*Populus* x *canescens* (Aiton) Sm.*	Clark VR, Coombs G 1029
Salicaceae	*Salix mucronata* subsp. *capensis* (Thunb.) Immelman	Clark VR, Andrews A 304
Salvadoraceae	*Azima tetracantha* Lam.	Clark VR, Andrews A 18

Santalaceae	*Osyris lanceolata* Hochst. & Steud.	Clark VR, Daniels R, Le Roux J, Frabricius M 187
Santalaceae	*Thesium acutissimum* A.DC.	MacOwan P 2218
Santalaceae	*Thesium hirsutum* A.W.Hill	MacOwan P 168
Santalaceae	*Thesium orientale* A.W.Hill	MacOwan P 1628
Santalaceae	*Thesium paniculatum* L.	Hill, 1925
Sapindaceae	*Dodonaea viscosa* var. *angustifolia* (L.f.) Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 403
Sapindaceae	*Hippobromus pauciflorus* (L.f.) Radlk.	Clark VR, Andrews A 51
Sapindaceae	*Pappea capensis* Eckl. & Zeyh.	Clark VR, Coombs G 1017
Sapotaceae	*Mimusops obovata* Nees ex Sond.	Clark VR, Coombs G 1021
Sapotaceae	*Sideroxylon inerme* L. subsp. *inerme*	Clark VR, Andrews A 306
Scrophulariaceae	*Bartsia trixago* L.	MacOwan P 1652
Scrophulariaceae	*Buchnera simplex* (Thunb.) Druce	McMaster C 17 November 2008
Scrophulariaceae	*Diascia capsularis* Benth.	Clark VR, Daniels R, Le Roux J, Frabricius M 119
Scrophulariaceae	*Diascia ramosa* Scott-Elliot	Hilliard and Burtt, 1984
Scrophulariaceae	*Glekia krebsiana* (Benth.) Hilliard	Clark VR, Andrews A 195
Scrophulariaceae	*Halleria lucida* L.	Clark VR, Andrews A 123
Scrophulariaceae	*Harveya bolusii* Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M149
Scrophulariaceae	*Harveya huttonii* Hiern.	Clark VR, Daniels R, Le Roux J, Frabricius M 279
Scrophulariaceae	*Hebenstretia dura* Choisy	Clark VR, Daniels R, Le Roux J, Frabricius M 56
Scrophulariaceae	*Jamesbrittenia filicaulis* (Benth.) Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 360
Scrophulariaceae	*Jamesbrittenia foliolosa* (Benth.) Hilliard	Clark VR, Andrews A 154
Scrophulariaceae	*Mimulus gracilis* R.Br.	Clark VR, Andrews A 53
Scrophulariaceae	*Nemesia mellissifolia* Benth.	MacOwan P 330
Scrophulariaceae	*Nemesia umbonata* (Hiern) Hilliard & B.L.Burtt	Clark VR, Andrews A 212
Scrophulariaceae	*Selago dolosa* Hilliard	Clark VR, Daniels R, Le Roux J, Frabricius M 368
Scrophulariaceae	*Sutera halimifolia* (Benth.) Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 222
Scrophulariaceae	*Sutera rotundifolia* (Benth.) Kuntze	Clark VR, Daniels R, Le Roux J, Frabricius M 443
Scrophulariaceae	*Teedia lucida* (Sol.) Rudolphi	Clark VR, Daniels R, Le Roux J, Frabricius M 299
Scrophulariaceae	*Veronica anagallis-aquatica* L.	Clark VR, Daniels R, Le Roux J, Frabricius M 24
Scrophulariaceae	*Zaluzianskya capensis* (L.) Welp.	Clark VR, Daniels R, Le Roux J, Frabricius M 355
Scrophulariaceae	*Zaluzianskya spathacea* (Benth.) Walp.	MacOwan P 1632
Solanaceae	*Lycium cinereum* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 65
Solanaceae	*Nicotiana glauca* Graham*	Clark VR, Daniels R, Le Roux J, Frabricius M 4
Solanaceae	*Physalis peruviana* L.*	Clark VR, Andrews A 231
Solanaceae	*Solanum linnaeanum* Hepper & Jaeger	Clark VR, Andrews A 169
Solanaceae	*Solanum pseudocapsicum* L.*	Clark VR, Andrews A 46
Solanaceae	*Solanum supinum* Dunal var. *supinum*	MacOwan P 1606
Solanaceae	*Solanum tomentosum* var. *coccineum* (Jacq.) Willd.	Clark VR, Daniels R, Le Roux J, Frabricius M 205
Solanaceae	*Withania somnifera* (L.) Dunal	Clark VR, Daniels R, Le Roux J, Frabricius M 348
Sterculiaceae	*Hermannia althaeoides* Link	Clark VR, Daniels R, Le Roux J, Frabricius M 249
Sterculiaceae	*Hermannia crassifolia* MS D.Gwynne-Evans	Clark VR, Andrews A 200
Sterculiaceae	*Hermannia filifolia* var. *robusta* I.Verd.	Clark VR, Andrews A 315
Sterculiaceae	*Hermannia flammea* Jacq.	MacOwan P 24b
Sterculiaceae	*Hermannia gracilis* Eckl. & Zeyh.	MacOwan P 935
Sterculiaceae	*Hermannia violacea* (Burch. ex DC.) K.Schum.	Clark VR, Daniels R, Le Roux J, Frabricius M 426
Thymelaeaceae	*Passerina montana* Thoday	Clark VR, Daniels R, Le Roux J, Frabricius M 300
Tiliaceae	*Grewia occidentalis* L. var. *occidentalis*	Clark VR, Daniels R, Le Roux J, Frabricius M 70
Ulmaceae	*Celtis africana* Burm.f.	Clark VR, Andrews A 48
Urticaceae	*Didymodoxa caffra* (Thunb.) Friis & Wilmot-Dear	MacOwan P s.n.
Urticaceae	*Laportea peduncularis* (Wedd.) Chew subsp. *peduncularis*	MacOwan P s.n.
Verbenaceae	*Lantana rugosa* Thunb.	Clark VR, Daniels R, Le Roux J, Frabricius M 255
Verbenaceae	*Priva adhaerens* (Forssk.) Chiov.	Clark VR, Daniels R, Le Roux J, Frabricius M 428
Verbenaceae	*Verbesina encelioides* (Cav.) Benth. & Hook.f. ex A.Gray*	Clark VR, Daniels R, Le Roux J, Frabricius M 321

Verbenaceae	*Verbena aristigera* S.Moore*	Clark VR, Andrews A 196
Viscaceae	*Viscum obscurum* Thunb.	Clark VR, Andrews A 2
Vitaceae	*Rhoicissus digitata* (L.f.) Gilg & M.Brandt	Clark VR, Andrews A 175
Vitaceae	*Rhoicissus revoilii* Planch.	Clark VR, Daniels R, Le Roux J, Frabricius M 322
Vitaceae	*Rhoicissus tridentata* subsp. *cuneifolia* (Eckl. & Zeyh.) Urton	Clark VR, Andrews A 55

Chapter 4: The Nuweveldberge.

4.1. Introduction

The Nuweveldberge, straddling the Northern Cape and Western Cape Provinces in South Africa, comprises the gently arcing section of the southern Great Escarpment located between the Roggeveld–Komsberg in the west and the Sneeuberg in the east, falling into the Sutherland, Merweville, Fraserburg and Beaufort West Districts. The Nuweveldberge can be neatly partitioned as stretching from the Dwyka River Gorge (Fig. 4.2E) in the west (separating it from the Roggeveld–Komsberg in the west), to Beaufort West in the east (Fig. 4.1). It is separated from the Sneeuberg by the 150 km-wide "Nelspoort Interval" (Nordenstam, 1969; Clark et al., 2009). To the south lie the Koup and Moordenaars Karoos, which are part of the lower Great Karoo (Hilton-Taylor, 1987) and which separate the Nuweveldberge from the Klein- and Groot-Swartberge of the inland Cape Fold Ranges. To the north of the Nuweveldberge lies the inland plateau section of the Great Karoo known as the Bo-Karoo.

The Nuweveldberge is an intriguing section of Great Escarpment in South Africa, situated in a climatic "no man's land" – the "all year rainfall" zone of Chase and Meadows (2007). Perhaps the Nuweveldberge are the "typical" Karoo mountains in South Africa, characterised by unpredictable rainfall (Esler et al., 2006); a harsh, angular geomorphology of mesas and buttes (Sugden, 1989); and vegetation dominated by arid karroid shrublands at all altitudes with little obvious ameliorating effects of altitude as elsewhere on the Great Escarpment.

The Nama-Karoo Biome, in which the Nuweveldberge is situated (Sugden, 1989), is an overall poorly studied region (Low and Rebelo, 1998; Burgess et al., 2004). The Nuweveldberge and its vegetation types are not well known (White, 1983; Sugden, 1989; Hilliard, 1994, 1999; Mucina and Rutherford, 2006), with no botanical publications available except for the Karoo National Park in the Eastern Nuweveldberge (Rubin and Palmer, 1996; Rubin et al., 2001). The purpose of this study is to provide an overview of the Nuweveldberge, its endemism, and to provide a contribution towards a flora. The study also considers the role of the Nuweveldberge as a component in connectivity along the southern Great Escarpment and possibly with the CFR.

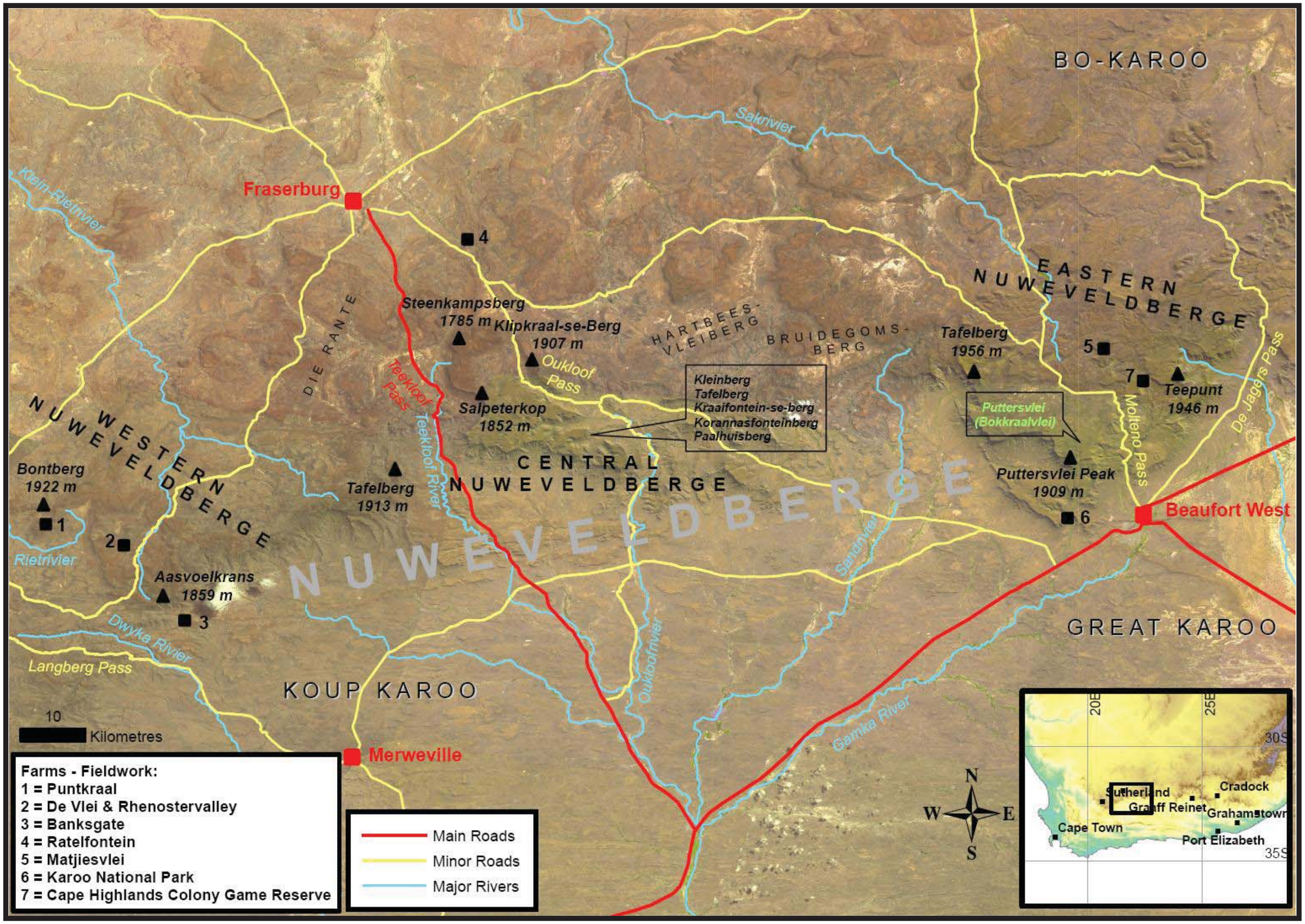


Figure 4.1: The Nuweveldberge, indicating the highest points, farms used as bases for fieldwork, and localities mentioned in the text. Satellite imagery sourced from the CSIR (2009), insert map source as for Fig. 1.1.

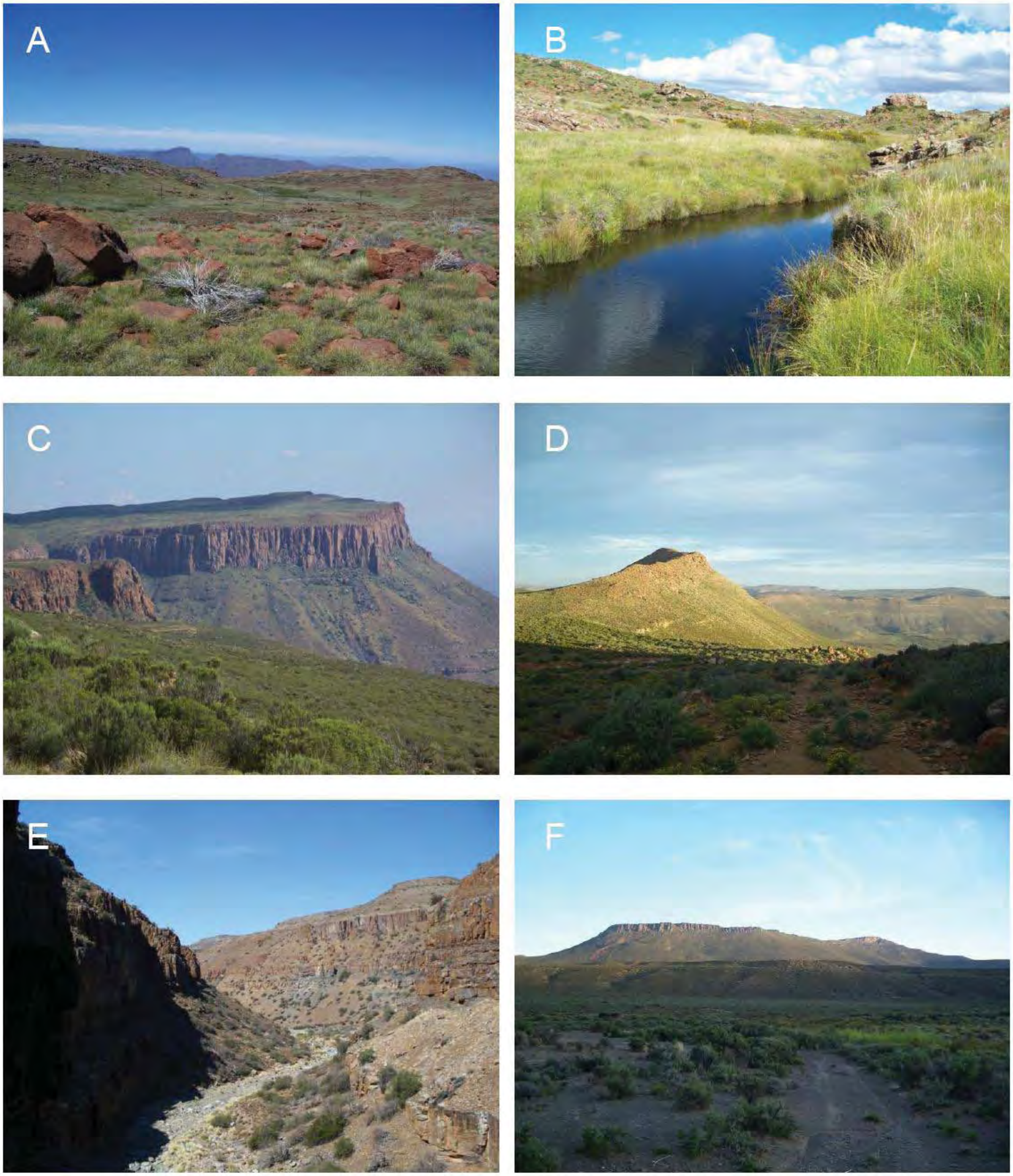


Figure 4.2: A selection of photographs from the Nuweveldberge: (A) Karoo Escarpment Grassland on the Eastern Nuweveldberge (1 700–1 900 m), Karoo National Park; (B) Puttersvlei (or Bokkraal Vlei) on the Eastern Nuweveldberge plateau (1 716 m), Karoo National Park; (C) Dramatic scarps of the Eastern Nuweveldberge, Karoo National Park; (D) Salpeterkop (1 852 m) in the Central Nuweveldberge; (E) The arid Dwyka River Gorge (1 050 m at the riverbed), Western Nuweveldberge; (F) Bontberg (1 922 m) in the Western Nuweveldberge.

4.2. The physical and historical environment of the Nuweveldberge

4.2.1. Geology and geomorphology

The geology of the Nuweveldberge is dominated by horizontal Beaufort Series sediments of the Abrahamskraal and Teekloof Formations heavily intruded by Jurassic dolerites (Du Toit, 1920; Sugden, 1989; Rubin and Palmer, 1996). These dolerites vary from prominent inclined sheets (e.g. Salpeterkop in the Steenkampsberge; Fig. 4.2D), to narrow dykes, to the near-horizontal sills which dominate much of the higher plateaux in the Nuweveldberge (Fig. 4.2C). Hornfells and quartzitic sandstones occur along the contact zones between dolerite and sediments (Rubin and Palmer, 1996).

The Nuweveldberge as part of the Great Escarpment is believed to represent part of the passive Gondwanan continental margin in southern Africa (Matmon et al., 2002; see Chapter 1). The Nuweveldberge itself can be divided into three main sections of higher ground (Fig. 4.1). These comprise the Western Nuweveldberge (from the Dwyka River Gorge to Teekloof Pass, but with an extensive low altitude plain where the Klein-Rietrivier has cut south almost to the Great Escarpment crest), the Central Nuweveldberge (from Teekloof Pass to Klipkraal-se-Berg and incorporating the Steenkampsberge), and the Eastern Nuweveldberge (from the Bruidegomsberg to De Jagers Pass). Each of these sections have peaks over 1 900 m in altitude, while the intervening sections of Great Escarpment drop as low as 1 400 m and consist mostly of extensive plains with negligible gradient.

The origin of these large, featureless intervening plains on the Great Escarpment is probably a combination of planation by fluvial systems (such as the Riet, Klein-Riet, Teekloof and the various river systems between Klipkraal-se-berg and the Eastern Nuweveldberge), and a dominance of the geology in these areas by shale. Shale is easily removed in the absence of any extensive, resistant dolerite sills while the higher sections of the Nuweveldberg Escarpment are almost without exception capped with dolerite. The plains then generally represent areas of low dolerite intrusion and higher erodability, while the higher, mountainous parts represent areas dominated by dolerite and have greater resistance against erosion (Sugden, 1989; Burgess et al., 2004).

Despite the dominance of resistant dolerite, the mountainous sections of the Nuweveldberge have suffered extensive headward erosion from south-flowing streams (Sugden, 1989). These streams, flowing south down the Great Escarpment, have the advantage of being steeper in gradient than streams originating north of the watershed, and consequently have more erosive power (Sugden, 1989). The result has been some deep incisions into the southern face of the Nuweveldberge. Notable examples of this are the Dwyka River, which has formed an impressive gorge separating the

Besemgoedberg (on the Komsberg – see Fig. 5.1 in Chapter 5) from the Nuweveldberge, and the Teekloof River with its landmark waterfall. Further major incisions are present in the Oukloof Pass region (a result of the various tributaries of the Koekemoersrivier), resulting in a very sinuous and dissected Great Escarpment frontage of free-standing mesas and buttes such as Kleinberg (1 602 m), Tafelberg (1 588 m), Kraaifontein-se-berg (1 655 m), Korannasfonteinberg (1 637 m) and Paalhuisberg (1 624 m) (Fig. 4.1). The Eastern Nuweveldberge has also been subject to deep incision in places, such as along the Molteno Pass (by the Molteno River) and in the De Jagers Pass area (by the western tributaries of the Platdoringrivier). None of these incisions have resulted in free-standing mountains in the Eastern Nuweveldberge however. The Western Nuweveldberge, in contrast to the Central and Eastern Nuweveldberge, forms a mostly single-faced Great Escarpment front with low sinuosity.

A noticeable feature of the Nuweveldberge compared to the Sneeuberg is the presence of massive (50–150 m high) shale and sandstone cliffs, a feature largely absent in the high Sneeuberg where high cliffs are usually composed of dolerite. This may be due to the drier Nuweveldberge climate and the resultant persistence of sedimentary cliffs, which are more quickly eroded away in the moister climate to the east. Another – more likely reason – is that the Sneeuberg has been more massively intruded by dolerites than the Nuweveldberge has been.

The highest peaks in the Nuweveldberge are Tafelberg (1 956 m; above the Karoo National Park, Eastern Nuweveldberge), Teepunt (1 924 m; Eastern Nuweveldberge), Bontberg (1 922 m; Western Nuweveldberge; Fig. 4.2F), Tafelberg (1 913 m; the conspicuous mesa west of the base of Teekloof Pass, Western Nuweveldberge); an unnamed peak in the Karoo National Park (1 909 m; the name "Puttersvlei Peak" is suggested; Fig. 5.2C), and Klipkraal-se-Berg (1 907 m, Central Nuweveldberge).

The Bo-Karoo to the north of the Nuweveldberge and the Koup and Moordenaars Karoos to the south of the Nuweveldberge are considered to be part of Partridge and Maud's (1987) African Surface of planation. Although the Nuweveldberge are simply included in Partridge and Maud's (1987; their Fig. 12) "*mountainous areas above the African Surface*" it is possible – as for the Sneeuberg (Clark et al., 2009; see Chapter 2) and Amatolas (Agnew, 1958; Phillipson, 1987) – that the summit plateaux of the highest sections of the Nuweveldberge mentioned above represent remnants of the original Gondwanan land-surface.

4.2.2. Hydrology

The Nuweveldberge form a true continental watershed, with each side draining to different oceans. This is in contrast to the both the Sneeuberg (Clark et al., 2009; see Chapter 2) and the Roggeveldberge (see Chapter 5). To the north, the Nuweveld is drained by the Sakrivier system that terminates in the large Grootvloer pan in Bushmanland (Mucina and Rutherford, 2006), and ultimately to the Orange River and the Atlantic Ocean. The principal rivers that are part of this north-flowing system are (from west to east) the Riet, the Klein-Riet, the Sout and the Sakrivier (Fig. 4.1). To the south, the Nuweveld is drained by the Dwyka and Gamka River systems, which form the Karoo catchment area of the Gouritz River system which discharges into the Indian Ocean west of Mossel Bay (Mucina and Rutherford, 2006).

The rivers arising on the Western and Central Nuweveldberge are largely episodic or at best non-perennial. Regardless of size, they are invariably characterised by grey or maroon gravel ("grys") beds of various depth overlying bedrock, often shale. The larger riverbeds vary from 5–20 m wide (such as the Dwyka River and Rietrivier), occasionally up to 50 m wide (Klein-Rietrivier). The main erosive power of these Nuweveld rivers is probably attributable to occasional flash flood events, the easy erodability of the Karoo sediments, and the paucity of vegetation cover.

The haphazard drainage network on the "flats" between the Central and Eastern Sections of the Nuweveldberge suggests that in a wetter climate these vast plains would form extensive marshlands, due to negligible gradient and poor drainage. Currently they comprise a series of haphazard stream courses with high sinuosity and terminate in large local pans or "vloere". (It is worth comparing these plains geomorphologically to the north-eastern Free State and south-eastern Mpumalanga Highveld, where a mean annual rainfall of 800+ mm and a high sinuosity from negligible gradient has resulted in an impressive system of ox-bow lakes and extensive vlei-lands).

The Eastern Nuweveldberge provides possibly the only area in the Nuweveldberge where reliable stream-flow can be encountered. A higher mean annual rainfall and increased rainfall reliability than further west may allow for this (Rubin and Palmer, 1996; Rubin et al., 2001). Remnant well-managed upland vlei systems – such as Puttersvlei in the Karoo National Park (also known as Bokkraal Vlei; Sugden, 1989; Fig. 4.1) – no doubt also facilitate stream-flow reliability. Many of the other larger vleis occurring in the Eastern Nuweveldberge have been canalised and drained for cultivation (Sugden, 1989).

4.2.3. Soils

Soil is a limited abiotic element in the Western and Central Nuweveldberge. The arid climate inhibits the chemical weathering of rock into regolith and its contribution to the mineral component of soil, and the sparse vegetation cover and heavy thundershowers quickly erode any exposed soil. In addition, prominent geological sediments such as shale do not form soil, crumbling rather into a nutrient deficient “grys” (gravel) that retains little moisture. Nuweveld soils are also generally orthic (lacking in humic material) and calcerous (Sugden, 1989; Rubin and Palmer, 1996; Low and Rebelo, 1998). Soils in the prominent dolerite uplands, the broad upland valleys, and the extensive intervening flats are particularly considered.

a) Dolerite Uplands

A shallow, red-brown loamy clay *in situ* soil forms on the higher dolerite plateaux and gentler plateaux slopes of the Western and Central Nuweveldberge, and is protected from erosion by the “imbedded” dolerite boulders that dominate these plateaux. This dolerite “klipveld” consists of black, rounded dolerite stones and boulders (ca. 50 m x 20 cm to 1 m x 1 m), and which form an almost continuous “pavement” of rounded boulders. At lower altitudes, dolerite “klipveld” often consists of a loose surface of small round boulders (ca. 10 cm x 10 cm), and which could aptly be called “cannonballveld”.

The best developed soils are in the Eastern Nuweveldberge, where – given the higher rainfall of 406 mm (Rubin and Palmer, 1996; Rubin et al., 2001) – a rich, black turf clay occurs on the dolerite-capped plateaux. This is similar to the soils on the Sneeuberg plateau (Clark et al., 2009), and is possibly one reason why the Nuweveldberge is floristically similar to the Sneeuberg (see Chapter 6). Although Rubin et al. (2001) indicate that sedimentary rocks in the Nuweveldberge produce more fertile soils, it is the author’s experience that dolerites generally produce a more fertile, loamy-clay soil and consequently support a richer plant diversity than weathered sediments do.

b) Upland Valleys

The large upland valleys in the Nuweveldberge often host gravelly, sandy or loamy-clay soils which are often deep (>1 m) and also highly susceptible to erosion from sheetwash and gully erosion. These colluvial deposits suggest a wetter climate in times past that allowed for a higher soil formation rate than at present and subsequent deposition in these valleys. Good examples of this soil can be seen on the Central Nuweveldberge.

c) Flats

The soil on the vast flats east of Klipkraal-se-berg varies from shale outcrops without soil, to a gravelly soil 10 cm deep, to a soil 25 cm deep comprised of a brown, sandy upper horizon becoming a reddish loam with depth and overlying shale fragments. It is possible that much of this soil is alluvial or aeolian rather than *in situ* in origin. Plains not overlain by soils are covered in shale-derived gravel. Wind may be an important agent of erosion on these featureless plains (Sugden, 1989).

4.2.4. Climate

The Nuweveldberge falls into the "all-year rainfall" region in southern Africa (Sugden, 1989; Chase and Meadows, 2007) and consequently falls into the transition zone between the winter rainfall regime in the west and the summer rainfall regime in the east. The result of this climatic "no man's land" is rainfall unreliability and regular drought (Venter et al., 1986; Burgess et al., 2004; Esler et al., 2006; Mucina and Rutherford, 2006).

a) Precipitation

The Western and Central Nuweveldberge receives between 200 and 300 mm per annum (Venter et al., 1986), substantially less than the Sneeuberg's 500 to 1 000 mm (Clark at al., 2009; see Chapters 2 and 3). Parts of the Eastern Nuweveldberge have a MAP of just over 400 mm (Rubin and Palmer, 1996; Rubin et al., 2001) and Sugden (1989) indicates that rainfall can even reach 750 mm here. Between 50 and 70% percent of the MAP falls in summer i.e. October to March (Venter et al., 1986; Sugden, 1989; Rubin and Palmer, 1996), with a rainfall peak throughout the Nuweveldberge occurring in March (Sugden, 1989; Esler et al., 2006; Mucina and Rutherford, 2006; K. Olivier, pers. comm.). The late rains result in a very short growth period for plants before the onset of the harsh winter conditions (Hoffman and Cowling, 1987; Mucina and Rutherford, 2006). Locally Sutherland (on the Roggeveld) is considered to be the principal cut-off between summer and winter rainfall in the region (Sieberhagen, pers. comm.), although Fraserburg is closer to the 50/50 divide (Venter et al., 1986).

Rainfall is often in the form of heavy thundershowers resulting from convection activity or frontal systems (Sugden, 1989; Esler et al., 2006). Summer thundershowers can bring local ("plek-plek") rain rather than regional rain, resulting in one farm being well-watered in any particular summer while neighbouring farms suffer drought. This was evident in March 2009 when the Farm Puntkraal had received 77 mm for the month while the Farm De Vlei, 12 km away, was in the grip of a severe drought (K. Olivier, pers. comm.; D. Olivier, pers. comm.).

The local farmers speak of "suiderwee", which in contrast to local rain showers is a persistent, gentle rain falling on the Great Escarpment over the course of two or three days following cold fronts when the wind shifts to the south or south-east (Cowling and Lombard, 2002; K. Olivier, pers. comm.; D. Olivier, pers. comm.). Apparently this rain has decreased over the past few years, possibly as a result of the 10–12-year wet-dry oscillations occurring the in the region (such as Palmer, 1988, and Boardman et al., 2003, indicate for the Sneeuberg). This type of rain is generally considered to be the most beneficial rain on the Nuweveldberge, although it is generally confined to the Great Escarpment crest and immediately adjacent plateaux (K. Olivier, pers. comm.).

Other significant forms of precipitation are regular frost and snowfalls in winter at higher altitudes (Sugden, 1989; K. Olivier, pers. comm.), and mist along the Great Escarpment (Rubin and Palmer, 1996; pers. obs.). Overall, the Nuweveldberge is moister than the lower slopes and surrounding plains as it attracts advective fog and is more conducive to convective cloud formation (Sugden, 1989; Rubin and Palmer, 1996).

b) Temperature

The Nuweveldberge has a cool steppe climate (Rubin and Palmer, 1996), with mean annual temperatures of between 15 and 17.5^{o}C (Venter et al., 1986). Seasonal extremes are typical, with maximum summer temperatures exceeding 40^{o}C (Sugden, 1989) and 10–50 days per year with a minimum temperature below 0^{o}C (Venter et al., 1986). The base of the Great Escarpment is considerably warmer than the summit plateau (Venter et al., 1986; Rubin and Palmer, 1996).

c) Wind

The Nuweveldberge are considered to be windy, with south-easterlies dominating in summer and north-westerlies in winter (Sugden, 1989).

d) Important micro-climates

Micro-climates are created by aspect, with south-facing slopes being shaded, moister and cooler than north-facing slopes (Sugden, 1989). South-east facing slopes receive more moisture than any other aspect, and consequently host a richer flora. The highest peaks can be expected to be subject to more extreme wind and cold conditions than elsewhere on the Nuweveldberge.

4.2.5. Vegetation

Despite the general aridity of the Nuweveldberge, four biomes are represented on this section of the Great Escarpment together with several important azonal vegetation communities.

a) Fynbos Biome

The Fynbos Biome is represented on the Nuweveldberge by Roggeveld Shale Renosterveld (Mucina and Rutherford, 2006). This vegetation unit occurs from the Roggeveld onto the Western and Central Nuweveldberge as far east as Klipkraal-se-Berg.

Roggeveld Shale Renosterveld is a component of the broader Escarpment Mountain Renosterveld of Low and Rebelo (1998) and Acocks's (1988) Mountain Renosterveld (A43) vegetation types that extends from the Nuweveldberge to the Hantamberge. Acocks (1988) considers this Renosterveld to be invasive of a previously much grassier habitat, possibly as a result of overgrazing following the extermination of the original nomadic plains game and replacement by concentrated livestock (Manning and Goldblatt, 2002; Low and Rebelo, 1998; Van der Merwe et al., 2009a). Although Roggeveld Shale Renosterveld is indicated by Mucina and Rutherford (2006) as dominating the high plateaux of the Western and Central Nuweveldberge, much of these high plateaux are in fact dominated by dolerite (as opposed to shale), and host a grassy shrubland with a strong succulent presence on a rich loamy-clay. Typical species include *Arctotis diffusa*, *Crassula sarcocaulis* subsp. *sarcocaulis*, *Eriocephalus ericoides*, *Euphorbia caturviflora*, *Felicia fascicularis*, *F. filifolia*, *Massonia depressa*, *Merxmuellera disticha*, *M. dura*, *M. stricta*, *Oxalis melanosticta*, *Passerina* sp., *Pelargonium abrotanifolium*, *P. tragacanthoides*, *Pentzia tortuosa*, *Polygala ephedroides*, *Pteronia glomerata*, *Ruschia cradockensis* subsp. *tricticiformis*, *R. hamata* and *Themeda triandra*. It is not difficult to imagine a much grassier montane vegetation if there was an increased regular rainfall combined with judicious grazing management, as the same soil conditions support extensive grassland on the Eastern Nuweveldberge and on the Sneeuberg. Renosterveld is prevalent on the steeper slopes and usually on sedimentary rock.

b) Succulent Karoo Biome

The lower-altitude areas of the Nuweveld plateau as far west as Oukloof Pass consist of Roggeveld Karoo (Mucina and Rutherford, 2006). Although placed in the Succulent Karoo Biome, it is considered transitional between Succulent Karoo and Nama-Karoo (Mucina and Rutherford, 2006). It is a largely undisturbed and uninvaded vegetation unit but remains botanically poorly explored (Mucina and Rutherford, 2006). As with Roggeveld Shale Renosterveld, it indicates a strong connection between the western and central Nuweveld and the Roggeveld.

c) Nama-Karoo Biome

Upper Karoo Hardeveld of the Nama-Karoo Biome dominates the drier, lower-altitude foothills of the Nuweveldberge from below the Steenkampsberg and Klipkraal-se-berg eastwards, with smaller patches on the dolerite "rooikoppies" scattered inland of the Great Escarpment front (Mucina and Rutherford, 2006). This is a widespread although scattered vegetation unit in the central-eastern Karoo (Mucina and Rutherford, 2006). North of the Nuweveldberge, the vegetation is dominated by the very widespread Western Upper Karoo and Eastern Upper Karoo vegetation units (Mucina and Rutherford, 2006). The plains south of the Nuweveldberge consist of Gamka Karoo (Mucina and Rutherford, 2006).

d) Grassland Biome

The Eastern Nuweveldberg summit consists of Karoo Escarpment Grassland, the same grassland units as occurring on the Sneeuberg and on the drier, inland slopes of the Great Winterberg–Amatolas and Stormberg (Mucina and Rutherford, 2006). This grassland in the Nuweveldberge is the western-most outlier of the Grassland Biome in South Africa (Mucina and Rutherford, 2006). It is dominated by *Merxmuellera disticha* (Acocks, 1988) and can be considered marginal, both in terms of species diversity compared to the Sneeuberg, and in terms of being in a probable permanent tension with karroid shrubland. Acocks (1988) referred to this vegetation type as Karroid *Merxmuellera* Mountain Veld, and viewed it having a close relationship to Mountain Renosterveld (i.e. Roggeveld Shale Renosterveld of Mucina and Rutherford, 2006, in this instance). He also postulated that *Merxmuellera disticha* is the probably naturally dominant grass species on sandstone, while on dolerite and on better developed soils the dominant grasses would be *Themeda triandra* and *Tetrachne dregei*. The field investigations in this study support this.

The summit plateau in the Karoo National Park gives a good idea of the tension between karroid montane shrubland and grassland in this region. Overgrazing and or the absence of fire probably encourages the formation of the dense karroid montane shrubland up to 1 m tall dominated by *Euryops* spp., *Dicerothanmus rhinocerotis* and *Passerina* sp.. Areas regularly burnt are a rich grassland dominated by *Themeda triandra* on rocky dolerite slopes, otherwise karroid montane shrubland and or *Merxmuellera disticha* is dominant on sedimentary and metamorphic substrates. Good veld management in the Karoo National Park has provided a base-line of ideal grassland conditions for the Eastern Nuweveldberge.

e) Azonal vegetation

Two important azonal vegetation types occur in the Nuweveldberge. Each is considered in turn.

Riparian systems and wetlands

South-flowing rivers off the Nuweveldberge are locally dominated by Southern Karoo Riviere vegetation, comprising thickets of *Acacia karroo*, *Tamarix usneoides* and *Salsola* spp. (Mucina and Rutherford, 2006). Bushmanland Vloere occurs on the vast flats to north of the Nuweveldberge and also on the intervening plains between the Western and Central Nuweveldberge and between the Central and Eastern Nuweveldberge (Mucina and Rutherford, 2006). It consists of pans often connected by flat, intermittent rivers (Mucina and Rutherford, 2006). Ephemeral wetland vegetation elements are confined to man-made dams in the area.

Seasonal "wetlands" occur on the summit plateau of the Eastern Nuweveldberge, occupying vast flat areas underlain by shale between outcrops of dolerite or sandstone. In years of higher rainfall, rainwater accumulates on these flats, turning the otherwise Karroid vegetation dominated by *Lycium* spp. and typical Karoo shrubs into an extensive temporary wetland. The endangered *Bunolagos monticularis* (Riverine Rabbit) is purported from this section of the Nuweveldberge, and may occur on these seasonally waterlogged flats.

In the Karoo National Park, where several decades of good veld management have been implemented on the summit, a very healthy vlei system occurs. This vlei – referred to as Puttersvlei or Bokkraal Vlei (Sugden, 1989; Figs 4.1 and 4.2B) – consists of good cover dominated by *Carex glomerabilis*, *Crassula natans*, *Fingerhuthia sesleriiformis*, *Fuirena coerulescens*, *Juncus inflexus*, *J. oxycarpus*, *Pennisetum thunbergii*, *Pseudoschoenis inanis* and *Tetrachne dregei*. Herbaceous species present include *Conyza pinnata*, *Gunnera perpensa*, *Limosella* sp., *Mentha longifolia* subsp. *capensis* and the alien *Urtica dioica*. Although not an unusual plant assemblage (most of the species are typical of wet areas on the southern Great Escarpment), the extraordinary health of this riparian system compared to wetlands elsewhere on the Nuweveld Escarpment is a baseline by which other riparian areas on this section of the Nuweveldberge can be measured. Unfortunately, this is the only healthy system encountered on this section of the Nuweveldberge, other sites having been largely eroded out, probably from decades of heavy grazing and trampling, and have been replaced by shrub-filled gullies.

For the remainder of the Nuweveld plateau, riparian systems range from having no riparian or hydrophilic vegetation to hosting dense stands of *Phragmites australis* and *Pseudoschoenus inanis* beds, both up to 3 m tall and often very dense and extensive (longer than 50 m). *Mentha longifolia* and *Cyperus marginatus* are usually abundant along all watercourses, wet or dry, and *Juncus inflexus* is also common in most riparian habitats. Riverbanks are regularly characterised by a shrubby community dominated by *Conyza scabra*, *Dicerothamnos rhinocerotis*, *Euryops annae*, *Penztia* spp. and *Stipagrostis namaquensis*. *Salix mucronata* subsp. *capensis* occurs occassionally, and the invasive aliens *Salix babylonica* and *Populus* x *canescens* are often common. Pools with regular standing water are characterised by *Juncus oxycarpus* and *J. exsertus*, and more rarely *Typha capensis* occurs. Damp areas along watercourses and in seeps are typified by *Agrostis lachnantha*, *Berula erecta* subsp. *thunbergii*, *Lobelia thermalis*, *Ranunculus multifidus*, *Pseudognaphalium luteo-album* and *Veronica anagallis-aquatica*. One watercourse on the Western Nuweveldberge had a local population of *Senecio erubescens* and *Scabiosa columbaria*, both species more typical of moist grassland to the east.

Cliff communities

Higher-altitude cliff communities in the Nuweveldberge are very similar to the cliff communities of the Roggeveld (see Chapter 5), and many of the same species occur in both of these sections of the Great Escarpment without interruption. *Cliffortia arborea*, although typically associated with the Roggeveld, is generally much more abundant in the Nuweveldberge. It can be found along the bases of most south-facing cliffs and on south-facing screes across the entire length of the Nuweveldberge. *Berkheya cardopatifolia* also dominates much of the south-facing cliffs, growing into large, cascading clumps several metres in extent. Other species shared between the Roggeveld and Nuweveld cliff communities are *Cromidon decumben*s, *Oxalis heterophylla*, *Selago rigida* and a new species of *Asparagus* (see Chapter 5). Several species more typical of the Sneeuberg and moister eastern Great Escarpment occur on the cliff-lines of the Eastern Nuweveldberge. Notable examples are *Asplenium trichomanes* subsp. *quadrivalens*, *Bupleurum mundii*, *Guthriea capensis*, *Heteromorpha arborescens* var. *arborescens* (interior form), *Senecio asperulus* and *Zaluzianskya ovata*. The cliffs are also the main habitat for numerous species found right along the southern Great Escarpment, notable examples being *Asplenium cordatum*, *Brachypodium bolusii*, *Cineraria aspera*, *C. mollis*, *Nemesia fruticans* (= *N. "foetens"*), *Sutera macrosiphon*, and *Urtica lobata*. The Great Escarpment cliff-line is thus suggested to provide an important comparatively mesic and shaded refugia or corridor for species on the Nuweveldberge (see Chapter 6).

4.2.6. Land-use and conservation

Prior to the arrival of Europeans, the Nuweveldberge was the domain of the San bushmen. The Nuweveld area was settled by Dutch farmers in the second half of the 1700s, the farm Hooyvlakte, where Beaufort West is now situated, being granted in 1760. These farmers came from the Roggeveld in the west, which was settled first (Schoeman, 1986). The Nuweveld has thus been under subsistence and commercial livestock farming for the past 250 years.

Limited crop agriculture occurs in some of the more fertile upland valleys, mostly being lucerne for livestock or subsistence crops for home use. More recent land-use activities include the ca. 75 000 Ha Karoo National Park (Rubin et al., 2001) and numerous private game farms. Threats to the natural heritage of the Nuweveldberge are overgrazing, invasive plants such as *Populus* x *canescens*, *Salix babylonica* var. *babylonica*, *Ailanthus altissima*, *Prosopis glandulosa* var. *glandulosa*, and *Atriplex* spp. (Henderson, 2001; Burgess et al., 2004). Some of these plants disrupt the hydrological cycle along watercourses (Burgess et al., 2004). There has been a renewed interest within the past two years in the uranium deposits in the Nuweveldberg (Verwoed et al., 1995; J. Van Wyk, pers. comm.), the possible mining of which may have devastating consequences for local fauna and flora.

4.2.7. Pioneer botanical work

The Karoo National Park has been well-collected since its proclamation in 1979, and has a flora of 864 taxa (Rubin et al., 2001). It is not certain how well collected the remainder of the Nuweveld is, nevertheless it appears to have been generally poorly collected, or studies undertaken have focused on specific genera or groups of plants. Known collectors are P.V. Bruyns, B. Gibbs Russell, P. Herman, H.W.R. Marloth, A.R. Palmer, B. Randall, R. Robinson, F. Rubin, D. Shearing, C. Stuart, C. Van Ginkel and E. Van Jaarsveld (Rubin and Palmer, 1996; Rubin et al., 2001; Van Jaarsveld, pers. comm.).

4.3. A Contribution to a flora of the Nuweveldberge

Four fieldtrips were undertaken between 2007 and 2009 (Table 4.1). Collecting focussed on the highest peaks and plateaux, but was also undertaken at lower altitudes in kloofs and on the Great Escarpment slopes. Mesic microhabitats such as vleis, stream-lines and south-facing cliff communities were intensively sampled. A total of 1 351 specimens was collected, and the species processed as for the Sneeuberg in Chapter 2. The species obtained from the fieldwork have been augmented in Appendix 4 by species noted from literature sources (mostly taxonomic revisions and treatments) and historical specimens in GRA where these have been encountered.

Table 4.1: Collecting localities in the Nuweveldberge during the study period (2007–2009).

Localities	Dates	Collectors	Grids
1. Banksgate (Aasvoëlkrans), Western Nuweveldberge.	September 2007.	Clark VR, Barker NP, Ramdhani S, Kelly C.	3221AC, 3221AD
2. Karoo National Park and surrounds, Eastern Nuweveldberge.	November 2007, March 2008.	Clark VR, Ngcobo L, Walton S; Clark VR, Cerros R.	3222AB, AD, BA, BC
4. Teekloof Pass and environs, Central Nuweveldberge.	October 2008.	Clark VR, Coombs G.	3221BA
5. Oukloof, Klipkraal-se-berg, Steenkampsberg and environs, and Aasvoëlkrans, Bontberg and Dwyka River Gorge and environs, Central and Western Nuweveldberge.	March 2009.	Clark VR, Midgley J.	3221AC, AD, BA, BB

The fieldwork has resulted in a flora of 450 species (Appendix 4). Appendix 4 together with the list of Rubin et al. (2001) for the Karoo National Park provides a flora of the Nuweveldberge totalling 1 116 taxa. This is considered to be representative of the flora of the Nuweveldberge. Such a flora will be useful for biogeographical analysis (Born et al., 2007, and Chapter 6) and conservation assessments.

The richness of the Nuweveldberge flora is due largely to the extensive previous botanical work in the Karoo National Park compared to elsewhere in the Nuweveldberge. The Park also represents the most intact habitat for most of the vegetation types in the Nuweveldberge, given the exclusion of livestock grazing for several decades. This is particularly true for the species-rich grasslands in the Eastern Nuweveldberge, which – together with montane wetlands – are most well-preserved in the Park. The representation of the flora of the Park in the Nuweveldberge flora is thus high, supplying 666 taxa not collected on the remainder of the Nuweveldberge to date. This may be offset by more intensive future sampling in the rest of the Nuweveldberge.

4.4. Important collections

Noteworthy range extensions are detailed in Table 4.2. Of particular interest is the westward range extension of four species (*Ficinia compasbergensis*, *Helichrysum tysonii*, *Lessertia sneeuwbergensis* and *Ruschia complanata*) previously considered by Clark et al. (2009) to be Sneeuberg endemics. What is interesting is that they are not confined to the Eastern Nuweveldberge, as would be expected,

Table 4.2: Range extensions and noteworthy collections on the Nuweveldberge. Species previously considered Sneeuberg endemics are detailed in Table 2.3 in Chapter 2.

Species	Family	Notes	References
Anthospermum monticola Puff	Rubiaceae	A DAC near-endemic. Now also known from the Nuweveldberge and as far west as Sneeukrans on the Roggeveldberge.	Carbutt and Edwards, 2006; Clark et al., 2009; Retief, pers. comm.
Cineraria geraniifolia DC.	Asteraceae	A DAC near-endemic. Now also known from the Western Nuweveldberge.	Carbutt and Edwards, 2006; Clark et al., 2009; Cron, pers. comm.
Cysticapnos pruinosa (Bernh.) Lidén	Fumariaceae	Known from the eastern Great Escarpment as far west as the Sneeuberg. Now also known from the Eastern Nuweveldberge.	Clark et al. 2009; Manning et al., 2009.
Delosperma brevisepalum L.Bolus	Mesembryanthemaceae	Known from the Sneeuberg, now also known from the Eastern and Central Nuweveldberge.	Hartmann, 2001a; Clark et al., 2009; Burgoyne, pers. comm.
Delosperma concavum L.Bolus	Mesembryanthemaceae	Previously only known from the Sneeuberg. Now also known from the Eastern Nuweveldberge.	Hartmann, 2001a; Clark et al., 2009; Burgoyne, pers. comm.
Delosperma lootsbergense Lavis	Mesembryanthemaceae	Known from the DAC to the Sneeuberg, now also known from the Eastern and Western Nuweveldberge.	Hartmann, 2001a; Clark et al., 2009; Burgoyne, pers. comm.
Delosperma multiflorum L.Bolus	Mesembryanthemaceae	Distribution recorded as Hankey in the Eastern Cape by Hartmann (2001a). Now known from the Eastern and Central Nuweveldberge.	Hartmann, 2001a; Burgoyne, pers. comm.
Ehrharta longigluma C.E.Hubb.	Poaceae	Known from the DAC to the Sneeuberg. Now also known from the Eastern Nuweveldberge.	Carbutt and Edwards, 2006; Clark et al., 2009; Fish, pers. comm.
Euryops annae E.Phillips	Asteraceae	Known from the DAC to the Sneeuberg. Now also known from the entire Nuweveldberge.	Nordenstam, 1969; Rubin and Palmer, 1996; Nordenstam, pers. comm.
Isolepis angelica B.L.Burtt	Cyperaceae	Considered to be a DAC and Sneeuberg endemic. Now also known from across the Nuweveldberge.	Carbutt and Edwards, 2006; Clark et al., 2009; Muasya, pers. comm.
Jamesbrittenia filicaulis (Benth.) Hilliard	Scrophulariaceae	A DAC near-endemic. Now also known from the Eastern Nuweveldberge.	Hilliard, 1994.
Kniphofia stricta Codd	Asphodelaceae	A DAC near-endemic. Now also known from the Eastern Nuweveldberge.	Codd, 1968; Carbutt and Edwards, 2006; Clark et al., 2009.
Kniphofia triangularis Kunth	Asphodelaceae	A DAC near-endemic. Now also known from the Eastern Nuweveldberge.	Codd, 1968; Carbutt and Edwards, 2006; Clark et al., 2009.

Lotononis caerulescens (E.Mey.) B.-E.van Wyk	Fabaceae	Endemic to the Sneeuberg, Great Winterberg–Amatolas and Stormberg. Now also known from the Eastern Nuweveldberge.	Van Wyk, 1988, 1991.
Lotononis decumbens (Thunb.) B.-E.van Wyk subsp. *decumbens*	Fabaceae	Known from the Albany Region and the Koudeveldberge in the Sneeuberg. Now also known from the Eastern Nuweveldberge.	Van Wyk, 1991; Clark et al., 2009; Boatwright, pers. comm.
Malephora crocea (Jacq.) Schwantes	Mesembryanthemaceae	Apparently a virtually unknown species, according to Hartmann (2001b). Collected on the flats inland of Oukloof Pass on the road to Fraserburg, in Roggeveld Karoo.	Hartmann, 2001b; Burgoyne, pers. comm.
Pentzia tortuosa (DC.) Fenzl ex Harv.	Asteraceae	Considered to be a DAC endemic by Carbutt and Edwards (2006), but also known from the Sneeuberg (Clark et al., 2009). Now also known from the Nuweveldberge.	Carbutt and Edwards, 2006; Clark et al., 2009.
Ruschia grisea (L.Bolus) Schwantes	Mesembryanthemaceae	Ecology and distribution unknown, according to Hartmann (2001b). Now known from the Central Nuweveldberge.	Hartmann, 2001b; Burgoyne, pers. comm.
Stachys dregeana Benth.	Lamiaceae	A DAC near-endemic. Now also known from the Eastern Nuweveldberge.	Codd, 1985; Carbutt and Edwards, 2006; Clark et al., 2009.
Stomatium duthiae L.Bolus	Mesembryanthemaceae	Common on the Sneeuberg. Now also known from the Eastern Nuweveldberge.	Hartmann, 2001b; Clark et al., 2009.
Trichodiadema pomeridianum L.Bolus	Mesembryanthemaceae	Distribution recorded as Fauresmith in the Free State by Hartmann (2001b). Also known from the Sneeuberg (Clark et al., 2009), and now also from the Central and Western Nuweveldberge.	Hartmann, 2001b; Clark et al., 2009; Burgoyne, pers. comm.
Trichodiadema setuliferum (N.E.Br.) Schwantes	Mesembryanthemaceae	Distribution recorded as "Somerset East?" by Hartmann (2001b). Now also known from the Eastern Nuweveldberge and from the Roggeveld.	Hartmann, 2001b; Burgoyne, pers. comm.; see also Chapter 5.

but occur right across the Nuweveldberge – *Ficinia compasbergensis* for instance has so far only been collected on the Western Nuweveldberge.

Ehrharta longigluma, *Isolepis angelica* and *Pentzia tortuosa* – considered by Carbutt & Edwards (2006) to be DAC endemics and found by Clark et al. (2009) to also occur on the Sneeuberg (see Chapter 2) – have now also been found on the Eastern Nuweveldberge. In addition, several range extensions of DAC near-endemics (as per Carbutt and Edwards, 2006) are also now known from the Nuweveldberge, notably *Anthospermum monticola*, *Cysticapnos pruinosa*, *Jamesbrittenia filicaulis*, *Kniphofia stricta*, *K. triangularis*, *Stachys dregeana* and *S. linearis* (Table 4.2). This brings the total of known DAC near-endemics on the Nuweveldberge to 19 species (see Table 2.5 in Chapter 2).

Other interesting range extensions and collections are *Stomatium duthiae*, *Delosperma brevisepalum* and *D. concavum* (known from the Sneeuberg, although not listed as endemic to it; Clark et al., 2009) onto the Nuweveldberge, and *D. lootsbergense*, a range extension onto the Nuweveldberge from the Witteberg and Sneeuberg (Clark et al., 2009; Burgoyne, pers. comm.). *Malephora crocea* – for which fruit, ecology and distribution are listed as unknown by Hartmann, 2001b – was collected between the Nuweveld Escarpment (Oukloof Pass) and Fraserburg. *Trichodiadema pomeridianum* is a range extension from Fauresmith in the Free State (Hartmann, 2001b) through the Sneeuberg (Clark et al., 2009) to the western Nuweveldberge, while *T. setuliferum* (with distribution listed as "*Somerset East?*" by Hartmann, 2001b) is now known from the Eastern Nuweveldberge and also from the Roggeveld (see Chapter 5). *Lotononis caerulescens*, previously considered endemic to the Sneeuberg, Great Winterberg–Amatolas and Stormberg (Van Wyk, 1991), is now also known from the Eastern Nuweveldberge (see Table 2.3 in Chapter 2).

4.5. Centres of endemism, endemism and biogeographical connections

4.5.1. Centres of endemism

Nordenstam (1969) and Hilliard (1994) considered the entire stretch of Great Escarpment from the Hantamberge through to Beaufort West as one phytogeographical centre, re. the "Western Upper Karroo Centre". This is similar to Hilton-Taylor's (1987) "Western Mountain Karoo, Hamtam Mountains and Nuiweveld" preliminary phytogeographical centre, although he separates the Roggeveld out as a separate centre. Current thinking is of a HRC as part of the Succulent Karoo Biome terminating at Teekloof Pass (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006) – thus dividing the Nuweveldberge into an HRC (Succulent Karoo-dominated) component in the west and central, and an eastern (grassland-dominated) component. Geomorphological continuity with the

Roggeveldberge is clearly an important factor for numerous HRC-centred endemics (e.g. *Cliffortia arborea*) as well as numerous other species that occur along the Nuweveldberge from the Roggeveld. The HRC is discussed in detail in Chapter 5.

4.5.2. Endemism

Unlike the Sneeuberg and the Hantam–Roggeveldberge, the Nuweveldberge has very few of its own plant and faunal endemics. Only six plant species appear to be endemic to the Nuweveldberge (Table 4.3), compared to the 28 Sneeuberg endemics (Clark et al., 2009; see Table 2.2 in Chapter 2) and the 204 HRC endemics (see Appendix 5.1 in Chapter 5). Further fieldwork by botanists in the Nuweveldberge may bring more new endemics to light however. The Nuweveldberge shares five endemics with the Sneeuberg (see Table 2.3 in Chapter 2) and 15 endemics with the Hantam–Roggeveld (See Appendix 5.1 in Chapter 5).

Table 4.3: Plant species endemic to the Nuweveldberge.

Species	Family	Notes	References
Adromischus humilis (Marl.) V.Poelln.	Crassulaceae	Collected twice by Marloth – since recollected by E. Van Jaarsveld. In the Karoo National Park list of Rubin et al. (2001). Appears to be a Nuweveldberg endemic.	Tölken, 1978; Van Jaarsveld, pers. comm.
Androcymbium karooparkense U.Müll.-Doblies, J.M.Anderson & D.Müll.-Doblies	Colchicaceae	Nuweveldberge in the Karoo National Park. Endemic.	Müller-Doblies and Müller-Doblies, 2002.
Lotononis azureoides B.-E.van Wyk	Fabaceae	Summit of the Eastern Nuweveldberge. Endemic.	Van Wyk, 1991.
Pteronia aspalatha DC.	Asteraceae	Roggeveld Karoo, Fraserburg area. Very poorly known. Endemic? Specimen from William Burchell (s.n.) on Aluka.	De Candolle, 1836; Mucina and Rutherford, 2006; Lowrey, pers. comm.
Ruschia beaufortensis L.Bolus	Mesembryanthemaceae	Nuweveldberge at Beaufort West. Endemic.	Bolus, 1934; Hartmann, 2001b.
Ruschia dejagerae L.Bolus	Mesembryanthemaceae	Cited for Beaufort West by Hartmann (2001b). Collected on Klipkraal-se-berg in 2009. Appears to be a Nuweveldberg endemic.	Hartmann, 2001b; Burgoyne, pers. comm.

Faunal endemics are also limited, with only two Nuweveldberge endemic reptiles: *Goggia braacki* (Braack's Dwarf Leaf-toed Gecko), restricted to dolerite outcrops in *Merxmuellera disticha* grassland above 1 900 m on the Eastern Nuweveldberge, and *Cordylus cloetei* (Cloete's Girdled Lizard), endemic to sandstone outcrops in *Themeda triandra* grassland in the Nuweveldberge near Fraserburg (Branch, 1998). One reptile is shared with the Roggeveldberge (*Pseudocordylus microlepidotus namaquensis*, Cape Crag Lizard; Branch, 1998). No endemic butterflies occur on the Nuweveldberge but three are shared with the Hantam–Roggeveld (Woodhall, 1995; see Chapter 5).

The Nuweveldberge appears thus to be a spill-over or "tail-end" area for endemics centred in the Roggeveld and Sneeuberg, with species representatives from both these mountain ranges overlapping across the Nuweveldberge. The reason for low endemicity could be the unreliable rainfall, compared to the comparatively regular winter rainfall on the Hantam–Roggeveldberge and the higher summer rainfall on the Sneeuberg. This is explored further in Chapter 6.

4.5.3. Biogeographical Connections

a) The Great Escarpment Track

Connectivity along the southern Great Escarpment is evident from species such as *Aspalathus acicularis* subsp. *acicularis*, *Asparagus ferox*, *Cliffortia ramosissima*, *Dianthus micropetalus*, *Eriocephalus eximius*, *Helichrysum trilineatum*, *Moraea unguiculata* and *Muraltia macrocarpa*, which occur from the Roggeveld across to the Sneeuberg, Great Winterberg–Amatolas and or DAC (Levyns, 1954; Hooper, 1959; Hilliard, 1983; Dahlgren, 1988; Goldblatt and Manning, 1998; Müller et al., 2001; Whitehouse, 2002; S. Burrows, pers. comm.). Many of these southern Great Escarpment species are confined to the Great Escarpment itself or to the highest points along the Great Escarpment. Some species, such as *Lotononis fruticoides* (Van Wyk, 1990a, 1991) and faunal species such as *Tetradactylus tetradactylus* (Common Long-tailed Seps; Branch, 1998) and the snail *Prestonella bowkeri* (Herbert, 2006) are restricted to the Nuweveldberge and the Sneeuberg, while others (more so) are restricted to the Hantam–Roggeveld and Nuweveldberge (see Chapter 5).

Of particular interest is the westward range extension of the four Sneeuberg endemics onto the Nuweveldberge. Although this weakens the notion of the Sneeuberg Centre of Endemism, it lends weight to the southern Great Escarpment track hypothesis (see Chapter 6), particularly as these species occur right across the Nuweveldberge and not only on the Eastern section. The 19 DAC near-endemics of Carbutt and Edwards's (2006) now known from the Nuweveldberg also support this.

All of the above downplays the biogeographical significance of the Nelspoort Interval, and it is possible that the Interval is more an effect of climate filtering than of geomorphological disjunction. The current aridity of the Nuweveldberge probably limits its usefulness as a montane corridor in the present climatic regime, and the ephemeral nature of the rainfall renders mesic refugia less tenable than in the Sneeuberg. It may have been that during the LGM the Nuweveldberge would have been a much wetter section of the southern Great Escarpment given its prime position to harvest moisture from increased and more intense frontal systems, and consequently facilitated the eastward expansion of Roggeveld and CFR species along the Great Escarpment. The reverse may also be true during the warmer, moister times in the Holocene, when a westward and southward movement of the summer rainfall regime may have facilitated the westward expansion of moister eastern species along the Nuweveldberge. The current grassland outlier on the Eastern Nuweveldberge may be a tenacious legacy from this time. The effect of climate on the connectivity role of the Nuweveldberge is considered in detail in Chapter 6.

b) Connections between the Nuweveldberge and the CFR

There are many examples of species which occur on the inland Cape Fold Ranges (Weimarck's Karoo Mountain (KM) Centre, which includes the Witteberg and Klein- and Groot-Swartberge) and on the Roggeveld–Komsberg, indicating a link across the Karoo Interval via the Klein-Roggeveldberge (the Matjiesfontein connection). There are also examples of species that occur on these inland Cape Fold Ranges and on the Nuweveldberge, e.g. *Lobostemon stachydeus* (Weimarck, 1941 – and east to the Kamdebooberge behind Aberdeen) and *Rosenia spinescens* (Bremer, 1976). A faunal parallel of this distribution is represented by *Pachydactylus kladeroderma* (Thin-skinned Thick-toed Gecko; Branch, 1998).

Some species occur widely in the CFR and along much of the southern Great Escarpment. Examples are *Euryops imbricatus*, *E. microphyllus* and *E. oligoglossus* (Nordenstam, 1969). Nordenstam (1969) considers these species as possible representatives of an important migration route in the past. Other examples are *Cliffortia ramosissima* and *Ischyrolepis laniger* (Weimarck, 1941), although no Restionaceae were encountered on the Nuweveldberge during this study. Clark et al. (2009) postulated that the Nuweveldberge may have been a feeder of CFR species eastward onto the Sneeuberg (from the Swartberg via the Komsberg), but – as for Great Escarpment connections discussed above – the Nuweveldberge are now too arid to facilitate the movement of Cape species or to retain any indication of their past presence on the Nuweveldberge.

4.6. Conclusion

The low endemism (0.5%) on the Nuweveldberge – despite geological substrate being identical to the Sneeuberg and its geomorphological connectivity with the endemic-rich Roggeveldberge – begs some questions. This is particularly so as the Nuweveldberge has a comparable species count to the Sneeuberg, suggesting that under-collection is not responsible for this low endemism. This low endemism is most likely a consequence of the aridification of the Nuweveldberge since the LGM (explored in depth in Chapter 6). Despite the low levels of local endemism on the Nuweveldberge, there is strong support for connectivity along the southern Great Escarpment through the Nuweveldberge, particularly in terms of the 15 shared endemics with the Hantam–Roggeveldberge, five with the Sneeuberg, and the 19 DAC near-endemics now known from across the Nuweveldberge.

Appendix 4: A contribution to the flora of the Nuweveldberge.

Family	Species	Collectors/References
Pteridophytes		
Aspleniaceae	*Asplenium adiantum-nigrum* L. var. *adiantum-nigrum*	Clark VR, Barker NP, Ramdhani S, Kelly C 110
Aspleniaceae	*Asplenium cordatum* (Thunb.) Sw.	Clark VR, Barker NP, Ramdhani S, Kelly C 100
Aspleniaceae	*Asplenium trichomanes* subsp. *quadrivalens* D.E.Mey.	Clark VR, Ngcobo L, Walton S 128
Pteridaceae	*Adiantum capillus-veneris* L.	Clark VR, Ngcobo L, Walton S 167
Pteridaceae	*Cheilanthes eckloniana* (Kunze) Mett.	Clark VR, Ngcobo L, Walton S 98.3
Pteridaceae	*Cheilanthes hastata* (L.f.) Kunze	Clark VR, Barker NP, Ramdhani S, Kelly C 109
Pteridaceae	*Cheilanthes induta* Kunze	Clark VR, Barker NP, Ramdhani S, Kelly C 90
Pteridaceae	*Cheilanthes multifida* (Sw.) Sw.	Clark VR, Midgley J 208
Pteridaceae	*Cheilanthes quadripinnata* (Forssk.) Kuhn	Clark VR, Ngcobo L, Walton S 62
Pteridaceae	*Pellaea rufa* A.F.Tryon	Clark VR, Ngcobo L, Walton S 4
Polypodiaceae	*Polypodium vulgare* L.	Clark VR, Ngcobo L, Walton S 121
Monocotyledons		
Alliaceae	*Tulbaghia acutiloba* Harv.	Clark VR, Cerros R 404
Amaryllidaceae	*Gethyllis longistyla* Bolus	Clark VR, Cerros R 273
Amaryllidaceae	*Nerine humilis* (Jacq.) Herb.	Clark VR, Midgley J 397
Asparagaceae	*Asparagus capensis* L. var. *capensis*	Clark VR, Midgley J 315
Asparagaceae	*Asparagus* cf. *concinnus* (Baker) Kies (S. Burrows, pers. comm.)	Clark VR, Cerros R 581
Asparagaceae	*Asparagus exuvialis* Burch.	Clark VR, Ngcobo L, Walton S 162
Asparagaceae	*Asparagus ferox* MS S.M.Burrows	Clark VR, Barker NP, Ramdhani S, Kelly C 5
Asparagaceae	*Asparagus microraphis* (Kunth) Baker	Clark VR, Cerros R 271
Asparagaceae	*Asparagus mucronatus* Jessop	Clark VR, Midgley J 389
Asparagaceae	*Asparagus retrofractus* L.	Clark VR, Midgley J 153
Asparagaceae	*Asparagus occimontanus* MS S.M.Burrows (S. Burrows, pers. comm.)	Clark VR, Barker NP, Ramdhani S, Kelly C 91
Asparagaceae	*Asparagus striatus* (L.f.) Thunb.	Clark VR, Midgley J 189
Asparagaceae	*Asparagus* cf. *suaveolens* Burch. (S. Burrows, pers. comm.)	Clark VR, Cerros R 272
Asparagaceae	*Asparagus volubilis* Thunb.	Clark VR, Midgley J 217
Asphodelaceae	*Aloe aristata* Haw.	Clark VR, Barker NP, Ramdhani S, Kelly C 106
Asphodelaceae	*Bulbine abyssinica* A.Rich.	Clark VR, Cerros R 153
Asphodelaceae	*Bulbine asphodeloides* (L.) Spreng.	Clark VR, Midgley J 132
Asphodelaceae	*Bulbine frutescens* (L.) Willd.	Clark VR, Midgley J 200
Asphodelaceae	*Bulbine narcissifolia* Salm-Dyck	Clark VR, Ngcobo L, Walton S 30
Asphodelaceae	*Haworthia marumiana* Uitewaal	Clark VR, Ngcobo L, Walton S 144
Asphodelaceae	*Kniphofia stricta* Codd	Clark VR, Cerros R 57, 296
Asphodelaceae	*Kniphofia triangularis* Kunth	Clark VR, Ngcobo L, Walton S 88
Colchicaceae	*Androcymbium karooparkense* U.Müll.-Doblies, J.M.Anderson & D.Müll.-Doblies	Müller-Doblies and Müller-Doblies, 2002
Colchicaceae	*Androcymbium striatum* A.Rich.	Clark VR, Cerros R 101, 309
Cyperaceae	*Bulbostylis humilis* (Kunth) C.B.Clarke	Clark VR, Cerros R 444
Cyperaceae	*Carex cognata* Kunth var. *cognata*	Clark VR, Cerros R 539
Cyperaceae	*Carex glomerabilis* Krecz.	Clark VR, Cerros R 553
Cyperaceae	*Cyperus longus* L.	Clark VR, Cerros R 483
Cyperaceae	*Cyperus marginatus* Thunb.	Clark VR, Cerros R 546
Cyperaceae	*Cyperus usitatus* Burch.	Clark VR, Cerros R 258
Cyperaceae	*Ficinia compasbergensis* Drège	Clark VR, Barker NP, Ramdhani S, Kelly C 138
Cyperaceae	*Ficinia ramosissima* Kunth	Clark VR, Ngcobo L, Walton S 18
Cyperaceae	*Fuirena coerulescens* Steud.	Clark VR, Cerros R 505
Cyperaceae	*Isolepis angelica* B.L.Burtt	Clark VR, Cerros R 433

Cyperaceae	*Isolepis cernua* (Vahl) Roem. & Schult. var. *cernua*	Clark VR, Cerros R 25a
Cyperaceae	*Isolepis costata* A.Rich.	Clark VR, Midgley J 260
Cyperaceae	*Isolepis karroica* (C.B.Clarke) J.Raynal	Clark VR, Midgley J 229
Cyperaceae	*Isolepis setacea* (L.) R.Br.	Clark VR, Cerros R 556
Cyperaceae	*Pseudoschoenus inanis* (Thunb.) Oteng-Yeb.	Clark VR, Barker NP, Ramdhani S, Kelly C 162
Cyperaceae	*Scirpoides dioecus* (Kunth) Browning	Clark VR, Cerros R 590
Cyperaceae	*Schoenoplectus muricinux* (C.B.Clarke) J.Raynal	Clark VR, Cerros R 193
Cyperaceae	*Schoenoxiphium lanceum* (Thunb.) Kük.	Clark VR, Cerros R 374
Cyperaceae	*Schoenoxiphium sparteum* (Wahlenb.) C.B.Clarke	Clark VR, Cerros R 567
Hyacinthaceae	*Albuca maxima* Burm.f.	Clark VR, Barker NP, Ramdhani S, Kelly C 153
Hyacinthaceae	*Albuca setosa* Jacq.	Clark VR, Cerros R 592
Hyacinthaceae	*Albuca spiralis* L.f.	Clark VR, Barker NP, Ramdhani S, Kelly C 116
Hyacinthaceae	*Dipcadi brevifolium* (Thunb.) Fourc.	Clark VR, Barker NP, Ramdhani S, Kelly C 117
Hyacinthaceae	*Lachenalia campanulata* Baker	Clark VR, Ngcobo L, Walton S 50
Hyacinthaceae	*Massonia depressa* Houtt.	Clark VR, Barker NP, Ramdhani S, Kelly C 113
Hyacinthaceae	*Ornithogalum* sp. aff. *sauveolens* (Manning, pers. comm.)	Clark VR, Ngcobo L, Walton S 98
Hyacinthaceae	*Ornithogalum* sp. aff. *flexuosum* (Thunb.) U. & D. Müller-Doblies (Snijman, pers. comm.)	Clark VR, Cerros R 21
Hyacinthaceae	*Veltheimia capensis* (L.) DC.	Clark VR, Midgley J 398
Hypoxidaceae	*Empodium elongatum* (Nel) B.L.Burtt	Clark VR, Cerros R 345, 400
Iridaceae	*Hesperantha bachmannii* Baker	Clark VR, Ngcobo L, Walton S 110
Iridaceae	*Moraea unguiculata* Ker Gawl.	Clark VR, Cerros R 134
Juncaceae	*Juncus dregeanus* Kunth subsp. *dregeanus*	Clark VR, Cerros R 528
Juncaceae	*Juncus exsertus* Buchenau subsp. *exsertus*	Clark VR, Cerros R 555
Juncaceae	*Juncus inflexus* L.	Clark VR, Cerros R 103
Juncaceae	*Juncus oxycarpus* E.Mey. ex Kunth	Clark VR, Cerros R 588
Poaceae	*Agrostis lachnantha* Nees	Clark VR, Ngcobo L, Walton S 11
Poaceae	*Aristida adscensionis* L.	Clark VR, Cerros R 520
Poaceae	*Aristida congesta* Roem. & Schult. subsp. *congesta*	Clark VR, Cerros R 474
Poaceae	*Aristida diffusa* subsp. *burkei* (Stapf) Melderis	Clark VR, Cerros R 246
Poaceae	*Brachypodium bolusii* Stapf	Clark VR, Cerros R 54
Poaceae	*Bromus catharticus* Vahl*	Clark VR, Ngcobo L, Walton S 29
Poaceae	*Bromus pectinatus* Thunb.	Clark VR, Cerros R 424
Poaceae	*Bromus tectorum* L.*	Clark VR, Barker NP, Ramdhani S, Kelly C 104
Poaceae	*Cenchrus ciliaris* L.	Clark VR, Midgley J 38
Poaceae	*Chaetobromus involucratus* subsp. *dregeanus* (Nees) Verboom	Clark VR, Barker NP, Ramdhani S, Kelly C 144
Poaceae	*Chloris virgata* Swartz	Clark VR, Cerros R 15
Poaceae	*Cynodon incompletus* Nees	Clark VR, Cerros R 521
Poaceae	*Digitaria eriantha* Steud.	Clark VR, Cerros R 13
Poaceae	*Ehrharta calycina* J.E.Sm.	Clark VR, Barker NP, Ramdhani S, Kelly C 48
Poaceae	*Ehrharta erecta* Lam. var. *erecta*	Clark VR, Ngcobo L, Walton S 164
Poaceae	*Ehrharta longigluma* C.E.Hubb.	Clark VR, Cerros R 380
Poaceae	*Enneapogon scoparius* Stapf	Clark VR, Cerros R 425
Poaceae	*Eragrostis lehmanniana* Nees var. *lehmanniana*	Clark VR, Cerros R 524
Poaceae	*Eragrostis obtusa* Munro ex Fical. & Hiern	Clark VR, Cerros R 460
Poaceae	*Eragrostis procumbens* Nees	Clark VR, Cerros R 501
Poaceae	*Festuca scabra* Vahl	Clark VR, Cerros R 463
Poaceae	*Fingerhuthia africana* Lehm.	Clark VR, Ngcobo L, Walton S 10
Poaceae	*Fingerhuthia sesleriiformis* Nees	Clark VR, Cerros R 300
Poaceae	*Helictotrichon hirtulum* (Steud.) Schweick.	Clark VR, Cerros R 215
Poaceae	*Helictotrichon turgidulum* (Stapf) Schweick.	Clark VR, Cerros R 560
Poaceae	*Heteropogon contortus* (L.) Beauverd ex Roem. & Schult.	Clark VR, Midgley J 20
Poaceae	*Hyparrhenia hirta* (L.) Stapf.	Clark VR, Cerros R 470
Poaceae	*Karroochloa purpurea* (L.f.) Conert & Tuerpe	Clark VR, Ngcobo L, Walton S 64

Poaceae	*Melica decumbens* Thunb.	Clark VR, Cerros R 31
Poaceae	*Melica racemosa* Thunb.	Clark VR, Cerros R 52
Poaceae	*Merxmuellera disticha* (Nees) Conert	Clark VR, Cerros R 256
Poaceae	*Merxmuellera dura* (Stapf) Conert	Clark VR, Barker NP, Ramdhani S, Kelly C 85
Poaceae	*Merxmuellera stricta* (Schrad.) Conert	Clark VR, Ngcobo L, Walton S 24
Poaceae	*Pennisetum sphacelatum* (Nees) Dur. & Schinz	Clark VR, Cerros R 561
Poaceae	*Pentaschistis airoides* (Nees) Stapf subsp. *airoides*	Clark VR, Barker NP, Ramdhani S, Kelly C 103
Poaceae	*Pentaschistis glandulosa* (Schrad.) H.P.Linder	Clark VR, Cerros R 42
Poaceae	*Pentaschistis setifolia* (Thunb.) McClean	Clark VR, Cerros R 295
Poaceae	*Phragmites australis* subsp. *altissimus* (Benth.) Clayton	Clark VR, Cerros R 496
Poaceae	*Polypogon monspeliensis* (L.) Desf.*	Clark VR, Cerros R 527
Poaceae	*Polypogon viridis* (Gouan) Breistr.*	Clark VR, Cerros R 11
Poaceae	*Schismus barbatus* (Loefl. ex L.) Thell.	Clark VR, Barker NP, Ramdhani S, Kelly C 28
Poaceae	*Schismus scaberrimus* Nees	Clark VR, Barker NP, Ramdhani S, Kelly C 47
Poaceae	*Stipagrostis namaquensis* (Nees) De Winter	Clark VR, Cerros R 466
Poaceae	*Stipagrostis obtusa* (Del.) Nees	Clark VR, Cerros R 519
Poaceae	*Tetrachne dregei* Nees	Clark VR, Cerros R 106
Poaceae	*Themeda triandra* Forssk.	Clark VR, Cerros R 149
Potamogetonaceae	*Potamogeton pusillus* L.	Clark VR, Cerros R 551
Typhaceae	*Typha capensis* (Rohrb.) N.E.Br.	Clark VR, Midgley J 345

Dicotyledons

Achariaceae	*Guthriea capensis* H.Bolus	Clark VR, Cerros R 564
Aizoaceae	*Galenia procumbens* L.f.	Clark VR, Midgley J 170
Aizoaceae	*Tetragonia spicata* L.f.	Clark VR, Midgley J 113
Anacardiaceae	*Searsia burchellii* (Sond. ex Engl.) Moffett	Clark VR, Barker NP, Ramdhani S, Kelly C 11
Anacardiaceae	*Searsia dregeana* (Sond.) Moffett	Clark VR, Ngcobo L, Walton S 172
Anacardiaceae	*Searsia lancea* (L.f.) F.A.Barkley	Clark VR, Barker NP, Ramdhani S, Kelly C 168
Anacardiaceae	*Searsia pyroides* (Burch.) Moffett var. *pyroides*	Clark VR, Ngcobo L, Walton S 170
Apiaceae	*Berula erecta* subsp. *thunbergii* (DC.) B.L.Burtt	Clark VR, Cerros R 142
Apiaceae	*Bupleurum mundii* Cham. & Schltdl.	Clark VR, Cerros R 406
Apiaceae	*Chamarea longipedicellata* B.L.Burtt	Clark VR, Cerros R 216
Apiaceae	*Conium chaerophylloides* (Thunb.) Sond.	Clark VR, Barker NP, Ramdhani S, Kelly C 123
Apiaceae	*Conium sphaerocarpum* Hilliard & B.L.Burtt	Clark VR, Cerros R 533
Apiaceae	*Dasispermum humile* (Meisn.) Magee & B.-E.van Wyk	Clark VR, Ngcobo L, Walton S 102
Apiaceae	*Deverra burchellii* (DC.) Eckl. & Zeyh.	Clark VR, Cerros R 504
Apiaceae	*Deverra denudata* subsp. *aphylla* (Cham. & Schltdl.) Pfisterer & Podlech	Clark VR, Midgley J 93
Apiaceae	*Heteromorpha arborescens* (Spreng.) Cham. & Schltdl. var. *arborescens* (interior form)	Clark VR, Cerros R 5, 568
Apiaceae	*Notobubon laevigatum* (Aiton) A.R.Magee	Clark VR, Ngcobo L, Walton S 148
Apocynaceae	*Carissa haematocarpa* (Eckl.) A.DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 18
Apocynaceae	*Huernia humilis* (Masson) Haw.	Bruyns, 2005
Apocynaceae	*Pectinaria longipes* (N.E.Br.) Bruyns subsp. *longipes*	Bruyns, 2005
Apocynaceae	*Xysmalobium gomphocarpoides* cf. (E.Mey.) D.Dietr. var. *gomphocarpoides* (Bester, pers. comm.)	Clark VR, Cerros R 234
Asteraceae	*Amellus strigosus* (Thunb.) Less.	Clark VR, Ngcobo L, Walton S 52
Asteraceae	*Amellus tridactylus* DC. subsp. *tridactylus*	Clark VR, Cerros R 72
Asteraceae	*Arctotis arctotoides* (L.f.) O.Hoffm.	Clark VR, Barker NP, Ramdhani S, Kelly C 45
Asteraceae	*Arctotis diffusa* Thunb.	Clark VR, Cerros R 362
Asteraceae	*Artemisia afra* Jacq. ex Willd. var. *afra*	Clark VR, Cerros R 477
Asteraceae	*Berkheya cardopatifolia* (DC.) Roessler	Clark VR, Barker NP, Ramdhani S, Kelly C 41
Asteraceae	*Berkheya carlinifolia* (DC.) Roessler	Clark VR, Cerros R 152
Asteraceae	*Berkheya onobromoides* (DC.) O.Hoffm. & Muschl.	Clark VR, Ngcobo L, Walton S 6
Asteraceae	*Chrysocoma ciliata* L.	Clark VR, Barker NP, Ramdhani S, Kelly C 34

Asteraceae	*Cichorium intybus* L. subsp. *intybus**	Clark VR, Cerros R 594
Asteraceae	*Cineraria* cf. *albicans* N.E.Br. (Cron, pers. comm.)	Clark VR, Barker NP, Ramdhani S, Kelly C 87
Asteraceae	*Cineraria aspera* Thunb.	Clark VR, Barker NP, Ramdhani S, Kelly C 141
Asteraceae	*Cineraria geraniifolia* DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 42
Asteraceae	*Cineraria mollis* E.Mey. ex DC.	Clark VR, Ngcobo L, Walton S 112
Asteraceae	*Cirsium vulgare* (Savi) Ten.*	Clark VR, Cerros R 108
Asteraceae	*Conyza pinnata* (L.f.) Kuntze	Clark VR, Cerros R 544
Asteraceae	*Conyza scabrida* DC.	Clark VR, Midgley J 51
Asteraceae	*Cotula coronopifolia* L.	Clark VR, Cerros R 151
Asteraceae	*Dicerothamnus rhinocerotis* (L.f.) Koekemoer	Clark VR, Barker NP, Ramdhani S, Kelly C 1
Asteraceae	*Dicoma spinosa* (L.) Druce	Clark VR, Midgley J 416
Asteraceae	*Dimorphotheca cuneata* (Thunb.) Less.	Clark VR, Barker NP, Ramdhani S, Kelly C 143
Asteraceae	*Eriocephalus ericoides* (L.f.) Druce subsp. *ericoides*	Clark VR, Barker NP, Ramdhani S, Kelly C 14
Asteraceae	*Euryops annae* E.Phillips	Clark VR, Barker NP, Ramdhani S, Kelly C 26
Asteraceae	*Euryops imbricatus* (Thunb.) DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 21
Asteraceae	*Euryops lateriflorus* (L.f.) DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 58
Asteraceae	*Euryops multifidus* (Thunb.) DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 13
Asteraceae	*Euryops nodosus* B.Nord.	Clark VR, Barker NP, Ramdhani S, Kelly C 6
Asteraceae	*Euryops trifidus* (L.f.) DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 145
Asteraceae	*Felicia fascicularis* DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 76
Asteraceae	*Felicia filifolia* (Vent.) Burtt Davy	Clark VR, Barker NP, Ramdhani S, Kelly C 9
Asteraceae	*Felicia hirsuta* DC.	Clark VR, Ngcobo L, Walton S 33
Asteraceae	*Felicia ovata* (Thunb.) Compton	Clark VR, Barker NP, Ramdhani S, Kelly C 55
Asteraceae	*Garuleum bipinnatum* (Thunb.) Less	Clark VR, Cerros R 321
Asteraceae	*Gazania heterochaeta* DC.	Clark VR, Cerros R 158
Asteraceae	*Gazania krebsiana* Less.	Clark VR, Cerros R 319
Asteraceae	*Gerbera piloselloides* (L.) Cass.	Clark VR, Ngcobo L, Walton S 81
Asteraceae	*Helichrysum asperum* var. *appressifolium* (Moeser) Hilliard	Clark VR, Barker NP, Ramdhani S, Kelly C 102
Asteraceae	*Helichrysum hamulosum* E.Mey. ex DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 30
Asteraceae	*Helichrysum micropoides* DC.	Clark VR, Cerros R 229
Asteraceae	*Helichrysum rosum* (P.J.Bergius) Less. var. *rosum*	Clark VR, Midgley J 115
Asteraceae	*Helichrysum rugulosum* Less.	Clark VR, Cerros R 81
Asteraceae	*Helichrysum scitulum* Hilliard & B.L.Burtt	Clark VR, Ngcobo L, Walton S 25
Asteraceae	*Helichrysum trilineatum* DC.	Clark VR, Ngcobo L, Walton S 20
Asteraceae	*Helichrysum tysonii* Hilliard	Clark VR, Barker NP, Ramdhani S, Kelly C 101
Asteraceae	*Helichrysum zeyheri* Less.	Clark VR, Cerros R 36
Asteraceae	*Ifloga decumbens* (Thunb.) Schltr.	Clark VR, Cerros R 148
Asteraceae	*Lactuca inermis* Forssk.	Clark VR, Cerros R 140
Asteraceae	*Lactuca serriola* L.*	Clark VR, Cerros R 14
Asteraceae	*Lasiopogon glomerulatus* (Harv.) Hilliard	Clark VR, Barker NP, Ramdhani S, Kelly C 132
Asteraceae	*Leysera gnaphalodes* (L.) L.	Clark VR, Ngcobo L, Walton S 101
Asteraceae	*Osteospermum grandidentatum* DC.	Clark VR, Cerros R 119
Asteraceae	*Osteospermum leptolobum* (Harv.) Norl.	Clark VR, Midgley J 265
Asteraceae	*Osteospermum microphyllum* DC.	Clark VR, Midgley J 103
Asteraceae	*Osteospermum rigidum* Aiton	Clark VR, Midgley J 49
Asteraceae	*Pentzia dentata* (L.) Kuntze	Clark VR, Barker NP, Ramdhani S, Kelly C 39
Asteraceae	*Pentzia globosa* Less.	Clark VR, Barker NP, Ramdhani S, Kelly C 22
Asteraceae	*Pentzia incana* (Thunb.) Kuntze	Clark VR, Midgley J 27
Asteraceae	*Pentzia punctata* Harv.	Clark VR, Cerros R 385
Asteraceae	*Pentzia quinquefida* (Thunb.) Less.	Clark VR, Barker NP, Ramdhani S, Kelly C 140
Asteraceae	*Pentzia spinescens* Less.	Clark VR, Midgley J 160
Asteraceae	*Pentzia tortuosa* (DC.) Fenzl ex Harv.	Clark VR, Cerros R 322
Asteraceae	*Phymaspermum aciculare* (E.Mey. ex Harv.) Benth. & Hook. ex B.D.Jacks	Clark VR, Midgley J 164

Asteraceae	*Phymaspermum pubescens* (DC.) Kuntze	Clark VR, Barker NP, Ramdhani S, Kelly C 12
Asteraceae	*Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt subsp. *luteo-album*	Clark VR, Cerros R 131
Asteraceae	*Pseudognaphalium undulatum* (L.) Hilliard & B.L.Burtt	Clark VR, Cerros R 451
Asteraceae	*Pteronia glomerata* L.f.	Clark VR, Midgley J 328
Asteraceae	*Pteronia membranacea* L.f.	Clark VR, Midgley J 273
Asteraceae	*Pteronia stoehelinoides* DC.	Clark VR, Midgley J 123
Asteraceae	*Pteronia stricta* Aiton var. *stricta*	Clark VR, Midgley J 272
Asteraceae	*Pteronia tricephala* DC.	Clark VR, Midgley J 182
Asteraceae	*Pterothrix spinescens* DC.	Clark VR, Cerros R 448
Asteraceae	*Rosenia glandulosa* Thunb.	Bremer, 1976
Asteraceae	*Rosenia humilis* (Less.) K.Bremer	Clark VR, Midgley J 193
Asteraceae	*Rosenia oppositifolia* (DC.) K.Bremer	Clark VR, Barker NP, Ramdhani S, Kelly C 38
Asteraceae	*Rosenia spinescens* DC.	Clark VR, Midgley J 333
Asteraceae	*Senecio asperulus* DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 86
Asteraceae	*Senecio burchellii* DC.	Clark VR, Ngcobo L, Walton S 49
Asteraceae	*Senecio erubescens* Aiton	Clark VR, Midgley J 307
Asteraceae	*Senecio hastatus* L.	Clark VR, Barker NP, Ramdhani S, Kelly C 146
Asteraceae	*Senecio parvifolius* DC.	Clark VR, Midgley J 201
Asteraceae	*Senecio polyodon* DC. var. *polyodon*	Clark VR, Cerros R 244, 354
Asteraceae	*Senecio radicans* (L.f.) Sch.Bip.	Clark VR, Ngcobo L, Walton S 78
Asteraceae	*Senecio reptans* Turcz.	Clark VR, Midgley J 254
Asteraceae	*Sonchus asper* (L.) Hill subsp. *asper**	Clark VR, Midgley J
Asteraceae	*Sonchus dregeanus* DC.	Clark VR, Cerros R 312
Asteraceae	*Sonchus oleraceus* L.*	Clark VR, Cerros R 17
Asteraceae	*Tagetes minuta* L.*	Clark VR, Cerros R 19
Asteraceae	*Taraxacum officinale* Weber (sens. lat.)*	Clark VR, Cerros R 157
Asteraceae	*Tarchonanthus minor* Less.	Clark VR, Cerros R 586
Asteraceae	*Tolpis capensis* (L.) Sch.Bip.	Clark VR, Cerros R 75
Asteraceae	*Tragopogon porrifolius* L.*	Clark VR, Cerros R 89
Asteraceae	*Tripteris aghillana* DC. var. *aghillana*	Clark VR, Barker NP, Ramdhani S, Kelly C 72
Asteraceae	*Vellereophyton dealbatum* (Thunb.) Hilliard & B.L.Burtt	Clark VR, Ngcobo L, Walton S 13
Boraginaceae	*Anchusa capensis* Thunb.	Clark VR, Ngcobo L, Walton S 70
Boraginaceae	*Anchusa riparia* DC.	Clark VR, Cerros R 175
Boraginaceae	*Cynoglossum obtusicalyx* Retief & A.E.van Wyk	Clark VR, Ngcobo L, Walton S 116
Boraginaceae	*Lappula heteracantha* Ledeb.*	Clark VR, Ngcobo L, Walton S 103
Boraginaceae	*Lithospermum affine* A.DC.	Clark VR, Barker NP, Ramdhani S, Kelly C 126
Boraginaceae	*Lithospermum hirsutum* E.Mey. ex A.DC.	Clark VR, Midgley J 202
Boraginaceae	*Myosotis stricta* Roem. & Schult.*	Clark VR, Ngcobo L, Walton S 127
Brassicaceae	*Heliophila carnosa* (Thunb.) Steud.	Clark VR, Ngcobo L, Walton S 34
Brassicaceae	*Heliophila crithmifolia* Willd.	Clark VR, Barker NP, Ramdhani S, Kelly C 131
Brassicaceae	*Heliophila suavissima* Burch. ex DC.	Clark VR, Ngcobo L, Walton S 135
Brassicaceae	*Lepidium africanum* (Burm.f.) DC	Clark VR, Ngcobo L, Walton S 16
Brassicaceae	*Lepidium suluense* Marais	Clark VR, Cerros R 387
Brassicaceae	*Sisymbrium capense* Thunb.	Clark VR, Ngcobo L, Walton S 117
Buddlejaceae	*Buddleja glomerata* H.L.Wendl.	Clark VR, Cerros R 64
Buddlejaceae	*Buddleja salviifolia* (L.) Lam.	Clark VR, Cerros R 209
Buddlejaceae	*Gomphostigma incomptum* (L.f.) N.E.Br.	Verdoorn, 1963
Campanulaceae	*Wahlenbergia* cf. *androsacea A.DC.*	Clark VR, Cerros R 548
Campanulaceae	*Wahlenbergia nodosa* (H.Buek) Lammers	Clark VR, Barker NP, Ramdhani S, Kelly C 65
Campanulaceae	*Wahlenbergia undulata* (L.f.) A.DC.	Clark VR, Ngcobo L, Walton S 97
Caryophyllaceae	*Cerastium capense* Sond.	Clark VR, Barker NP, Ramdhani S, Kelly C149
Caryophyllaceae	*Dianthus micropetalus* Ser.	Clark VR, Barker NP, Ramdhani S, Kelly C 37
Caryophyllaceae	*Herniaria erckertii* Herm. subsp. *erckertii*	Clark VR, Cerros R 375

Caryophyllaceae	*Silene burchellii* Otth var. *angustifolia* Sond.	Clark VR, Barker NP, Ramdhani S, Kelly C 43
Caryophyllaceae	*Silene undulata* Aiton	Clark VR, Cerros R 71
Caryophyllaceae	*Spergularia rubra* (L.) J.Presl & C.Presl subsp. *rubra**	Clark VR, Cerros R 334
Celastraceae	*Gymnosporia buxifolia* (L.) Szyszyl.	Clark VR, Barker NP, Ramdhani S, Kelly C 20
Celastraceae	*Gymnosporia linearis* (L.f.) Loes. subsp. *linearis*	Clark VR, Ngcobo L, Walton S 173
Chenopodiaceae	*Atriplex lindleyi* Moq. subsp. *inflata* (F.Muell.) Paul G.Wilson*	Clark VR, Midgley J 84
Chenopodiaceae	*Atriplex semibaccata* R.Br. var. *appendiculata* Aellen	Clark VR, Midgley J 151
Chenopodiaceae	*Chenopodium foliosum* Asch.	Clark VR, Barker NP, Ramdhani S, Kelly C 92
Chenopodiaceae	*Chenopodium mucronatum* Thunb.	Clark VR, Midgley J 61
Chenopodiaceae	*Chenopodium murale* L.*	Clark VR, Midgley J 275
Chenopodiaceae	*Chenopodium schraderianum* Roem. & Schult.*	Clark VR, Cerros R 28
Chenopodiaceae	*Salsola kali* L.*	Clark VR, Midgley J 251
Convolvulaceae	*Convolvulus sagittatus* Thunb.	Clark VR, Cerros R 63, 449
Crassulaceae	*Adromischus humilis* (Marloth) Poelln.	Tölken, 1978
Crassulaceae	*Cotyledon orbiculata* L.	Clark VR, Barker NP, Ramdhani S, Kelly C 121
Crassulaceae	*Crassula corallina* Thunb.	Clark VR, Barker NP, Ramdhani S, Kelly C 108
Crassulaceae	*Crassula dependens* Bolus	Clark VR, Barker NP, Ramdhani S, Kelly C 150
Crassulaceae	*Crassula lanceolata* (Eckl. & Zeyh.) Endl. ex Walp. subsp. *lanceolata*	Clark VR, Ngcobo L, Walton S 132
Crassulaceae	*Crassula lanuginosa* Harv. var. *lanuginosa*	Clark VR, Ngcobo L, Walton S 141
Crassulaceae	*Crassula montana* subsp. *quadrangularis* (Schönland) Tölken	Clark VR, Midgley J 400
Crassulaceae	*Crassula natans* Thunb. var. *natans*	Clark VR, Cerros R 552
Crassulaceae	*Crassula obovata* Haw. var. *obovata*	Clark VR, Cerros R 423
Crassulaceae	*Crassula sarcocaulis* Eckl. & Zeyh. subsp. *sarcocaulis*	Clark VR, Barker NP, Ramdhani S, Kelly C 31
Crassulaceae	*Crassula subaphylla* (Eckl. & Zeyh.) Harv. var. *subaphylla*	Clark VR, Cerros R 212
Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Clark VR, Midgley J 417
Cucurbitaceae	*Cucumis myriocarpus* Naudin	Clark VR, Cerros R 61
Dipsacaceae	*Scabiosa columbaria* L.	Clark VR, Ngcobo L, Walton S 122
Ebenaceae	*Diospyros austro-africana* De Winter var. *austro-africana*	Clark VR, Barker NP, Ramdhani S, Kelly C 3
Ebenaceae	*Diospyros lycioides* Desf.	Clark VR, Cerros R 3
Ebenaceae	*Euclea crispa* (Thunb.) Gürke subsp. *crispa*	Clark VR, Cerros R 276
Ebenaceae	*Euclea undulata* Thunb.	Clark VR, Barker NP, Ramdhani S, Kelly C 2
Euphorbiaceae	*Clutia thunbergii* Sond.	Clark VR, Barker NP, Ramdhani S, Kelly C 35
Euphorbiaceae	*Euphorbia caterviflora* N.E.Br.	Clark VR, Barker NP, Ramdhani S, Kelly C 62
Euphorbiaceae	*Euphorbia clavarioides* Boiss. var. *clavarioides*	Clark VR, Cerros R 161
Euphorbiaceae	*Euphorbia hypogaea* Marloth	White et al., 1941
Euphorbiaceae	*Euphorbia mauritanica* L. var. *mauritanica*	Clark VR, Ngcobo L, Walton S 42
Fabaceae	*Acacia karroo* Hayne	Clark VR, Barker NP, Ramdhani S, Kelly C 167
Fabaceae	*Aspalathus acicularis* E.Mey. subsp. *acicularis*	Clark VR, Cerros R 277
Fabaceae	*Indigofera alternans* DC. var. *effusa* ined. (Schrire, pers. comm.)	Clark VR, Cerros R 179
Fabaceae	*Indigofera* cf. *hantamensis* Diels (Schrire, pers. comm.)	Clark VR, Ngcobo L, Walton S 166
Fabaceae	*Indigofera meyeriana* Eckl. & Zeyh.	Clark VR, Barker NP, Ramdhani S, Kelly C 95
Fabaceae	*Indigofera sessilifolia* DC.	Clark VR, Ngcobo L, Walton S 2
Fabaceae	*Indigofera* sp. nov. 3 (= *I. oxytropoides*) (Schrire, pers. comm.)	Clark VR, Ngcobo L, Walton S 142
Fabaceae	*Lessertia inflata* Harv.	Clark VR, Ngcobo L, Walton S 86
Fabaceae	*Lessertia sneeuwbergensis* Germish.	Clark VR, Ngcobo L, Walton S 44
Fabaceae	*Lotononis azureoides* B.-E.van Wyk	Clark VR, Cerros R 59
Fabaceae	*Lotononis caerulescens* (E.Mey.) B.-E.van Wyk	Clark VR, Cerros R 509
Fabaceae	*Lotononis decumbens* (Thunb.) B.-E.van Wyk subsp. *decumbens*	Clark VR, Ngcobo L, Walton S 100
Fabaceae	*Lotononis fruticoides* B.E-van Wyk	Van Wyk, 1990a, 1991
Fabaceae	*Lotononis laxa* Eckl. & Zeyh.	Clark VR, Cerros R 393
Fabaceae	*Lotononis pungens* Eckl. & Zeyh.	Clark VR, Ngcobo L, Walton S 158
Fabaceae	*Medicago polymorpha* L.*	Clark VR, Cerros R 38
Fabaceae	*Melolobium candicans* (E.Mey.) Eckl. & Zeyh.	Clark VR, Barker NP, Ramdhani S, Kelly C 114

Fabaceae	*Melolobium microphyllum* (L.f.) Eckl. & Zeyh.	Clark VR, Ngcobo L, Walton S 27
Fabaceae	*Prosopis glandulosa* Torr. var. *glandulosa**	Clark VR, Cerros R 478
Fabaceae	*Sutherlandia frutescens* (L.) R.Br.	Clark VR, Ngcobo L, Walton S 63
Fabaceae	*Trifolium burchellianum* Ser. subsp. *burchellianum*	Clark VR, Cerros R 125
Flacourtiaceae	*Kiggelaria africana* L.	Clark VR, Cerros R 65
Fumariaceae	*Cysticapnos pruinosa* (Bernh.) Lidén	Clark VR, Cerros R 538
Geraniaceae	*Erodium cicutarium* (L.) L'Hér.*	Clark VR, Barker NP, Ramdhani S, Kelly C 80
Geraniaceae	*Geranium harveyi* Briq.	Clark VR, Ngcobo L, Walton S 43
Geraniaceae	*Geranium incanum* var. *multifidum* (Sweet) Hilliard & B.L.Burtt	Clark VR, Ngcobo L, Walton S 125
Geraniaceae	*Pelargonium abrotanifolium* (L.f.) Jacq.	Clark VR, Barker NP, Ramdhani S, Kelly C 63
Geraniaceae	*Pelargonium articulatum* (Cav.) Willd.	Van der Walt et al., 1981
Geraniaceae	*Pelargonium glutinosum* (Jacq.) L'Hér.	Clark VR, Ngcobo L, Walton S 79
Geraniaceae	*Pelargonium grossularioides* (L.) L'Hér. ex Aiton	Clark VR, Ngcobo L, Walton S 7
Geraniaceae	*Pelargonium multicaule* Jacq. subsp. *multicaule*	Clark VR, Cerros R 239
Geraniaceae	*Pelargonium tragacanthoides* Burch.	Clark VR, Ngcobo L, Walton S 71
Geraniaceae	*Sarcocaulon crassicaule* Rehm.	Clark VR, Barker NP, Ramdhani S, Kelly C 170
Geraniaceae	*Sarcocaulon salmoniflorum* Moffett	Moffett, 1979
Gisekiaceae	*Gisekia africana* (Lour.) Kuntze	Clark VR, Midgley J 138
Haloragaceae	*Gunnera perpensa* L.	Clark VR, Cerros R 536
Lamiaceae	*Mentha longifolia* subsp. *capensis* (Thunb.) Briq.	Clark VR, Cerros R 166
Lamiaceae	*Stachys cuneata* Banks ex Benth.	Clark VR, Midgley J 56
Lamiaceae	*Stachys dregeana* Benth.	Clark VR, Ngcobo L, Walton S 48
Lamiaceae	*Stachys linearis* Burch. ex Benth.	Clark VR, Barker NP, Ramdhani S, Kelly C 16
Lentibulariaceae	*Utricularia livida* E.Mey.	Clark VR, Cerros R 165
Linaceae	*Linum thunbergii* Eckl. & Zeyh.	Clark VR, Cerros R 82
Lobeliaceae	*Lobelia dregeana* (C.Presl) A.DC.	Clark VR, Cerros R 83
Lobeliaceae	*Lobelia thermalis* Thunb.	Clark VR, Cerros R 130
Malvaceae	*Anisodontea malvastroides* (Baker f.) Bates	Clark VR, Ngcobo L, Walton S 41
Malvaceae	*Anisodontea procumbens* (Harv.) Bates	Clark VR, Cerros R 489
Melianthaceae	*Melianthus comosus* Vahl	Clark VR, Barker NP, Ramdhani S, Kelly C 4
Mesembryanthemaceae	*Antimima dekenahi* (N.E.Br.) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima ivori* (N.E.Br.) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Aptenia geniculiflora* (L.) Bittrich ex Gerbaulet	Clark VR, Midgley J 89B
Mesembryanthemaceae	*Aridaria noctiflora* subsp. *straminea* (Haw.) Gerbaulet	Clark VR, Midgley J 152
Mesembryanthemaceae	*Chasmatophyllum musculinum* (Haw.) Dinter & Schwantes	Clark VR, Barker NP, Ramdhani S, Kelly C 122
Mesembryanthemaceae	*Delosperma brevisepalum* L.Bolus	Clark VR, Ngcobo L, Walton S 65
Mesembryanthemaceae	*Delosperma concavum* L.Bolus	Clark VR, Cerros R 76
Mesembryanthemaceae	*Delosperma lootsbergense* Lavis	Clark VR, Barker NP, Ramdhani S, Kelly C 73
Mesembryanthemaceae	*Delosperma multiflorum* L.Bolus	Clark VR, Barker NP, Ramdhani S, Kelly C 494
Mesembryanthemaceae	*Delosperma subincanum* (Haw.) Schwantes	Clark VR, Midgley J 150
Mesembryanthemaceae	*Drosanthemum archeri* L.Bolus	Clark VR, Midgley J 90
Mesembryanthemaceae	*Malephora crocea* (Jacq.) Schwantes	Clark VR, Midgley J 88
Mesembryanthemaceae	*Mesembryanthemum crystallinum* L.	Clark VR, Midgley J 65
Mesembryanthemaceae	*Psilocaulon junceum* (Haw.) Schwantes	Clark VR, Midgley J 89
Mesembryanthemaceae	*Ruschia beaufortensis* L.Bolus	Hartmann, 2001b
Mesembryanthemaceae	*Ruschia complanata* L.Bolus	Clark VR, Barker NP, Ramdhani S, Kelly C 61
Mesembryanthemaceae	*Ruschia cradockensis* subsp. *tricticiformis* (L.Bolus) H.E.K.Hartmann	Clark VR, Midgley J 316
Mesembryanthemaceae	*Ruschia dejagerae* L.Bolus	Clark VR, Midgley J 119
Mesembryanthemaceae	*Ruschia grisea* (L.Bolus) Schwantes	Clark VR, Midgley J 71
Mesembryanthemaceae	*Ruschia hamata* (L.Bolus) Schwantes	Clark VR, Ngcobo L, Walton S 55
Mesembryanthemaceae	*Ruschia spinosa* (L.) Dehn	Clark VR, Cerros R 102
Mesembryanthemaceae	*Ruschia beaufortensis* L.Bolus	Stuart C s.n.
Mesembryanthemaceae	*Stomatium duthiae* L.Bolus	Clark VR, Cerros R 259

Mesembryanthemaceae	*Stomatium suaveolens* (Schwantes) Schwantes	Clark VR, Midgley J 241
Mesembryanthemaceae	*Stomatium villettii* L.Bolus	Hartmann, 2001b
Mesembryanthemaceae	*Trichodiadema pomeridianum* L.Bolus	Clark VR, Midgley J 30
Mesembryanthemaceae	*Trichodiadema setuliferum* (N.E.Br.) Schwantes	Clark VR, Cerros R 192
Molluginaceae	*Pharnaceum aurantium* (DC.) Druce	Clark VR, Ngcobo L, Walton S 111
Moraceae	*Morus alba* L.*	Clark VR, Cerros R 482
Nyctaginaceae	*Boerhavia cordobensis* Kuntze*	Gibbs Russell B, Robinson R, Herman P 511
Orobanchaceae	*Alectra capensis* Thunb.	Clark VR, Cerros R 136
Oxalidaceae	*Oxalis depressa* Eckl. & Zeyh.	Clark VR, Midgley J 109
Oxalidaceae	*Oxalis hirsuta* Sond.	Salter, 1944
Oxalidaceae	*Oxalis melanosticta* Sond.	Clark VR, Barker NP, Ramdhani S, Kelly C 77
Oxalidaceae	*Oxalis obliquifolia* Steud. ex A.Rich.	Clark VR, Ngcobo L, Walton S 136
Oxalidaceae	*Oxalis obtusa* Jacq.	Clark VR, Barker NP, Ramdhani S, Kelly C 135
Oxalidaceae	*Oxalis smithiana* Eckl. & Zeyh.	Clark VR, Cerros R 55
Papaveraceae	*Argemone ochroleuca* Sweet subsp. *ochroleuca**	Clark VR, Cerros R 439
Papaveraceae	*Papaver aculeatum* Thunb.	Clark VR, Cerros R 569
Phytolaccaceae	*Phytolacca heptandra* Retz.	Clark VR, Cerros R 420
Plantaginaceae	*Plantago lanceolata* L.*	Clark VR, Cerros R 346
Polygalaceae	*Muraltia macrocarpa* Eckl. & Zeyh.	Clark VR, Barker NP, Ramdhani S, Kelly C 32
Polygalaceae	*Polygala ephedroides* Burch.	Clark VR, Ngcobo L, Walton S 93
Polygalaceae	*Polygala hottentotta* C.Presl	Clark VR, Ngcobo L, Walton S 94
Polygonaceae	*Polygonum aviculare* L.*	Clark VR, Cerros R 320
Polygonaceae	*Rumex cordatus* Poir.	Clark VR, Midgley J 270
Polygonaceae	*Rumex lanceolatus* Thunb.	Clark VR, Barker NP, Ramdhani S, Kelly C 112
Portulacaceae	*Avonia ustulata* (E.Mey. ex Fenzl) G.D.Rowley	Gerbaulet, 1992
Ranunculaceae	*Clematis brachiata* Thunb.	Clark VR, Cerros R 90
Ranunculaceae	*Ranunculus aquatilis* L.	Clark VR, Cerros R 585
Ranunculaceae	*Ranunculus multifidus* Forssk.	Clark VR, Cerros R 182
Rhamnaceae	*Rhamnus prinoides* L'Hér.	Clark VR, Cerros R 534
Rosaceae	*Cliffortia arborea* Marloth	Clark VR, Barker NP, Ramdhani S, Kelly C 23
Rosaceae	*Cliffortia ramosissima* Schltr.	Clark VR, Ngcobo L, Walton S 21
Rosaceae	*Rosa rubiginosa* L.*	Clark VR, Cerros R 479
Rubiaceae	*Anthospermum monticola* Puff	Clark VR, Ngcobo L, Walton S 149
Rubiaceae	*Galium capense* Thunb. subsp. *capense*	Clark VR, Midgley J 395
Rubiaceae	*Galium spurium* subsp. *africanum* Verdc.	Clark VR, Midgley J 4
Rubiaceae	*Nenax microphylla* (Sond.) T.M.Salter	Clark VR, Cerros R 41
Salicaceae	*Populus nigra* L.*	Clark VR, Cerros R 481
Salicaceae	*Populus* x *canescens* (Aiton) Sm.*	Clark VR, Cerros R 437
Salicaceae	*Salix babylonica* L. var. *babylonica**	Clark VR, Cerros R 492
Salicaceae	*Salix mucronata* subsp. *capensis* (Thunb.) Immelman	Clark VR, Midgley J 247
Santalaceae	*Thesium imbricatum* Thunb.	Clark VR, Cerros R 386
Santalaceae	*Thesium impeditum* A.W.Hill	Clark VR, Cerros R 222
Santalaceae	*Thesium lineatum* L.f.	Clark VR, Midgley J 29
Scrophulariaceae	*Aptosimum indivisum* Burch. ex Benth.	Clark VR, Barker NP, Ramdhani S, Kelly C 44
Scrophulariaceae	*Aptosimum procumbens* (Lehm.) Steud.	Clark VR, Ngcobo L, Walton S 165
Scrophulariaceae	*Cromidon decumbens* (Thunb.) Hilliard	Clark VR, Barker NP, Ramdhani S, Kelly C 88
Scrophulariaceae	*Diascia alonsooides* Benth.	Clark VR, Barker NP, Ramdhani S, Kelly C 142
Scrophulariaceae	*Hebenstretia dura* Choisy	Clark VR, Cerros R 133
Scrophulariaceae	*Jamesbrittenia atropurpurea* (Benth.) Hilliard subsp. *atropurpurea*	Clark VR, Midgley J 6
Scrophulariaceae	*Jamesbrittenia filicaulis* (Benth.) Hilliard	Clark VR, Ngcobo L, Walton S 92
Scrophulariaceae	*Jamesbrittenia tysonii* (Hiern) Hilliard	Clark VR, Midgley J 121, 375
Scrophulariaceae	*Nemesia fruticans* (Thunb.) Benth.	Clark VR, Ngcobo L, Walton S 40
Scrophulariaceae	*Peliostomum leucorrhizum* E.Mey. ex Benth.	Clark VR, Midgley J 37

Scrophulariaceae	*Reyemia nemesioides* (Diels) Hilliard	Hilliard, 1994
Scrophulariaceae	*Selago albida* Choisy	Clark VR, Cerros R 104
Scrophulariaceae	*Selago rigida* Rolfe	Clark VR, Barker NP, Ramdhani S, Kelly C 25
Scrophulariaceae	*Selago saxatilis* E.Mey.	Clark VR, Barker NP, Ramdhani S, Kelly C 39
Scrophulariaceae	*Sutera halimifolia* (Benth.) Kuntze	Clark VR, Ngcobo L, Walton S 19
Scrophulariaceae	*Sutera macrosiphon* (Schltr.) Hiern	Clark VR, Ngcobo L, Walton S 133
Scrophulariaceae	*Sutera rotundifolia* (Benth.) Kuntze	Clark VR, Ngcobo L, Walton S 9
Scrophulariaceae	*Veronica anagallis-aquatica* L.	Clark VR, Ngcobo L, Walton S 3
Scrophulariaceae	*Zaluzianskya capensis* (L.) Welp.	Clark VR, Ngcobo L, Walton S 115
Scrophulariaceae	*Zaluzianskya ovata* (Benth.) Walp.	Clark VR, Ngcobo L, Walton S 124
Simabouraceae	*Ailanthus altissima* Swingle*	Clark VR, Cerros R 190
Solanaceae	*Datura ferox* L.*	Clark VR, Midgley J 274
Solanaceae	*Datura stramonium* L. var. *stramonium**	Clark VR, Cerros R 91
Solanaceae	*Lycium cinereum* Thunb.	Clark VR, Cerros R 314
Solanaceae	*Lycium horridum* Thunb.	Clark VR, Cerros R 435
Solanaceae	*Lycium oxycarpum* Dunal	Clark VR, Cerros R 7
Solanaceae	*Solanum retroflexum* Dunal	Clark VR, Cerros R 16
Solanaceae	*Solanum tomentosum* L. var. *coccineum* (Jacq.) Willd.	Clark VR, Barker NP, Ramdhani S, Kelly C 33
Solanaceae	*Withania somnifera* (L.) Dunal	Clark VR, Cerros R 580
Sterculiaceae	*Hermannia althaeifolia* L.	Clark VR, Ngcobo L, Walton S 35
Sterculiaceae	*Hermannia cernua* Thunb.	Clark VR, Barker NP, Ramdhani S, Kelly C 78
Sterculiaceae	*Hermannia coccocarpa* (Eckl. & Zeyh.) Kuntze	Clark VR, Ngcobo L, Walton S 47
Sterculiaceae	*Hermannia cuneifolia* var. *glabrescens* (Harv.) I.Verd.	Clark VR, Barker NP, Ramdhani S, Kelly C 64
Sterculiaceae	*Hermannia desertorum* Eckl. & Zeyh.	Clark VR, Midgley J 114
Sterculiaceae	*Hermannia grandiflora* Aiton	Clark VR, Barker NP, Ramdhani S, Kelly C 120
Sterculiaceae	*Hermannia johanssenii* N.E.Br.	Clark VR, Barker NP, Ramdhani S, Kelly C 74
Sterculiaceae	*Hermannia vestita* Thunb.	Clark VR, Midgley J 192
Thymelaceae	*Gnidia deserticola* Gilg	Clark VR, Barker NP, Ramdhani S, Kelly C 115
Urticaceae	*Forsskaolea candida* L.f.	Clark VR, Midgley J 409
Urticaceae	*Urtica dioica* L.*	Clark VR, Cerros R 176
Urticaceae	*Urtica lobulata* Blume	Clark VR, Barker NP, Ramdhani S, Kelly C 52
Viscaceae	*Viscum continuum* E.Mey. ex Sprague	Polhill and Wiens, 1998
Viscaceae	*Viscum hoolei* (Wiens) Polhill & Wiens	Clark VR, Midgley J 413
Viscaceae	*Viscum rotundifolium* L.f.	Polhill & Wiens, 1998
Zygophyllaceae	*Zygophyllum lichtensteinianum* Cham. & Schltdl.	Clark VR, Midgley J 59
Zygophyllaceae	*Tribulus terrestris* L.	Clark VR, Midgley J 75

Chapter 5: The Roggeveldberge.

5.1. Introduction

The south-western edge of the Karoo plateau (Northern and Western Cape, South Africa) is one of the botanically richest areas of the Karoo. This edge – formed by the Hantamberge, the Roggeveldberge and the Komsberg – is part of the Great Escarpment exceedingly rich in local endemics, and is an important component of the HRC (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006; Van der Merwe et al., 2008, 2009a, b). Many of these Great Escarpment endemics are poorly known (Van Wyk and Smith, 2001; Manning and Goldblatt, 2006), with new endemics being discovered on a regular basis (Manning and Goldblatt, 2006, 2007, 2008, etc.). The Hantam–Roggeveld is also the section of Great Escarpment deepest within the winter rainfall regime, and is part of probably the richest geophyte area in the world (Van Wyk and Smith, 2001). In addition to this, fynbos is represented by Renosterveld vegetation units (Mucina and Rutherford, 2006), and Succulent Karoo and Nama-Karoo vegetation units converge on the Roggeveld Escarpment (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006; Van der Merwe et al., 2009b). The HRC has been poorly studied (Hilliard, 1999) except for parts of the Nieuwoudtville area (Van Wyk and Smith, 2001; Van der Merwe et al., 2009b), and the Middelpos–Sutherland–Fraserburg area is indicated in particular as requiring major botanical investigation (Van Wyk and Smith, 2001).

The aim of this chapter is to contribute towards a flora of the Roggeveld and Komsberg (Fig 5.1) and to augment other taxonomic, floristic and biogeographic research in this region (see Van der Merwe et al., 2008, 2009a, b). Such floristic inventories are fundamental to biogeographical analysis (Born et al., 2007) and conservation planning. Although part of a broader biogeographical region (the HRC), this contribution is mostly confined to the author’s activities in the Roggeveld and Komsberg areas of the HRC.

5.2. The study area

5.2.1. The Komsberg and Roggeveldberge

The Komsberg forms the 45 km east-west section of the Great Escarpment between Verlatenkloof Pass (R354) and the Dwyka River Gorge in the Sutherland District (Fig. 5.1). It is also the most southerly section of the Great Escarpment in South Africa, and is situated only 80 km north of the inland Cape Fold Ranges (the Witteberg, Laingsburg District). The Roggeveldberge roughly

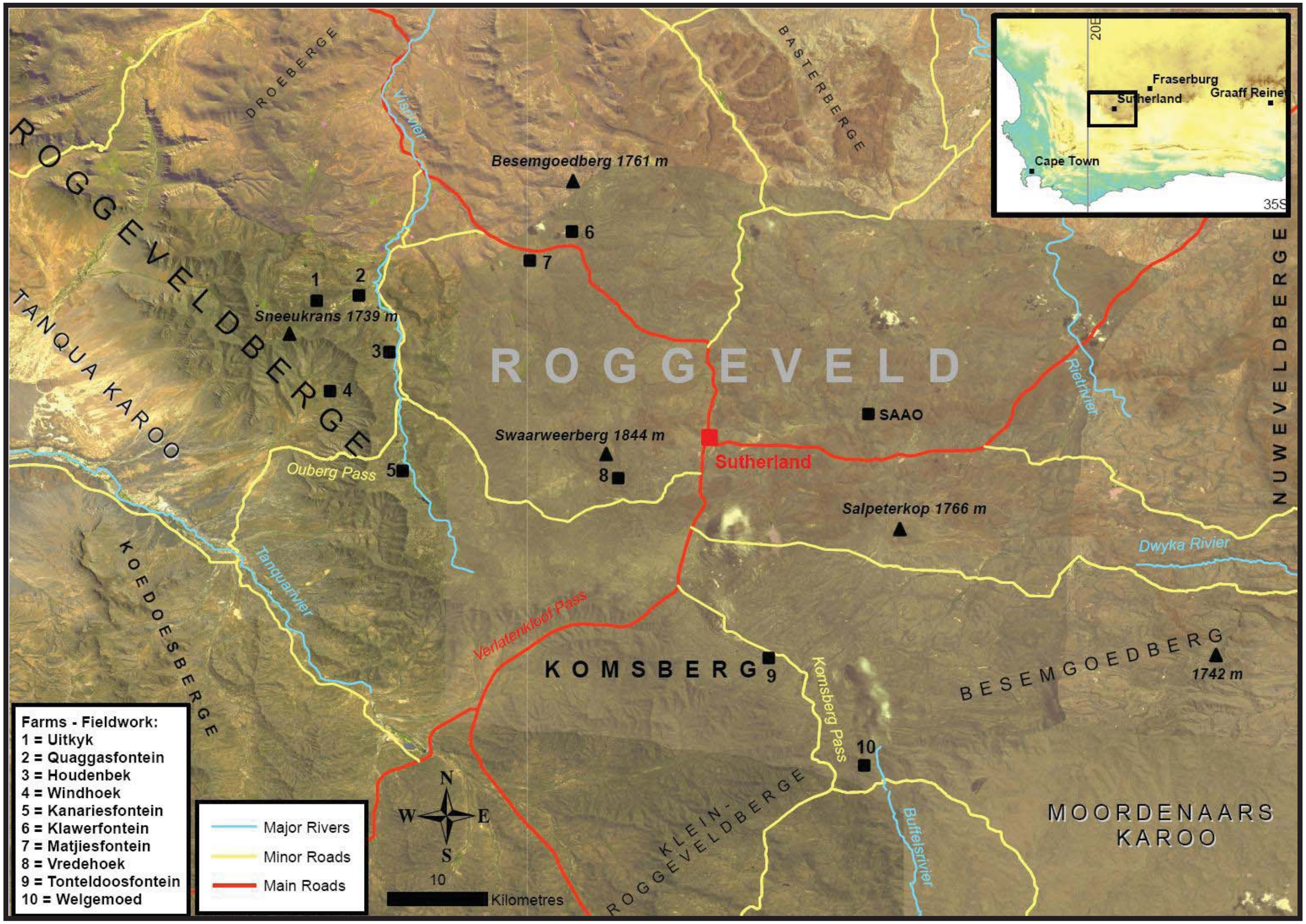


Figure 5.1: The southern Roggeveldberge and the Komsberg, indicating the highest points, farms used as bases for fieldwork, and localities mentioned in the text. SAAO = South African Astronomical Observatory. Satellite imagery sourced from the CSIR (2009), insert map source as for Fig. 1.1.

comprises that section of Great Escarpment between Verlatenkloof Pass and the Keiskieberge south of Calvinia, is approximately 90 km long, and runs in a north–westerly direction. The Roggeveld is the plateau inland of the Roggeveldberge, and is roughly bounded by the main road (R354)/South African Astronomical Observatory (SAAO) in the east to Middelpos and the Basterberge and Keiskieberge in the north, and the Roggeveld Escarpment in the south and west (please note that for the sake of a suitable scale only the southern Roggeveldberge and the Komsberg are shown in Fig. 5.1 and not the entire Hantam–Roggeveld Escarpment; as a result of this, some of the names mentioned in this paragraph are not be in Fig. 5.1).

5.2.2. Geology and geomorphology

The geology of the Roggeveld and the Komsberg is relatively simple, being composed of horizontal sediments of Beaufort Group (Adelaide Subgroup) sandstones and mudstones of the Karoo Supergroup (Van Wyk and Smith 2001; Verwoed et al., 1995; Woodford and Chevallier, 2002). Landscapes dominated by this geology are typically "layered", comprising a series of tablelands interspersed by "steps" of harder sandstone. Intrusions of mid-Jurassic dolerite (Woodford and Chevallier, 2002) are common, but in certain areas – such as behind the Farms Quaggasfontein and Houdenbek (Fig. 5.1) – are dominant, resulting in landscapes characterised by rounded batholiths, precarious tors and long ridges of rounded boulders. These dolerites – believed to be the feeder veins of the Drakensberg Basalts during the break-up of Gondwanaland in the Jurassic (Brink, 1983; Van Zijl, 2006) – are virtually at the western and southern limits of their occurrence in this region, co-inciding largely with the Great Escarpment except where they extend west from the Hantamberg to Nieuwoudtville (Manning and Goldblatt, 2002). Their durability compared to the sediments they have intruded renders them prominent features of the landscape (Agnew, 1958; Van Wyk and Smith, 2001). They have thus no doubt played an essential role in protecting the Roggeveld Escarpment from more rapid erosion (Agnew, 1958), and many of the highest points on the Roggeveld are capped with dolerite. Metamorphic or "baked" sediments occur along the contact zones between the sedimentary strata and the dolerite intrusions (Hill, 1993).

Salpeterkop (Fig. 5.2F), on the Komsberg plateau, is the volcanic plug of an eroded central volcano from the late Cretaceous (Verwoed et al., 1995). It is the central and largest component of the Sutherland Suite of hypabyssal olivine melilitite intrusions that extend 100 km north and 80 km north-east of Salpeterkop (Verwoed et al., 1995). The crater sediments contain tree trunk fossils and vertebrate fossils, indicating a crater lake existed at some stage in the past (Verwoed et al., 1995).

The highest point on the Komsberg is 1 742 m (on the Besemgoedberge) with Salpeterkop on the plateau reaching 1 766 m (Figs 5.1 and 5.2F). The highest points on the Roggeveld are the Swaarweerberg at 1 844 m and Sneeukrans at 1 739 m (Figs 5.2A, B). The Roggeveld Escarpment is not as dramatic as the Great Escarpment further east, but nevertheless represents an altitudinal difference of ca. 500 m (Komsberg) and 1 000 m (Roggeveldberge) between the lower Karoo plains and the general summit plateau.

As for the rest of the Great Escarpment, the Roggeveld and Komsberg are defined by Partridge and Maud (1987; their Fig. 12) as "*mountainous areas above the African Surface*". The African Surface lies to the north of the Great Escarpment, and dissected areas of various ages lie to the south. It may be possible that some of the higher-lying parts of the Roggeveld (such as Sneeukrans and the Swaarweerberg) represent fragments of the original Gondwanan surface (compare Agnew, 1958), although the Roggeveld is also much lower than other purported Gondwanan landform relicts, such as the Elandsberg (2 017 m) and Gaika's Kop (1 963 m) in the Great Winterberg–Amatolas (Agnew, 1958; Phillipson, 1992) and the Sneeuberg plateaux (ca. 2 100 m; Clark et al., 2009). This suggests that the Great Escarpment sections in southern South Africa furtherest from the Lesotho Highlands have had more time to be planed (Matmon et al., 2002). Another possible reason is there is less igneous rock to protect the easily eroded sedimentary strata (Agnew, 1958; Brink, 1983; Van Wyk and Smith, 2001). A further possible reason is the higher uplift in the east of southern Africa than in the west during the Miocene and Pliocene (Partridge and Maud, 1987; McCarthy and Rubidge, 2005). There is in fact a general decrease in altitude along the southern Great Escarpment from east (2 504 m in the Sneeuberg) to west (1 844 m in the Roggeveld).

5.2.3 Hydrology

The Roggeveld Escarpment is drained by the Tankwa and Doorn Rivers, which form part of the Olifants River system, discharging into the Atlantic Ocean at Papendorp. The Komsberg Escarpment is drained by the Buffels and Dwyka Rivers, which from part of the Groot–Gouritz system, discharging into the Indian Ocean at Gouritsmond near Mossel Bay. (The continental watershed thus runs along the Klein-Roggeveldberge onto the Komsberg and east along the Nuweveldberge). The effect of the south- and west-flowing Roggeveld Escarpment streams has been the creation of numerous "embayments" in the Roggeveldberge, especially north of Sneeukrans where the Roggeveld Escarpment becomes increasingly sinuous and disconnected. The summit plateau is drained by the Vis and Renoster Rivers, which are tributaries of the Sak system that terminates in the large Grootvloer pan in Bushmanland.

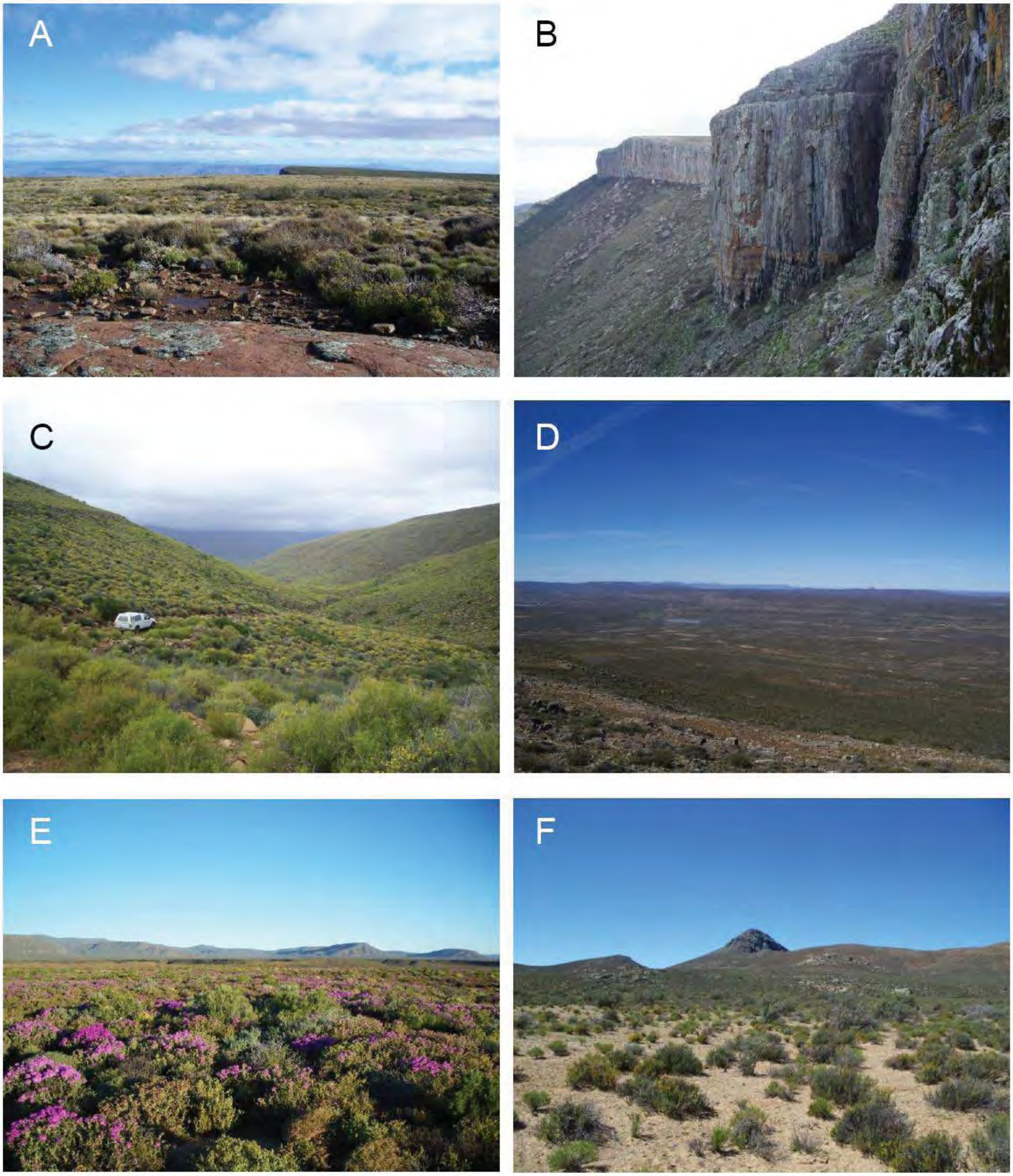


Figure 5.2: A selection of photographs of the southern Roggeveldberge and Komsberg: (A) Sneeukrans summit plateau (1 700 m), dominated by *Merxmuellera stricta*; (B) Sneeukrans, one of the most dramatic sections of the Roggeveld Escarpment (summit 1 700 m); (C) Succulent Karoo on the lower slopes of the Roggeveld Escarpment, below Sneeukrans (950 m); (D) The almost featureless Roggeveld plateau (1 400–1 600 m) from the Swaarweerberg (1 844 m); (E) The Tanqua Karoo in spring, with the Roggeveld Escarpment in the background; (F) Salpeterkop (1 766 m), an ancient volcanic plug, on the Komsberg plateau.

5.2.4. Soils

The Roggeveld and Komsberg region is notorious for its dolerite clays, which are particularly treacherous in winter, when large areas of hillslope consist of soils 20–50 cm deep that appear dry but are in fact saturated from the continuous movement of water through the soil. On the flat plateaux, extensive areas are covered in reddish sandy-clays (Van Wyk and Smith, 2001) derived from horizontal shale, sandstone and mudstone strata that have been deeply weathered *in situ*. These soils can be as deep as 1 m (pers. obs.), are also typically associated with high seasonal groundwater levels and the irregular drainage systems that characterise the flattest parts of the plateau. These areas usually host an abundance of geophytes.

Soils derived from dolerite flats are fertile, neutral to alkaline, reddish-brown, clay soils (Van Wyk and Smith, 2001). Generally formed *in situ*, these soils occur as a matrix in which rounded dolerite boulders are found, and support most of the endemics in the HRC (Van Wyk and Smith, 2001; Goldblatt and Manning, 2002; Mucina and Rutherford, 2006). The remainder of the soils in the area, such as on dolerite outcrops, among tors and on other shallow stony ground, are lithosols (Van Wyk and Smith, 2001), while colluvium and regolith occupy the steeper mountain slopes. Alluvial boulder piles, and beige alluvium deposits up to 3 m deep occupy the broader valleys at the base of the Great Escarpment (pers. obs.).

5.2.5. Climate

Cold regions in Africa are often so due to their high elevation, such as the Sneeuberg (>2 000 m), Great Winterberg (2 369 m), and Main Drakensberg Escarpment (>3 000 m). The Roggeveld however is well-known for its cold climate (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006), despite elevation not even reaching 1 850 m. The reason for the extreme cold is considered to be a combination of the following (from Van Wyk and Smith, 2001; Mucina and Rutherford, 2006): (1) the Roggeveld Escarpment is the second area of high ground (after the Cederberg) in the path of cool air from temperate cyclones coming in from the south-west; (2) its relative proximity to the cool Atlantic Ocean and Benguela Current; (3) its relatively high elevation; (4) and the effect of continentality. The predominance of a winter rainfall regime ensures that the Roggeveld winter temperatures are not just cold (such as the continental but dry winter climates of the interior Karoo and Highveld) but are also characterised by snow and ice (the Roggeveld receives about five snowfalls per annum; Van Wyk and Smith, 2001).

Essentially, the Sutherland District occupies a “cool node” on the Karoo plateau, having the lowest mean annual temperature (12.5^{o}C), the lowest mean daily maximum temperature (<30^{o}C), the highest mean annual frequency of days with minimum temperature below 0^{o}C (80 days), and the highest number of frost days (153 days) out of any other region in the Karoo (Venter et al., 1986). Van Wyk and Smith (2001) crown this data stating that the Roggeveld experiences an average of 20 days of maximum temperature below 10^{o}C per annum, being twice that experienced in the DAC, which reaches over 3 000 m in elevation.

The Roggeveld and Komsberg receives 60–70% of its rainfall in winter (Venter et al., 1986), with a transition from predominantly winter to summer rainfall taking place just to the east of Sutherland (Van Wyk and Smith, 2001). Mean annual precipitation is between 200 and 300 mm for the Komsberg and between 300 and 400 mm for the Roggeveld Escarpment (Venter et al., 1986; Van Wyk and Smith, 2001). Rainfall is cyclonic and (comparably) reliable, usually in the form of gentle, widespread rain (Mucina and Rutherford, 2006). Some 30% to 40% of the mean annual rainfall falls in summer (Van Wyk and Smith, 2001; Sieberhagen, pers. comm.).

The low-altitude plains of the Tanqua and Koup Karoo are warmer than the Komsberg and Roggeveldberge, with a mean annual temperature of 15.8^{o}C (Mucina and Rutherford, 2006), although in summer maximum temperatures can exceed 40^{o}C (Sieberhagen, pers. comm.). Rainfall is lower than on the Roggeveld Escarpment, at 274 mm per annum (Mucina and Rutherford, 2006). The favourable winter climate at the bottom of the Escarpment is enjoyed by many Roggeveld farmers, who migrate each year with their flocks to the base of the mountains to avoid the harshest winter months (Sieberhagen, pers. comm.; Esterhuyse, pers. comm, etc.).

5.2.6. Vegetation

The Roggeveldberge and Komsberg comprise a region of transition from Succulent Karoo to Nama-Karoo Biomes, with the Fynbos Biome represented as various Renosterveld vegetation units (Mucina and Rutherford, 2006).

a) Fynbos Biome

Fynbos Biome vegetation in the Hantam–Tanqua–Roggeveld region is represented by several Renosterveld vegetation units dominated by *Dicerothamnos rhinocerotis*. *Dicerothamnos rhinocerotis* (Renosterbos) is part of an endemic Cape lineage (Bergh et al., 2007; Bergh and Linder, 2009), and Renosterveld vegetation units represent the only “true” fynbos on the Great Escarpment (Low and Rebelo, 1998; Mucina and Rutherford, 2006; Van der Merwe et al., 2009b). In this regard, Renosterveld is perhaps the clearest link between the CFR and the southern Great Escarpment, and – based on palaeoclimate reconstructions for an extended winter-rainfall area and associated fynbos during the Last Glacial Maximum – may represent a dry, relict fynbos on the mountains of Namaqualand and the southern Great Escarpment from a much more widely distributed, moister fynbos from that time (Midgley et al., 2005; Bergh et al., 2007; see Chapter 6). Renosterveld, although only recorded as far east as the Nuweveldberge by Low and Rebelo (1998) and Mucina and Rutherford (2006), also occurs on the Sneeuberg (Clark et al., 2009; see Chapter 2), suggesting that much of the southern Great Escarpment is an important arm of Renosterveld radiating from the south-western Cape. Low and Rebelo (1998) note that virtually nothing is known about this Great Escarpment Renosterveld.

Van der Merwe et al. (2008) indicate three types of "Mountain Renosterveld" as occurring in the Hantam–Tanqua–Roggeveld region: *Rosenia oppositifolia* Mountain Renosterveld, *Dicerothamnos rhinocerotis* Mountain Renosterveld and *Passerina truncata* Mountain Renosterveld. These Renosterveld entities are paralleled by Mucina and Rutherford's (2006) Roggeveld Shale Renosterveld, Nieuwoudtville Shale Renosterveld, Nieuwoudtville–Roggeveld Dolerite Renosterveld and Hantam Plateau Dolerite Renosterveld vegetation units. All of these Renosterveld units fall into Low and Rebelo's (1998) Escarpment Mountain Renosterveld, which mirrors Acocks's (1988) Mountain Renosterveld (A43) vegetation type. Acocks (1988) considered this Renosterveld to be invasive of a previously much grassier habitat, possibly as a result of overgrazing following the extermination of the original nomadic plains game and replacement by concentrated livestock (Manning and Goldblatt, 2002; Low and Rebelo, 1998; Van der Merwe et al., 2009a).

b) Succulent Karoo and Nama-Karoo Biomes

Mucina and Rutherford (2006) place the remainder of the Hantam–Tanqua–Roggeveld region into the Succulent Karoo Biome, although much of the area is transitionary between summer and winter rainfall regimes and is therefore biogeographically complicated, being ecotonal to the Fynbos, Succulent Karoo and Nama-Karoo Biomes (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006). Obvious Succulent Karoo vegetation laps the base of the Roggeveld Escarpment as Mucina and Rutherford's (2006) Tanqua Karoo, and comprises an abundance of annuals and succulent and karoo shrubs, particularly Mesembryanthemaceae (Fig. 5.2E). Tanqua Karoo grades into Mucina and Rutherford's (2006) Tanqua Escarpment Shrubland on the Roggeveld Escarpment slopes, and varies from grassy shrubland dominated by species such as *Merxmuellera disticha* and *Euryops lateriflorus* to drier slopes dominated by often abundant *Ruschia* and *Drosanthemum* species, with many other shrubs such as *Anisodontea triloba*, *Galenia africana*, *Oedera genistifolia*, *Osteospermum sinuatum*, *Pteronia incana*, *P. pallens* and *Senecio cinarescens* (Fig. 5.2C). These drier sections of Roggeveld

Escarpment are no doubt synonymous with Van der Merwe et al.'s (2008, 2009b) *Pteronia glauca–Euphorbia decussata* Escarpment Karoo. With altitude the Roggeveld Escarpment vegetation gives way to Renosterveld (discussed above) and Mucina and Rutherford's (2006) Hantam Karoo and Roggeveld Karoo vegetation units on the plateau, the latter two being synonymous with Van der Merwe et al.'s (2008) *Eriocephalus purpureus* Hantam Karoo and *Pteronia glomerata* Roggeveld Karoo vegetation types respectively. Roggeveld Karoo occurs on the higher-lying areas as far east as Fraserburg in the Nuweveldberge, and represents the eastern limit of the Succulent Karoo Biome (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006; see also Chapter 4). Hantam Karoo is confined to the areas between Loeriesfontein, Nieuwoudtville and Calvinia (Mucina and Rutherford, 2006). Much of the broad sedimentary plateaux inland of the Roggeveld Escarpment are dominated by Karoo "tableland shrublands", with *Euryops* species often dominant.

c) Other Noteworthy Vegetation

Riparian *Acacia karroo* thickets occur along the rivers and watercourses at the base of the Roggeveld Escarpment (Mucina and Rutherford's, 2006, Tanqua Wash Riviere vegetation unit), while on the plateau rivers and watercourses are characterised by large beds of *Phragmites australis*, *Pseudoschoenis inanis* and the occasional (alien) *Salix babylonica*. Numerous pans – fresh and saline – occur on the flat areas of the plateau, particularly on the Komsberg plateau and between the Swaarweerberg and the Roggeveld Escarpment. Dry pans are often covered in a fine red carpet of *Crassula* cf. *vaillantii*, and may support a range of geophytes that are evident only in the wet season.

It is worth mentioning that an unusual form of grassland occurs on Sneeukrans (Figs 5.1 and 5.2A), the highest and possibly wettest point on the actual Roggeveld Escarpment. Large (1 m wide) circular tussocks of *Merxmuellera stricta* dominate, with scattered shrubs. Other "high altitude" specialists occurring here are *Ischyrolepis laniger* and *I. distracta*, these being the only Restionaceae encountered in this research on the Roggeveld–Komsberg in this study, and *Helichrysum trilineatum*, also only encountered in this study on Sneeukrans. The Sneeukrans area is rich in local endemics, with several species currently only known from that area (e.g. *Oxalis marlothii*, *Devia xeromorpha* and *Hesperantha ciliolata*).

Cliff communities (and to a similar degree rock-outcrop communities) comprise species seldom found in other habitats in the area. Typical species are *Asparagus asparagoides*, *A. microraphis*, *A.* sp. nov., *Asplenium cordatum*, *Cerastium capense*, *Cineraria alchemillioides* subsp. *alchemillioides*, *Conium sphaerocarpum*, *Cromidon decumbens*, *Diascia parviflora*, *Stilpnogyne bellidioides*, *Troglophyton capillaceum* subsp. *capillaceum* and *Urtica lobulata*. Of particular interest is the very high (100 m+), relatively moist, well-shaded south-east-facing dolerite cliffs of Sneeukrans (Fig. 5.2B), which support numerous species not encountered elsewhere on the Roggeveld and Komsberg. These species include a variety of soft grasses such as *Vulpia myuros* (an alien), herbs such as *Ranunculus multifidus*, cushion plants such as *Berkheya cardopatifolia,* a *Crassula* sp., and soft shrubs such as *Melianthus major*. *Oxalis marlothii* is abundant at the base of the sandstone cliffs to the south-east in the vicinity.

5.3. Endemic and near-endemic species and centres of endemism

The Komsberg and Roggeveld fall into Van Wyk and Smith's (2001) HRC. The HRC – generally considered to be part of the Succulent Karoo Biome (Hilton-Taylor, 1996; Van Wyk and Smith, 2001; Van der Merwe et al., 2009a, b) – broadly extends from the Bokkeveld Plateau (Nieuwoudtville District) east to the Nuweveldberge (Fraserburg District), and from the De Kop District in the north south to the Klein-Roggeveldberge south of the Komsberg (Van Wyk and Smith, 2001). Born et al. (2007) put endemism in the HRC at 8.6% (with a flora of 1 254 species). Combined with near-endemics, these jumps to 10% (or ca. 250 taxa; Van Wyk and Smith, 2001), with ca. 163 endemic to the "Western Mountain Karoo" of Hilton-Taylor (1996).

In terms of Great Escarpment, the HRC incorporates the Hantamberge (Calvinia District), the Roggeveldberge (Middelpos and Sutherland Districts), the Komsberg (Sutherland District), and the western and central Nuweveldberge (Fraserburg and Merweville Districts) (Van Wyk and Smith, 2001; see also Chapter 4). The concept of a centre of endemism in this region is supported on both family and generic levels of endemism. The area is a centre of diversity for Asteraceae (Koekemoer, 1996) and is an especially marked centre for *Euryops* (Nordenstam, 1969). Annual Manuleae (Scrophulariaceae) are also very well represented, with several annual endemic species in *Diascia* Link & Otto, *Cromidon* Compton and *Zaluzianskya* F.W.Schmidt (Hilliard, 1994; Van Wyk and Smith, 2001; Mucina and Rutherford, 2006), while numerous *Selago* L. species are also local endemics (Hilliard, 1999). The most spectacular array of endemics however – visually and numerically – is in the monocot geophytes (Snijman and Perry, 1987), with numerous representatives in the Amaryllidaceae, Colchicaceae, Iridaceae, Hyacinthaceae, particularly in genera such as *Hesperantha* Ker Gawl. (the centre of diversity for the genus being the Hantamberg, followed by the Roggeveld; Goldblatt, 1984; Snijman and Perry, 1987), *Ixia* L., *Gladiolus* L., *Babiana* Ker Gawl., *Daubenya* Lindl., *Moraea* Mill., *Romulea* Maratti and *Lachenalia* J.Jacq. ex Murray. Such geophytes contribute up to 40% of the flora in certain parts of the HRC (Mucina and Rutherford, 2006). Other endemic-rich families in the HRC are Mesembryanthemaceae (Van Wyk and Smith, 2001) and Oxalidaceae (Salter, 1944), while of the several endemic Poaceae, the origins of *Secale africanum* has been the most speculated over (Van Wyk and Smith, 2001; A. Van Wyk, pers. comm.).

The HRC and parts thereof have been variously termed the "Hantam–Roggeveld Subcentre" (Wiemarck, 1941), "Western Upper Karoo Centre" (Nordenstam, 1969), "Roggeveld and Western Mountain Karoo" (Hilton-Taylor, 1987) and "Hantam Centre" (Koekemoer, 1996). More recently, Mucina and Rutherford (2006) consider their Nieuwoudtville Shale Renosterveld, Roggeveld Shale Renosterveld, Nieuwoudtville–Roggeveld Dolerite Renosterveld, Hantam Plateau Dolerite Renosterveld, Hantam Karoo and Roggeveld Karoo vegetation units to form the core of the HRC. They also suggest including their Koedoesberge–Moordenaars Karoo vegetation unit, and the areas adjoining the Tanqua Basin, into this Centre (Mucina and Rutherford, 2006).

It is difficult to compile a conclusive and unambiguous list of endemic plants for the HRC. In the west the HRC abuts the Bokkeveld Mountains of the CFR (Van Wyk and Smith, 2001; Manning and Goldblatt, 2002, 2006), and several local endemics straddle both the HRC and the CFR (Manning and Goldblatt, 2002). In the east, delimitation is vague (Van Wyk and Smith, 2001), and seven species (e.g. *Cliffortia arborea* and *Selago rigida*) that are centred on the Roggeveld Escarpment also extend beyond Teekloof Pass/Fraserburg area as far east as the Beaufort West section of the Nuweveldberge. This continuation of these species is however biogeographically reasonable given that the Hantam–Roggeveld–Nuweveld is effectively one continuous section of the Great Escarpment with no major intervals (see Chapter 1), although there is an important climate gradient from winter rainfall in the west to summer rainfall in the east (Van Wyk and Smith, 2001). Faunal endemism mirrors plant endemism in this regard, with the *Pseudocordylus microlepidotus namaquensis* (Cape Crag Lizard) occurring from Sutherland to Beaufort West (Branch, 1998), and three butterfly species shared between the Roggeveld and Nuweveld (Woodhall, 2005). Appendix 5.1 is thus a review of all species indicated as HRC endemics by Hall and Veldhuis (1985), Van Wyk and Smith (2001) and Mucina and Rutherford (2006), with comments and notes on actual endemic status based on available literature, and including Hantam–Roggeveld Escarpment endemic species that occur as far east as Beaufort West. In terms of delimiting HRC endemics, it may be worth considering geology as the primary indicator of endemism in the HRC (for instance Van Wyk and Smith, 2001, exclude the Bokkeveld Escarpment, composed of Cape Supergroup rocks, from the HRC). Strict HRC endemics will be those confined to Karoo sediments, Karoo dolerites, and Dwyka Tillites, while near-endemics will also occur on Cape Supergroup rocks, for example on the Bokkeveld mountains (Manning and Goldblatt, 2002). In this regard it is not easy to delimit endemic status to some species in the Nieuwoudtville area, as some literature indicates presence on the Bokkeveld Escarpment (CFR) while some indicates exclusivity to the Bokkeveld Plateau for the same species. Such uncertainty has been indicated in Appendix 5.1, and a precautionary approach has been adopted in designating endemism. Dolerite is certainly one of the principal edaphic indicators of HRC endemism (Snijman and Perry, 1987; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006), although sister taxa on adjacent but different substrates are common in the Nieuwoudtville area (Mucina and Rutherford, 2006). A total of 204 endemic and 40 near-endemic species are identified (Appendix 5.1).

Faunal endemism in the Roggeveld is known to include *Cordylus minor* (Dwarf Girdled Lizard) in the Matjiesfontein area (Branch 1998). The recently described bee *Capicola hantamense* is endemic to the Hantamberge, and pollinates *Wahlenbergia* spp. (Michez and Kuhlmann, 2007). Ninety-five percent of bee species in the xeric winter rainfall area of South Africa are endemic, and includes basal taxa of different families that are of special interest for the understanding of bee phylogeny and evolution (Kuhlmann, 2005). The arid and semi-arid areas of South Africa are the only place in the world where a centre of bee diversity co-incides with a phytogeographical centre, suggesting co-evolution of the both bees and flowers in this area (Kuhlmann, 2005). *Thestor pringlei* (Pringle's Skolly) and *Phasis pringlei* (Pringle's Arrowhead) are butterflies endemic to the Roggeveld Escarpment, while *Chrysoritis azurius* (Azure Opal) extends from the Roggeveldberge to Nieuwoudtville (Woodhall, 2005). *Trimenia wykehami* (Wykeham's Silver-spotted Copper), *Aloeides kaplani* (Kaplan's Copper) and *Chrysoritis midas* (Midas Opal) are endemic to the Roggeveldberge and Nuweveldberge (as far as Beaufort West; Woodhall, 2005). *Chrysoritis beaufortius* (Beaufort Opal) extends from the Kamiesberg in the north through the Roggeveld and Nuweveldberge (Woodhall, 2005). *Lepidochrysops macgregori* (McGregor's Blue) (sic) occurs on the Roggeveld Escarpment and near Nieuwoudtville, and *L. jamesii* (James's Blue) on the Hantam–Roggeveldberge. Interestingly enough, there is a disjunction between higher sections of the Roggeveld (such as the Swaarweerberg) and the Hantamberge in some of these butterfly species (Woodhall, 2005).

5.4. Biogeographical Connections

The HRC has interesting biogeographical connections both locally and abroad. Van Wyk and Smith (2001) elucidate very thoroughly the various biogeographical linkages present, summarised as follows.

5.4.1. HRC–CFR connections

Weimarck (1941) delimited a Hantam–Roggeveld Subcentre as a satellite part of his North-western (NW) Centre, based on the large number of species common to the northern CFR mountains and this section of the Great Escarpment (Born et al., 2007). He notes Cape elements only occurring on the highest sections of the Roggeveld Escarpment. He cites Diels (1909) as indicating the Hantamberge above 1 400 m as "*having a purely Cape character*" (Weimarck, 1941, p. 67), but notes that typical

CFR families such as Ericaceae and Proteaceae are absent while "*other Cape species occur in quantities*" (Weimarck, 1941, p.67). His conclusion is that the Subcentre is somewhat weakly supported based on the comparatively few Cape elements, but that the Cape species represented have enough biogeographical virility to warrant subcentre delimitation. Nordenstam (1969) likewise noted strong links between his Western Upper Karoo Centre (i.e. Hantam–Roggeveld–Nuweveld) and the CFR (Van Wyk and Smith, 2001).

The interval between the Hantam–Roggeveld Escarpment and the CFR is referred to by Weimarck (1941) as the Doorn River Interval, referring specifically to the gap between the Cederberg and the Roggeveld, i.e. the Tankwa (or Ceres) Karoo. Species indicated as disjunct across this interval are *Elegia asperiflora* (Nees) Kunth, *Ischyrolepis curviramis* (Kunth) H.P.Linder, *Ischyrolepis monanthos* (Mast.) H.P.Linder and *Cliffortia ramosissima* (Weimarck, 1941). Weimarck (1941) postulates a route across the Doorn River valley in the north-west or an easterly route via the Klein-Roggeveldberge and Koedoesberge (i.e. the Matjiesfontein connection; see Chapter 6). The latter is quite feasible considering there is a gap less than 20 km wide between the Witteberg and the Klein-Roggeveldberge in the vicinity of Matjiesfontein, and the Komsberg is only 80 km north of the Witteberg. As most CFR species on the Hantam–Roggeveld show close connection to Weimarck's (2001) KM Centre (especially the Witteberg) and NW Centre (especially the Cederberg), it is probable that local dispersal events can account for most of the abundant examples of species shared between the HRC and adjacent CFR mountains (Van Wyk and Smith, 2001). Similarly, as the HRC abuts the CFR in the west (Bokkeveld Mountains, Nieuwoudtville District), it is not surprising that the HRC has a close affinity with the CFR (Van Wyk and Smith, 2001). Connections are particularly evident in geophytes such as *Lachenalia*, *Babiana*, *Hesperantha*, *Gladiolus*, *Romulea*, etc. (Goldblatt 1984; Duncan, 1997; Goldblatt and Manning, 1998, 2004; Manning et al., 2002; Duncan and Edwards, 2006, etc.), and succulent genera such as *Euphorbia* and *Haworthia* Duval (Van Wyk and Smith, 2001). The Fabaceae genus *Polhillia* C.H.Stirt. (less than 10 species, with *P. involucrata* endemic to the Roggeveld; Stirton, 1986; Van Wyk, 1992), *Euryops* (Nordenstam, 1969), and the grass genus *Prionanthum* Desv. (two species in the CFR and *P. dentatum* endemic to the HRC; Gibbs Russell et al., 1990) are further examples of connections with the CFR. *Ischyrolepis distracta* and *I. laniger* – widespread montane Restionaceae – were collected on Sneeukrans, where they are common but not encountered elsewhere on the Roggeveld or Komsberg in this study.

More ancient connection and subsequent disjunction is suggested by *Cliffortia arborea*, *C. dichotoma* Fellingham and *C. conifer* E.G.H.Oliv. & Fellingham, the three species in *Cliffortia* section Arboreae (Van Wyk and Smith, 2001; Whitehouse, 2002). While *C. conifera* is confined to the Anysberg (adjacent to the Witteberg in Weimarck's, 1941, KM Centre), *C. arborea* is endemic to the Great

Escarpment from the Hantamberge to the Nuweveldberge (Oliver and Fellingham, 1994; Van Wyk and Smith, 2001), and *C. dichotoma* is endemic to the sandstone escarpment of the CFR south of Nieuwoudtville. (Whitehouse, 2002, indicates that a form of *C. arborea* has been found which may constitute a new species). The long-lost *C. bolusii* from the Sneeuberg (Whitehouse, 2002; Clark et al., 2009) may also be a component of section Arboreae, suggesting Great Escarpment links to the east as well.

Born et al. (2007) suggest a reclassification of the CFR that constitutes a "Greater CFR", essentially incorporating the pure winter rainfall areas of South Africa (Bergh et al., 2007), i.e. the Fynbos and Succulent Karoo Biomes, and which includes the HRC west of Sutherland. The problematic element in this regard is the Nuweveldberge. Being in transition between summer and winter rainfall zones in South Africa, the Nuweveldberge is considered (at least partly) to be part of the HRC by Van Wyk and Smith (2001) but not so by Born et al. (2007), being primarily summer rainfall. Nevertheless numerous HRC-centred endemics run along the southern Great Escarpment from the Hantamberge to Beaufort West, indicating some floristic linkage regardless of rainfall regime. This issue of boundary delimitation will probably never be completely resolved (Born et al., 2007).

5.4.2. Hantam–Roggeveld–DAC connections

There are several taxa which suggest a connection between the HRC and the DAC (Weimarck, 1941; Van Wyk and Smith, 2001). Weimarck's (1941) *Cliffortia* section Complanatae has four species, three in the CFR (including the previously-considered Hantam-endemic *C. hantamensis* Diels; Whitehouse, 2002), and one species in the DAC (Van Wyk and Smith, 2001), although Whitehouse (2002) has revised Weimarck's (1941) classification substantially. Another possible HRC–DAC link is the genus *Saniella* Hilliard & B.L.Burtt, which has two species – *S. verna* Hilliard & B.L.Burtt in the DAC and *S. occidentalis* in the HRC (Burtt, 2000; Van Wyk and Smith, 2001). Three *Heliophila* L. species occurring in the DAC (*H. carnosa*, *H. rigidiuscula*, *H. suavissima*) are nested in a clade which has the Richtersveld (or the Richtersveld and the Roggeveld) as its ancestral area (Mummenhoff et al., 2005). Mummenhoff et al. (2005) postulate that the harsh DAC "alpine" environment might have similarities to the harsh semi-desert environment of the Namaqualand Escarpment. *Romulea luteoflora* var. *luteoflora* (from the Kamiesberg through the HRC to Riversdale) and *R. luteoflora* var. *sanisensis* M.P.de Vos (DAC), *Manulea incarnata* (an HRC endemic most closely related to *M. dregei* Hilliard & B.L.Burtt and *M. platystigma* Hilliard & B.L.Burtt, both from the DAC), *Aponogeton fugax* J.C.Manning & Goldblatt (from the Bokkeveld through the the Elim plain) and *A. ranunculiflorus* Jacot Guill. & Marais (a DAC endemic) are additional examples (Van Wyk and Smith, 2001; Manning et al., 2008). *Cynoglossum obtusicalyx*, which occurs on the Hantamberge, the

Nuweveldberge at Beaufort West, and in the Ceres area, indicates connections along the western Great Escarpment and with the CFR, while other species in the genus are mainly eastern, DAC species (Retief and Van Wyk, 1996).

Given both the DAC and HRC's extreme cold (Van Wyk and Smith's, 2001, Positive Chill Units of 1 500 for the Roggeveld are equalled only by the summits of some of the inland Cape Fold Ranges and the Kamiesberg) and clay soils, it is not surprising that certain links between them occur. Another similarity is that HRC endemics are often found on dolerite (Van Wyk and Smith, 2001; Goldblatt and Manning, 2002; Mucina and Rutherford, 2006) – dolerite is geochemically similar to the basalts of the DAC (Marsh and Mndaweni, 1998), and several DAC endemics have recently been discovered on the Sneeuberg, which are largely comprised of dolerite (Clark et al., 2009; see Chapter 2). Basalt/dolerite-derived soils may thus be a factor in endemism on the southern Great Escarpment. Key differences between the HRC and DAC however are the rainfall, with the Roggeveldberge having a MAP of 400 mm per annum and the DAC receiving no less than 650 mm per annum (Van Wyk and Smith, 2001; Mummenhoff et al., 2005). The rainfall regime in the HRC is winter rainfall, and summer in the DAC (Van Wyk and Smith, 2001; Mummenhoff et al., 2005) although both have
(relatively in terms of the Roggeveld Escarpment compared to other arid areas on the subcontinent including the Nuweveldberge) reliable rainfall and regular snowfalls.

Other species suggestive of remnants of such a Great Escarpment corridor or connection are *Helichrysum trilineatum* (common in the Sneeuberg but only found on the higher peaks of the Roggeveld and Nuweveldberge such as Sneeukrans, Bontberg and Karelkraal-se-berg), *Brachypodium bolusii* (confined to shaded cliff-bases), *Cromidon decumbens* (Hilliard, 1990; Mummenhoff et al., 2005), and *Euryops empetrifolius* and *E. petraeus* (Nordenstam, 1969). As mentioned previously, the Sneeuberg endemic *Cliffortia bolusii* may be a relictual species in section Arboreae, as suggested by Whitehouse and Fellingham (2007), and would strongly support a Great Escarpment connection. Similarly, the affinity of the recently described Sneeuberg endemic *Hesperantha helmei* with the Roggeveld species *H. ciliolata* and *H. teretifolia* (Goldblatt and Manning, 2007), suggests connections along the southern Great Escarpment. It is effectively only the Western and Central Nuweveldberge, which being more arid than the rest of the southern Great Escarpment, that does not exhibit connections with the DAC. This may be simply due to the current aridity of the Nuweveldberge, falling into the “no man's land” in terms of rainfall regime, and subsequent local extinction of DAC indicator species. The lack of Ericaceae and Proteaceae in the HRC is interesting, as elements are present in the Sneeuberg, DAC and Kamiesberg, but absent from the Hantam–Roggeveld–Nuweveld Escarpment (Oliver et al., 1983).

It is also worth noting the evidence of connection between the Roggeveldberge and the Kamiesberg (Van Wyk and Smith, 2001), which then suggests a greater Great Escarpment "highway" from the Kamiesberg south to the Roggeveldberge (with an "off-ramp/on-ramp" to the CFR) and then across to the DAC.

5.4.3. Hantam–Roggeveld–Eurasian connections

Secale africanum presents a biogeographical enigma in that it is the only representative of *Secale* L. to occur in southern Africa (and in the southern hemisphere; Khush and Stebbins, 1961; Van Wyk and Smith, 2001). Van Wyk and Smith (2001) propose long-distance dispersal as a possible means by which it came to be established in the HRC. This is feasible considering the large number of waterfowl that occur in the HRC (pers. obs.). A Eurasian migrant wader or duck may have brought the species-precursor in (A. Van Wyk, pers. comm.). The similar disjunct distribution pattern is mirrored by the Fumariaceae, which occurs in the northern hemisphere and with three genera in the southern hemisphere endemic to southern Africa (Van Wyk and Smith, 2001, and Manning et al 2009), and by local indigenous versions of Eurasian grass genera such as *Hordeum* L. and *Holcus* L. (Gibbs Russell et al., 1990). Other Eurasian species occurring in the HRC are mostly alien species more recently anthropogenically introduced (Van Wyk and Smith, 2001), particularly Poaceae, Brassicaceae and Boraginaceae. Based on how well such Eurasian aliens do on the Roggeveld, Van Wyk and Smith (2001) suggest that some of the endemic CFR genera with obvious connections to the Mediterranean region (e.g. *Lobostemon* Lehm. and *Echiostachys* Levyns in the CFR vs. *Echium* L. in Europe) may have originally arrived by long-distance dispersal, rather than along the African mountain chain.

5.4.4. HRC–South American and other connections

The genus *Alonsoa* Ruiz & Pav. has connections to South and Central American Scrophulariaceae, and *Bulbinella* Kunth has centres of diversity in the HRC (on the Bokkeveld Plateau around Nieuwoudtville) and New Zealand (Van Wyk and Smith, 2001). *Salvia* L. is centred in Central and northern South America, with a secondary centre in the CFR, and a few species (none endemic) to the HRC.

5.5. Human settlement and impacts

The first European farm to be established in the Roggeveld was the Farm Uitkyk in 1746 (Schoeman, 1986). (The Farm Uitkyk includes Sneeukrans, discussed above). The Roggeveld has thus been settled for some 250 years by European pastoralists, although initially impacts on vegetation were probably minimal given the low population numbers, large farm sizes and many absentee landowners (Schoeman, 1986). Prior to this the region was occupied by the Khoikhoi and San (Schoeman, 1986), who would have had a minimal impact on the vegetation. In 1805 there were only 62 farms with 26 landowners in Middel–Roggeveld, while the Onder–Roggeveld had 47 farms with 22 landowners. The Roggeveld lay on the route to the inland mission stations and interior and was thus passed through by several well known explorers to the Cape, such as C.P. Thunberg and F. Masson on 1774 and W. Burchell in 1811 (Schoeman, 1986).

The biggest debate over human impact on the Roggeveld has been the demise of *Secale africanum*. Acocks (1988; also in Zacharias, 1990) is of the opinion that this grass (and grassland in general) was much more prominent on the Roggeveld plateau at the time of European colonisation (Schoeman, 1986; Van Wyk and Smith, 2001). Acocks (1988; also in Zacharias, 1990) believed that overgrazing exacerbated by soil erosion and drought has resulted in the current Karoo shrublands typical of these mountains, including Renosterveld (Van Wyk and Smith, 2001). Allegedly *Secale africanum* was abundant on the Roggeveld at the time of European colonisation, and from which the region got its name (Schoeman, 1986; Van Wyk and Smith, 2001). Although grazing has been implicated in its current virtual extinction (the grass is very soft and nutritious), it is also susceptible to a rust pathogen that possibly contributed to its demise (Van Wyk and Smith, 2001). Widespread use of the species for thatch may have also been a contributing factor. Currently, the species is only known to occur on the Farm Kanariesfontein (Sutherland District), where it is being propagated by Mr Koos Esterhuyse (Esterhuyse, pers. comm.; A. Van Wyk, pers. comm.). It has since also been reintroduced into the Komsberg Private Game Reserve from this farm (Esterhuyse, pers. comm.).

Suggestions have been made that *Secale africanum* is naturally confined to such moist areas along the larger rivers and in seeps, or the highest sections of the Roggeveld Escarpment, and may not ever have covered the upland, drier parts of the Roggeveld (Esterhuyse, pers. comm.; A. Van Wyk, pers. comm.), particularly when considering early descriptions such as Burchell (1815, in Schoeman, 1986, pp. 30–31): "*The country from the Roggeveld mountains to the northern boundary of the colony may be characterised as a high plain, free from large mountains, but thickly strewed over with moderate hills and elevations; having very few rivers, and all of them nearly dried up in summer; quite destitute of trees and grass, but everywhere covered with bushes springing out of a very naked red soil deprived of moisture during a great part of the year*". However Burchell (1822, pp. 255–256) notes, referring to the summit of the Roggeveld Escarpment, "*It is probable that many plants which grow on the snowey tops of great mountains, will endure the cold of the English climate*" and "*I saw non of the wild rye which has been said to be so abundant as to give the name to this district, but this might be* *owing to the season of the year*” It doesn't sound like *Secale africanum* was very widespread in 1815, at least not at that time of the year, although farmers at beginning of the 1800s reported a decline in rainfall over the previous six years. It is possible though that a purported reduction in rainfall over the past 200–300 years (A. Van Wyk, pers. comm.) may have assisted in constricting its range to perennially wet areas. It is possible that the range of the species expanded and contracted with wetter and drier cycles. The combination of grazing, susceptibility to rust, dam building, and cultivation of its moist refugial areas along the major rivers has interrupted that cycle (e.g. Van Wyk and Smith, 2001). Perhaps *Secale africanum* was only perennial in places such as the higher areas of the Roggeveld Escarpment, where it is the wettest and best for farming (Schoeman, 1986), and to mesic areas along larger rivers, which have also been mostly converted into agricultural lands.

The region has low alien infestation (Mucina and Rutherford, 2006), although the presence of innocuous (?) annual aliens such as *Erodium cicutarium* and *Amsinckia retrorsa* are abundant in disturbed areas around homesteads and along roads, while others such as *Alyssum minutum*, *Bromus diandrus* and *B. tectorum* are abundant in the natural veld (pers. obs.). Potential future threats to the vegetation of the area are possible uranium mining (Verwoed et al., 1995), wind farms, soil erosion, further cultivation and dam building, and overgrazing (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006). Mineral concerns require only basic environmental authorisation processes to be adhered to prior to any exploration or prospecting, and significant potential remains for detrimental impacts associated with mining. Van Wyk and Smith (2001) suggest priority areas for conservation being the Komsberg and Roggeveldberge and the plateau area around Sutherland. Given the high interest in the flora by the local farming community, it may be practical to implement a landowner-based conservation initiative, especially regarding local rarities such as *Polhillia involucrata* and *Cliffortia arborea*.

The main threat to the biological diversity of the Roggeveld – and perhaps the most difficult to manage – is that of global warming. There is virtually no higher ground to which most of the local endemics can migrate, and a warming of the area may result in mass extinctions and a change in vegetation to a more arid Nama-Karoo or Succulent Karoo-type flora.

5.6. Pioneer botanical work

Botanical collectors in the Roggeveld and Komsberg have been numerous, dating from C.P. Thunberg and F. Masson in 1774 (Masson, 1776; Manning and Goldblatt, 2002) to the present. It is not possible to list all of the collectors but they include well-known historical and contemporary names such as A. Batten, W. Burchell, W.F. Barker, M.P. De Vos, P. Goldblatt, K. Hiemstra, J. Lavranos, F.M.

Leighton, J.C. Manning, E.M. Marais, R. Marloth, E. Meyer, N. Helme, E.G.H. Oliver, E.A. Schelpe, F.R.R. Schlechter, D. Snijman, K.E. Steiner, G.C. Summerfield, M.L. Thomas, A.M. Van der Merwe, H. Van Zijl, A.M. Venter etc. (Leighton, 1945; Barker, 1979, 1984; Goldblatt, 1979a, b; De Vos, 1987; Steiner, 1992, 1995; Marais, 1998; Burtt, 2000; Van der Merwe and Marais, 2002; Manning and Goldblatt, 2006; Venter, 2007). Recent floristic work has been undertaken by Van der Merwe et al. (2009a, b), and the area has been receiving more collecting focus in recent years.

5.7. Compilation of a flora of the Roggeveld and Komsberg

Three extensive fieldtrips were undertaken between 2007 and 2009 (Table 5.1), covering a wide variety of habitat on the Roggeveld and Komsberg. A total of 1 098 specimens was collected, and the species processed as for the Sneeuberg in Chapter 2. The species obtained from the fieldwork have been augemented by species noted from literature sources (mostly taxonomic revisions and treatments) and historical specimens in GRA where these have been encountered.

A total of 506 taxa have been recorded (Appendix 5.2). While this list is by no means exhaustive, it provides a contribution towards a comprehensive flora that will be useful for biogeographical analysis (Born et al., 2007 and Chapter 6) and conservation assessments.

Table 5.1: Collecting localities in the Roggeveld and Komsberg during the study period (2007–2009).

Localities	Dates	Collectors	Grids
1. Komsberg.	September 2007.	Clark VR, Kelly C.	3220DA
2. Roggeveld.	September 2008.	Clark VR, O'Connor R.	3220AB, AD, BC, BD
3. Roggeveld.	October 2008.	Clark VR, Coombs G; Clark VR.	3220AD, BA

5.8. Important collections

Several finds of interest have been made since 2007, including several new species, contributions to several previously known but undescribed new species, and collection contributions to several poorly-collected and poorly known endemics.

5.8.1. New species

A new species of *Asparagus*, confined to south-facing cliff bases on the Roggeveld and western Nuweveld, was discovered and is being investigated further (S. Burrows, pers. comm.). A new species of *Euryops* was discovered on Sneeukrans (Nordenstam, pers. comm.). Further material of the recently identified *Ursinia* sp. nov. "*roggeveldensis*" was collected, as well as what appear to be to be two new species of *Cotula* (sp. no.'s 3 and 4; excluded from Appendix 5.1 pending further consideration). The first flowering material of the locally abundant *Agathosma* sp. nov. "*roggeveldensis*" (Trinder-Smith, pers. comm.) was obtained, as was material of a more widely distributed *Lachenalia* sp. nov. from Komsberg Pass (Duncan, pers. comm.).

5.8.2. Collections of poorly-known endemics

Polhillia involucrata, previously only known from the Middelpos area (Stirton, 1986), was collected on the southern Roggeveld, closer to Sutherland on the Farm Kanariesfontein. This rare species requires considerable conservation attention (B-.E. Van Wyk, pers. comm.), and the landowner has been communicated with in this regard. Additional material of the very poorly known endemic *Arctotis sulcocarpa* (McKenzie et al., in prep.) was collected. The poorly-collected species *Delosperma sphalmantoides* was collected on the Swaarweerberg, while *Oxalis marlothii*, only known from the type (Salter, 1944) was recollected twice from near the Sneeukrans type locality (Oberlander, pers. comm.). *Oxalis* sp. aff. s*trigosa* – a local anomaly very similar to the rare Western Cape species *O. strigosa* (Salter, 1944; Obermeyer, pers. comm.) – was collected below Sneeukrans. It is probably the same species as that collected at Hoenderhoek on the Roggeveld by Marloth (Salter, 1944). The plant has yet to be collected in flower however (Salter, 1944; Oberlander, pers. comm.). Further material of an endemic *Spiloxene* sp. nov. (Snijman, pers. comm.) was collected. *Delosperma acocksii* – apparently not collected since Acocks's collection (published by Bolus in 1958; Hartmann, 2001a) – was recollected on the Roggeveld Escarpment below Kanariesfontein. *Drosanthemum floribundum*, indicated by Hartmann (2001a) as having an unknown distribution, is abundant on the Roggeveld Escarpment at Ouberg Pass. *Stomatium villettii*, described from Beaufort West (probably on the Nuweveldberge; Hartmann, 2001b) has now also been collected on the Roggeveld.

5.8.3. Range extensions and other collections of interest

The range of *Gladiolus karooica* was extended from the Little Karoo onto the Komsberg section of the Roggeveld Escarpment (Manning, pers. comm.). Several specimens of what appears to be a range extension of the Sneeuberg endemic *Helichrysum tysonii* (Hilliard, 1983; Clark et al., 2009) across the

Nuweveldberge onto the Roggeveld were collected, but the species-complex of which *H. tysonii* is a part should probably be revised. Several specimens of *Asparagus ferox*, a newly discerned species ocurring from the Roggeveld across the Nuweveld to the Sneeuberg (S. Burrows, pers. comm.), were collected. Material of the recently described (but not endemic) *Ixia sobolifera* subsp. *sobolifera* was collected (Manning, pers. comm.). *Euphorbia eustacei* was collected on the Komsberg and Roggeveldberge, a species otherwise only known from the Matjiesfontein area (White et al., 1941). *Aethephyllum pinnatifidum*, a CFR species occurring from Worcester to van Rhynsdorp (Hartmann, 2001a) has now also be collected on the Roggeveld (Burgoyne, pers. comm.). *Cleretum lyratifolium*, *Ruschia altigena* and *R. nana* are all range extensions from the Laingsburg area (Hartmann, 2001a, b) onto the Roggeveld, while *R. putterillii* is a DAC near-endemic (Carbutt and Edwards, 2006) now also known from the Komsberg (Burgoyne, pers. comm. – but not from the Nuweveldberge surprisingly). *Trichodiadema setuliferum*, with distribution listed as "*Somerset East?*" by Hartmann (2001b), is now known from the eastern Nuweveldberge (see Chapter 4) and from the Roggeveld (Burgoyne, pers. comm.). *Anthospermum monticola*, a DAC near-endemic (Carbutt and Edwards, 2006) previously considered to occur only as far west as the Sneeuberg (Clark et al., 2009), has been recorded across the Nuweveldberge (see Chapter 4) and also now on Sneeukrans in the Roggeveldberge. The sedge *Isolepis angelica*, previously considered to be a DAC endemic (Carbutt and Edwards, 2006), is now also known from the Roggeveld.

5.9. Conclusion

The HRC is a difficult centre of endemism to delimit. Although the core of the HRC is clear and easily defined (as occurring on a substrate of Karoo sediments and dolerite and falling into a winter rainfall zone), the northern and eastern extents are not as easy to delimit. Fifteen HRC endemics (of 204) extend onto the Nuweveldberge, seven of which occur across to the Eastern Nuweveldberge. This suggests that the HRC could be extended to include the entire Nuweveldberge, thus supporting Nordenstam's (1969) "Upper Western Karoo Centre" and incorporating one discrete section of Great Escarpment, namely the Hantam–Roggeveld–Nuweveld Escarpment as identified in Chapter 1. This is supported by both geomorphology (being one orographic entity with no major or minor intervals) and shared faunal endemism. However one could also argue for a narrower HRC extending only as far east as the summer-winter transition zone on the Great Escarpment: this would mean an eastern limit at the Besemgoedberge (immediately east of the Komsberg) and the complete exclusion of the Nuweveldberge. Thus the endemics that extend onto the Nuweveldberge would be considered as near-endemics. From a climatic point of view – and in terms of the minority of endemics running onto the Nuweveldberge – this is reasonable, but the broad rainfall transition zone makes for a nebulous and unsatisfying boundary. Inland, the 50/50% summer-winter transition area is the only suitable (but still nebulous) cut-off point as there are no obvious or distinct land-surface features that offer a convenient and clear cut-off line. Detailed collecting in the transition area in the east and north may provide more data on the distributions of HRC endemics and provide data for a better floristic delimitation. Until such a time as this is obtained, it is proposed that the HRC be delimited as extending from the edge of the Karoo sediments and dolerites in the west and south, northwards to the 50/50% summer-winter transition area, and eastwards to include the entire Nuweveldberge.

It is hypothesised that the higher sections of mountain on the Hantam–Roggeveldberge are nodes of speciation or refugia and host a higher level of endemism and diversity than the remainder of the Great Escarpment in this region. This is evident by the numerous endemics only known from Sneeukrans and the Hantamberge. This is probably also true for other high points such as the Swaarweerberg. These high points should be important foci for future conservation initiatives in the HRC.

The Hantam–Roggeveldberge (including the Komsberg) forms the key montane component of the HRC. Despite an increase in plant collecting in recent years they still remain poorly botanised. It is possible with increased collecting that a flora of between 1 500 and 2 000 species will become available, which will substantially increase the accuracy of phytogeographical analysis of this section of the Great Escarpment and of the HRC.

Appendix 5.1: Notes on plant species purported in the literature to be endemic to the HRC: (A) Valid HRC endemics, including endemics found as far east as the Eastern Nuweveldberge; (B) Species near-endemic to the HRC; (C) Species purported to be HRC endemics or near-endemics in the literature but apparently neither. AFPD = African Flowering Plants Database (2009).

Species	Family	Notes	References
(A) Species endemic to the HRC.			
Agathosma sp. nov. "*roggeveldensis*"	Rutaceae	Dolerite tors in the Roggeveld, where locally abundant. Endemic.	Trinder-Smith, pers. comm.
Aloinopsis malherbei (L.Bolus) L.Bolus	Mesembryanthemaceae	Hantam Karoo, Calvinia. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Aloinopsis spathulata (Thunberg) L.Bolus	Mesembryanthemaceae	Sutherland area. Endemic.	Hartmann, 2001a.
Androcymbium crispum Schinz	Colchicaceae	Hantamberg in Hantam Karoo. Gravelly clay in karroid scrub. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Androcymbium hantamense Engl.	Colchicaceae	Roggeveld Shale Renosterveld. Endemic.	Müller-Doblies and Müller-Doblies, 2002; Mucina and Rutherford, 2006.
Androcymbium latifolium Schinz	Colchicaceae	Bokkeveld Plateau and western Karoo, on dolerite and clay flats. Endemic.	Manning et al., 2002.
Androcymbium praeirroratum U.Müll.-Doblies & D.Müll.-Doblies	Colchicaceae	Hantamberg. Endemic.	Müller-Doblies and Müller-Doblies, 2002.
Androcymbium pulchrum Schltr. & Krause	Colchicaceae	Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy clay in dolerite hills. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Antimima androsacea (Marloth & Schwantes) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo, Calvinia and Sutherland areas. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Antimima dekenahi (N.E.Br.) H.E.K.Hartmann	Mesembryanthemaceae	From Williston to Fraserburg. Endemic.	Hartmann, 2001a.
Antimima emarcescens (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Sutherland area. Endemic.	Hartmann, 2001a.
Antimima gracillima (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo, Calvinia. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.

Antimima hallii (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo, Calvinia. Endemic.	Hartmann, 2001a.
Antimima ivori (N.E.Br.) H.E.K.Hartmann	Mesembryanthemaceae	Sutherland and Fraserburg districts. Endemic.	Hartmann, 2001a.
Antimima lokenbergensis (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Calvinia. Endemic.	Hartmann, 2001a.
Antimima prolongata (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo, Calvinia and Sutherland areas. Endemic.	Hartmann, 2001a.
Antimima stayneri (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo. Calvinia. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Antimima subtruncata (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Calvinia and Sutherland areas. Endemic.	Hartmann, 2001a.
Arctotheca marginata Beyers	Asteraceae	Occurs in deep, sandy, waterlogged soil in the Nieuwoudtville area. Endemic.	Beyers, 2002.
Arctotis sulcocarpa K.Lewin (to become *Alatotheca sulcocarpa* (K.Lewin) R.J.McKenzie)	Asteraceae	Nieuwoudtville-Roggeveld Dolerite Renosterveld and Roggeveld Shale Renosterveld. Only known from eight collections. Endemic.	McKenzie et al., in prep.
Aspalathus obliqua Dahlg.	Fabaceae	Bokkeveld Plateau. Only known from the type. Endemic.	Dahlgren, 1988.
Babiana praemorsa Goldblatt & J.C.Manning	Iridaceae	From the Hantamberge to Bloukrans Pass, in Hantam Plateau Dolerite Renosterveld. Endemic.	Goldblatt and Manning, 2004; Mucina and Rutherford, 2006.
Babiana spathacea (L.f.) Ker Gawl	Iridaceae	Hantam Karoo, on clay and dolerite soils. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Babiana symmetrantha Goldblatt & J.C.Manning	Iridaceae	On the Langberg, west of Loeriesfontein. In heavy red dolerite clay on summit. Endemic.	Goldblatt et al., 2008.
Babiana virginea Goldblatt	Iridaceae	Roggeveld Escarpment at Middelpos. Endemic.	Goldblatt, 1979b; Manning et al., 2002.
Berkheya glabrata (Thunb.) Fourc.	Asteraceae	Hills east of Nieuwoudtville, in heavy red clay in low dolerite outcrops. Endemic.	Manning and Goldblatt, 2002.

Bulbinella latifolia subsp. *doleritica* P.L.Perry	Asphodelaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Restricted to dolerite clay. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Carex acocksii C.Archer	Cyperaceae	Hantamberge, on plateau along watercourses. Endemic.	Van Wyk and Smith, 2001.
Cephalophyllum hallii L.Bolus	Mesembryanthemaceae	Hantam Karoo, Calvinia, on shale. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Cliffortia arborea Marloth	Rosaceae	Hantamberge to the Eastern Section of the Nuweveldberge. Endemic.	Oliver and Fellingham, 1994; Mucina and Rutherford, 2006.
Corycium ingeanum E.G.H.Oliver	Orchidaceae	Nieuwoudtville Shale Renosterveld. Gravelly clay soils. Endemic.	Linder and Kurzweil, 1999; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Crassula roggeveldii Schonl.	Crassulaceae	Hantamberg and Roggeveld. Endemic.	Tölken, 1977.
Crassula vestita Thunb.	Crassulaceae	Southern Roggeveldberge. Endemic.	Tölken, 1977.
Cromidon varicalyx Hilliard	Scrophulariaceae	Hantam Karoo. Heavy dolerite clay in karroid scrub. Nieuwoudtville area and Roggeveld. Endemic.	Hilliard, 1990; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Cyanella aquatica G.Scott	Tecophilaeaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Occurs at the base of dolerite outcrops in heavy wet clay. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Daubenya alba A.M.van der Merwe	Hyacinthaceae	East of Nieuwoudtville and on the Roggeveld, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Endemic.	Van der Merwe and Marais, 2002; Mucina and Rutherford, 2006.
Daubenya aurea Lindl.	Hyacinthaceae	Roggeveld in the Middelpos area. Roggeveld Shale Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Daubenya capensis (Schltr.) A.M.van der Merwe & J.C.Manning	Hyacinthaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Daubenya stylosa (W.F.Barker) A.M.van der Merwe & J.C.Manning (=*Amphisiphon stylosa* W.F.Barker)	Hyacinthaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy clay in dolerite outcrops. Endemic.	Van Wyk and Smith, 2001; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.

Delosperma acocksii L.Bolus	Mesembryanthemaceae	Roggeveldberge. Endemic.	Hartmann, 2001a.
Delosperma sphalmantoides S.A.Hammer	Mesembryanthemaceae	Roggeveld and Komsberg. Endemic.	Hammer, 1993; Burgoyne, pers. comm.
Devia xeromorpha Goldblatt & J.C.Manning	Iridaceae	Roggeveld Escarpment in the vicinity of Sneeukrans. Endemic.	Goldblatt and Manning, 1990; Manning et al., 2002; Mucina and Rutherford, 2006.
Diascia cardiosepala Hiern	Scrophulariaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Deep, red dolerite clay. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Diascia dissimulans Hilliard & Burtt	Scrophulariaceae	Hantamberg area. Endemic.	Hilliard and Burtt, 1984.
Diascia floribunda MS.	Scrophulariaceae	Roggeveld. Endemic.	Steiner, pers. comm.
Diascia fragrans K.E.Steiner	Scrophulariaceae	Between Nieuwoudtville and Loeriesfontein, and between Tanqua Karoo and Roggeveldberge. Endemic.	Steiner, 1995.
Diascia lewisiae K.E.Steiner	Scrophulariaceae	Endemic to Nieuwoudtville and the Roggeveld Escarpment. Endemic.	Steiner, 1992.
Diascia macrophylla (Thunb.) Spreng.	Scrophulariaceae	Hantamberge and Roggeveld in Hantam Karoo. Endemic.	Hilliard and Burtt, 1984; Mucina and Rutherford, 2006.
Diascia nana Schltr.	Scrophulariaceae	Gravelly clay in the western Karoo. Endemic.	Manning and Goldblatt, 2002.
Dorotheanthus booysenii L.Bolus	Mesembryanthemaceae	In sandy fields, Roggeveld. Endemic.	Bolus, 1969; Hartmann, 2001a.
Dorotheanthus maughanii (N.E.Br.) Ihlenf. & Struck	Mesembryanthemaceae	Hantam Karoo, in gravelly clay near Calvinia. Endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Drosanthemum concavum L.Bolus	Mesembryanthemaceae	North of Calvinia. Endemic.	Bolus, 1929; Hartmann, 2001a.
Drosanthemum eburneum L.Bolus	Mesembryanthemaceae	Sutherland. Endemic.	Hartmann, 2001a.

Drosanthemum floribundum (Haw.) Schwantes	Mesembryanthemaceae	Distribution indicated as unknown by Hartmann, 2001a. Abundant on the Roggeveld Escarpment at Ouberg Pass, Sutherland area. Endemic?	Hartmann, 2001a.
Drosanthemum glabrescens L.Bolus	Mesembryanthemaceae	Hantam Karoo. Calvinia. Endemic.	Bolus, 1930; Hartmann, 2001a; Mucina and Rutherford, 2006.
Ehrharta eburnea Gibbs Russell	Poaceae	Hantamberg–Roggeveld, in Rensoterveld on mountain slopes. Endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001.
Emilia hantamensis J.C.Manning & Goldblatt	Asteraceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Endemic.	Manning and Goldblatt, 2001; Mucina and Rutherford, 2006.
Eriocephalus purpureus Burch.	Asteraceae	From Loeriesfontein to Matjiesfontein in mountainous areas. Endemic.	Müller et al., 2001.
Eriospermum lanimarginatum (=*lammarginatum*) P.L.Perry	Hyacinthaceae	Calvinia, and Roggeveld, on heavy clay soils. Endemic.	Perry, 1989, 1994.
Eriospermum macgregoriorum P.L.Perry	Hyacinthaceae	From Nieuwoudtville to Calvinia, in heavy dolerite clays on flats. Endemic.	Perry, 1994; Manning et al., 2002.
Euphorbia aspericaulis Pax	Euphorbiaceae	Hantamberge. Endemic.	White et al., 1941.
Euryops marlothii B.Nord.	Asteraceae	Hantamberge and Roggeveld. Endemic.	Nordenstam, 1969.
Euryops mirus B.Nord.	Asteraceae	Nieuwoudtville area in Nieuwoudtville Shale Renosterveld. Endemic.	Nordenstam, 1969; Mucina and Rutherford, 2006.
Euryops rosulatus B.Nord.	Asteraceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Endemic.	Nordenstam, 1969; Mucina and Rutherford, 2006.
Euryops sp. nov.	Asteraceae	Roggeveld, on Sneeukrans. Endemic.	Nordenstam, pers. comm.
Euryops sulcatus (Thunb.) Harv.	Asteraceae	Hantamberge and Komsberg. Roggeveld Shale Renosterveld. Endemic.	Nordenstam, 1969; Mucina and Rutherford, 2006.
Euryops trifidus (L.f.) DC.	Asteraceae	Hantamberge to the Eastern Section of the Nuweveldberge. Endemic.	Nordenstam, 1969.
Euryops virgatus B.Nord.	Asteraceae	Nieuwoudtville area. Endemic.	Nordenstam, 1969.

Galeomma oculus-cati (L.f.) Rauschert	Asteraceae	Calvinia and Sutherland areas, in Hantam Karoo. Endemic.	Hilliard, 1983; Mucina and Rutherford, 2006.
Geissorhiza corrugata Klatt	Iridaceae	South-west of Calvinia in Hantam Karoo. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Geissorhiza inaequalis L.Bolus	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy dolerite clay among rocks. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Geissorhiza karooica Goldblatt	Iridaceae	Roggeveldberge to Matjiesfontein. Endemic.	Manning et al., 2002.
Geissorhiza spiralis (Burchell) M.P.de Vos ex Goldblatt	Iridaceae	Roggeveld in the Sutherland area. Endemic.	Manning et al., 2002.
Gethyllis pectinata D.Müller-Doblies	Amaryllidaceae	Nieuwoudtville to Calvinia. Upland clay flats among dolerite boulders. Endemic.	Manning et al., 2002.
Gethyllis roggeveldensis D.Müller-Doblies	Amaryllidaceae	Calvinia to Matjiesfontein. Endemic.	Manning et al., 2002.
Gladiolus lapeirousioides Goldblatt	Iridaceae	Occurs in a small area near Loeriesfontein. Endemic.	Goldblatt and Manning, 1998.
Gladiolus marlothii G.J.Lewis	Iridaceae	Central Roggeveld Escarpment in Roggeveld Shale Renosterveld. Endemic.	Goldblatt and Manning, 1998; Mucina and Rutherford, 2006.
Haemanthus barkerae Snijman	Amaryllidaceae	Roggeveld and Calvinia and Loeriesfontein area, in Hantam Karoo. Endemic.	Snijman, 1984; Mucina and Rutherford, 2006.
Hammeria gracilis Burgoyne	Mesembryanthemaceae	Sutherland. Endemic.	Hartmann, 2001b.
Haworthia semiviva (V.Poelln.) Bayer	Asphodelaceae	Roggeveld and Nuweveldberge from Middepos to Beaufort West. Endemic.	Bayer, 1982.
Helictotrichon namaquense (Stapf) Schweick.	Poaceae	On the Roggeveld in Roggeveld Karoo. Endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001; Mucina and Rutherford, 2006.
Heliophila collina O.E.Schulz	Brassicaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy dolerite clay on the Bokkeveld Plateau. Endemic.	Marais, 1970; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Hermannia johanssenii N.E.Br.	Sterculiaceae	Nieuwoudtville Shale Renosterveld, on clay soils. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.

Hesperantha ciliolata Goldblatt	Iridaceae	On the Roggeveld in the vicinity of Sneeukrans, in Roggeveld Karoo. Endemic.	Goldblatt, 1984; Mucina and Rutherford, 2006.
Hesperantha hantamensis Schltr. ex R.C.Foster	Iridaceae	On the Hantam plateau, in Hantam Plateau Dolerite Renosterveld. Endemic.	Goldblatt, 1984; Mucina and Rutherford, 2006.
Hesperantha karroica Goldblatt	Iridaceae	The base of the Hantamberge. Endemic.	Goldblatt, 1984; Goldblatt and Manning, 2007.
Hesperantha luticola Goldblatt	Iridaceae	Hantamberg and Roggeveldberge in Roggeveld Karoo. Endemic.	Goldblatt, 1984; Mucina and Rutherford, 2006.
Hesperantha oligantha (Diels) Goldblatt	Iridaceae	On the Hantam plateau, in Hantam Plateau Dolerite Renosterveld. Endemic.	Goldblatt, 1984; Mucina and Rutherford, 2006.
Hesperantha purpurea Goldblatt	Iridaceae	In an area north of the Hantamberg. Endemic.	Goldblatt, 1984.
Hesperantha quadrangula Goldblatt	Iridaceae	Hantamberg. Endemic.	Goldblatt, 1984.
Hesperantha rivulicola Goldblatt	Iridaceae	Along streams in renosterveld on the Bokkeveld Plateau. Endemic.	Goldblatt, 1984; Manning and Goldblatt, 2002.
Hesperantha teretifolia Goldblatt	Iridaceae	On the Roggeveld in Roggeveld Karoo. Endemic.	Goldblatt, 1987b; Mucina and Rutherford, 2006.
Hesperantha vaginata (Sweet) Goldblatt	Iridaceae	Calvina-Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy doleritic clay soils. Endemic.	Goldblatt, 1984; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Indigofera hantamensis Diels	Fabaceae	Hantamberg. Endemic, although also possibly from the Eastern Nuweveldberge.	Diels, 1909; Schrire, pers. comm. (See also Chapter 4).
Indigofera sp. E	Fabaceae	Roggeveld, Klein-Roggeveld and Nuweveld mountains. Endemic.	Schrire, pers. comm.
Ixia amethystina J.C.Manning & Goldblatt	Iridaceae	Roggeveld Escarpment. Endemic.	Manning and Goldblatt, 2006.
Ixia brevituba G.J.Lewis	Iridaceae	Roggeveld. Endemic.	Lewis, 1962.
Ixia curvata G.J.Lewis	Iridaceae	Hantamberg and Roggeveld, in Hantam Karoo. Endemic.	Lewis, 1962; Mucina and Rutherford, 2006.
Ixia rapunculoides Delile	Iridaceae	Fom the Langberg west of Loeriesfontein south to Sutherland. Endemic.	Goldblatt and Manning, 2008.

Ixia rivulicola Goldblatt & J.C.Manning	Iridaceae	Bo-Visrivier on the Roggeveld Escarpment. Endemic.	Goldblatt and Manning, 2008.
Ixia robusta (G.J.Lewis) Goldblatt & J.C.Manning	Iridaceae	East and north of the Hantamberg, in heavy dolerite-derived clay among dolerite boulders. Endemic.	Goldblatt and Manning, 2008.
Ixia thomasiae Goldblatt	Iridaceae	Roggeveld Escarpment in Roggeveld Shale Renosterveld. Endemic.	Goldblatt, 1979b; Mucina and Rutherford, 2006.
Jamesbrittenia incisa (Thunb.) Hilliard	Scrophulariaceae	Calvinia and the Middle Roggeveld. Endemic.	Hilliard, 1994.
Lachenalia alba G.D.Duncan	Hyacinthaceae	Nieuwoudtville and Calvinia in Nieuwoudtville Shale Renosterveld. Clay soils. Endemic.	Manning and Goldblatt, 2002; Manning et al., 2002; Mucina and Rutherford, 2006.
Lachenalia congesta W.F.Barker	Hyacinthaceae	From Calvinia through the Roggeveld Escarpment to Komsberg Pass. Endemic.	Barker, 1978; Manning et al., 2002.
Lachenalia dasybotrya Diels	Hyacinthaceae	Calvinia area, in Hantam Karoo. Endemic.	Diels, 1909; Mucina and Rutherford, 2006 .
Lachenalia doleritica G.D.Duncan	Hyacinthaceae	Occurs in heavy dolerite clay soils in the Nieuwoudtville-Calvinia area. Endemic.	Duncan, 1998.
Lachenalia isopetala Jacquin	Hyacinthaceae	From Nieuwoudtville to Calvinia and along the Roggeveld Escarpment. Endemic.	Manning et al., 2002.
Lachenalia macgregorianum W.F.Barker	Hyacinthaceae	On dolerite klipkoppies on the Bokkeveld Plateau. Endemic.	Barker, 1979; Manning et al., 2002.
Lachenalia marlothii W.F.Barker ex G.D.Duncan	Hyacinthaceae	Roggeveld Escarpment. Endemic.	Manning et al., 2002.
Lachenalia neilii G.D.Duncan	Hyacinthaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Heavy doleritic clay. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Lachenalia schelpei W.Barker	Hycinthaceae	Hantamberge, on dolerite flats. Endemic.	Barker, 1984; Manning et al., 2002.
Lachenalia whitehillensis W.F.Barker	Hycinthaceae	Sutherland and Matjiesfontein areas. Endemic.	Manning et al., 2002.
Lapeirousia montana Klatt	Iridaceae	Roggeveld in Roggeveld Karoo. Endemic.	Mucina and Rutherford, 2006; Manning et al., 2002.
Lapeirousia oreogena Goldblatt	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Clay soils. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.

Lasiospermum poterioides Hutch.	Asteraceae	Roggeveld Shale Renosterveld. Endemic.	Müller et al., 2001; Mucina and Rutherford, 2006.
Lithops otzeniana Nel	Mesembryanthemaceae	Endemic to a small area N and NW of Loeriesfontein.	Hartmann, 2001b.
Lotononis venosa B.-E.van Wyk	Fabaceae	Roggeveld. Endemic.	Van Wyk, 1990b, 1991.
Lycium hantamense A.M.Venter	Solanaceae	Common on the Bokkeveld Plateau in the Nieuwoudtville and Calvinia Districts. Endemic.	Venter, 2007.
Malephora veruculoides (Sonder) Schwantes	Mesembryanthemaceae	Calvinia. Endemic.	Hartmann, 2001b.
Manulea diandra Hilliard	Scrophulariaceae	Roggeveld and Nuweveldberge, in Roggeveld Shale Renosterveld. Endemic.	Hilliard, 1994; Mucina and Rutherford, 2006.
Manulea incana Thunb.	Scrophulariaceae	Roggeveld and Komsberg. Endemic.	Hilliard, 1994.
Moraea fragrans Goldblatt	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Moraea fistulosa (Goldblatt) Goldblatt	Iridaceae	Dry, stony flats on the Roggeveld Escarpment. Only known from the type. Endemic.	Goldblatt, 1979a; Manning et al., 2002; Manning and Goldblatt, 2006.
Moraea hesperantha (Goldblatt) Goldblatt	Iridaceae	Bokkeveld Plateau and western Karoo, in Hantam Karoo. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Moraea marginata J.C.Manning & Goldblatt	Iridaceae	Sutherland area, on the Roggeveld Plateau. Endemic.	Manning and Goldblatt, 2006.
Moraea pseudospicata Goldblatt	Iridaceae	Bokkeveld Plateau, in Nieuwoudtville Shale Renosterveld on clay flats. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Moraea reflexa Goldblatt (=*Homeria hantamensis* Goldblatt & J.C.Manning)	Iridaceae	Restricted to the Hantam Plateau, in Hantam Plateau Dolerite Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Moraea tanquana Goldblatt & J.C.Manning	Iridaceae	Only known from the Tanqua Karoo National Park. Endemic.	Goldblatt and Manning, 2009.
Moraea verecunda Goldblatt	Iridaceae	Nieuwoudtville, on the edge of tillites. Endemic.	Goldblatt and Anderson, 1986.

Moraea vespertina Goldblatt & J.C.Manning	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld, and in the Tankwa Karoo National Park. Endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006; Goldblatt and Manning, 2009.
Moraea virgata subsp. *karooica* (Goldblatt) Goldblatt	Iridaceae	Roggeveld, near seepage zones among large boulders. Endemic.	Goldblatt, 1987a.
Nemesia leipoldtii Hiern	Scrophulariaceae	Hantam Karoo. In clays soils, particularly dolerite. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Nemesia suaveolens K.E.Steiner	Scrophulariaceae	Tanqua Karoo. Endemic.	Steiner, 2009.
Ornithogalum corticatum Mart.-Azorín	Hyacinthaceae	Roggeveld and Klein-Roggeveld, in heavy clays from dolerite, in renosterveld. Endemic.	Manning et al., 2007.
Ornithogalum pullatum Leighton	Hyacinthaceae	In the hills north of Calvinia. Endemic.	Leighton, 1945.
Ornithogalum rotatum U.Müll.-Doblies & D.Müll.-Doblies	Hyacinthaceae	Only known from an area SW of Loeriesfontein. Hantam Karoo. Endemic.	Müller-Doblies and Müller-Doblies, 1996; Mucina and Rutherford, 2006.
Oxalis sp. aff. *strigosa* Salter	Oxalidaceae	Roggeveld. Known from a collection by Marloth from Hoenderhoek, and recollected below Sneeukrans. Endemic.	Salter, 1944; Oberlander, pers. comm.
Oxalis calvinensis Knuth	Oxalidaceae	West of the Hantamberg. Apparently only known from the type. Endemic.	Salter, 1944.
Oxalis hirsuta Sond.	Oxalidaceae	Rhenosterkop at Beaufort West, and Calvinia. Endemic.	Salter, 1944.
Oxalis lasiorrhiza Salter	Oxalidaceae	North-east of Nieuwoudtville. Endemic.	Salter, 1944.
Oxalis marlothii Schltr.	Oxalidaceae	Only known from the Sneeukrans vicinity on the Roggeveld. Until recently only known from the type. Endemic.	Salter, 1944; Oberlander, pers. comm.
Oxalis neglecta Knuth	Oxalidaceae	Hantamberge. Only known from the type. Endemic.	Salter, 1944.
Oxalis odorata J.C.Manning & Goldblatt	Oxalidaceae	Hantamberg and Roggeveld Escarpment, in ephemeral pools in shallow soils on dolerite sills. Endemic.	Manning and Goldblatt, 2008.
Oxalis pulvinata Sond.	Oxalidaceae	Hantam Karoo. Endemic.	Salter, 1944; Mucina and Rutherford, 2006.

Pectinaria articulata (Aiton) Haw. subsp. *articulata*	Apocynaceae	Hantamberge, Roggeveld and Nuweveldberge as far as Fraserburg. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Pectinaria longipes (N.E.Br.) Bruyns subsp. *longipes*	Apocynaceae	Hantam Karoo. One of the most poorly known southern African stapeliads. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Pectinaria longipes subsp. *villetii* (C.A.Lückh.) Bruyns	Apocynaceae	Loeriesfontein area, in Hantam Karoo. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Pectinaria maughanii (R.A.Dyer) Bruyns	Apocynaceae	Between Nieuwoudtville and Calvinia, in Hantam Karoo. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Pelargonium githagineum E.M.Marais	Geraniaceae	Roggeveld plateau and around Matjiesfontein. Endemic.	Marais, 1998.
Phyllobolus amabilis Gerbaulet & Struck	Mesembryanthemaceae	On the transition of the summer and winter rainfall zones. Sutherland. Endemic.	Hartmann, 2001b.
Polhillia involucrata (Thunb.) Van Wyk & Schutte	Fabaceae	Roggeveld Escarpment, in clay soils in renosterveld. Endemic.	Stirton, 1986; Van Wyk, 1992.
Polycarena filiformis Diels	Scrophulariaceae	Calvinia area. Endemic.	Hilliard, 1994.
Polyxena longituba A.M.van der Merwe	Hyacinthaceae	Roggeveld and Komsberg in Roggeveld Shale Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Prionanthium dentatum (L.f.) Henr.	Poaceae	Nieuwoudtville area. Endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001.
Quaqua arenicola subsp. *pilifera* (N.E.Br.) Plowes	Apocynaceae	According to Mucina and Rutherford (2006) endemic to an area east of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. According to Bruyns (2005) endemic to the Roggeveld and Nuweveldberge.	Bruyns, 2005; Mucina and Rutherford, 2006.
Quaqua parviflora subsp. *swanepoelii* (Lavranos) Bruyns	Apocynaceae	Nieuwoudtville to Calvinia, in Hantam Karoo. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Reyemia chasmanthiflora Hilliard	Scrophulariaceae	Between Calvina and Middelpos. Endemic.	Hilliard, 1994.
Reyemia nemesioides (Diels) Hilliard	Scrophulariaceae	Southern Great Escarpment from Calvinia to Fraserburg on rugged dolerite hills. Endemic.	Hilliard, 1994.

Romulea albiflora Goldblatt & J.C.Manning	Iridaceae	Roggeveld, Middelpos area. Endemic.	Manning et al., 2002.
Romulea diversiformis M.P.de Vos	Iridaceae	Hantam and Roggeveld plateaux. On moist clay flats. Endemic.	De Vos, 1972; Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Romulea hallii M.P.de Vos	Iridaceae	Roggeveld plateau above Verlatenkloof Pass, in Roggeveld Shale Renosterveld. Endemic.	De Vos, 1972; Manning et al., 2002; Mucina and Rutherford, 2006.
Romulea hantamensis (Diels) Goldblatt	Iridaceae	Hantam plateau, in Hantam Plateau Dolerite Renosterveld. Heavy dolerite clay. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Romulea komsbergensis M.P.de Vos	Iridaceae	Komsberg and Roggeveld plateau in Roggeveld Shale Renosterveld. Endemic.	De Vos, 1972; Manning et al., 2002; Mucina and Rutherford, 2006.
Romulea multifida M.P.de Vos	Iridaceae	Roggeveld plateau in Roggeveld Shale Renosterveld. Endemic.	De Vos, 1972; Mucina and Rutherford, 2006.
Romulea subfistulosa M.P.de Vos	Iridaceae	Calvina and Roggeveld plateau in Roggeveld Shale Renosterveld. Endemic.	De Vos, 1972; Manning et al., 2002; Mucina and Rutherford, 2006.
Romulea syringodeoflora M.P.de Vos	Iridaceae	Roggeveld in Roggeveld Karoo and Roggeveld Shale Renosterveld. Endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Romulea unifolia M.P.de Vos	Iridaceae	Calvinia and Roggeveld Plateau in Roggeveld Karoo. Endemic.	De Vos, 1987; Manning et al., 2002; Mucina and Rutherford, 2006.
Rosenia glandulosa Thunb.	Asteraceae	Hantamberge through the Roggeveld to the Nuweveldberge. Endemic.	Bremer, 1976.
Ruschia acocksii L.Bolus	Mesembryanthemaceae	Sutherland. A poorly known species. Endemic.	Hartmann, 2001b.
Ruschia campestris (Burchell) Schwantes	Mesembryanthemaceae	Roggeveld. Apparently common but poorly collected. Endemic.	Hartmann, 2001b.
Ruschia insidens L.Bolus	Mesembryanthemaceae	Calvinia. Endemic.	Hartmann, 2001b.
Ruschia punctulata (L.Bolus) L.Bolus ex H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo, Calvinia. Endemic	Hartmann, 2001b; Mucina and Rutherford, 2006.
Saniella occidentalis (Nel) B.L.Burtt	Hypoxidaceae	Hantam and Roggeveld plateaux, in Hantam Plateau Dolerite Renosterveld. Endemic.	Burtt, 2000; Mucina and Rutherford, 2006.

Secale africanum Stapf (=*S. strictum* subsp. *africanum* (Stapf) Hammer)	Poaceae	Undisturbed places on riverbanks. Restricted to rare patches on Farm Kanariesfontein on the Roggeveld, from where being reintroduced to other areas in historical range on the Roggeveld. Roggeveld Karoo. Endemic.	Khush and Stebbins, 1961; Gibbs Russell et al., 1990; Van Wyk and Smith, 2001; De Bustos and Jouve, 2002; Mucina and Rutherford, 2006; Esterhuyse, pers. comm.
Selago articulata Thunb.	Scrophulariaceae	Nieuwoudtville, Calvinia and Klein-Roggeveld, in Roggeveld Karoo. Endemic.	Hilliard, 1999; Mucina and Rutherford, 2006.
Selago chalarantha Hilliard	Scrophulariaceae	Nieuwoudtville area in Nieuwoudtville Shale Renosterveld. Endemic.	Hilliard, 1999; Mucina and Rutherford, 2006.
Selago florifera Hilliard	Scrophulariaceae	Roggeveld. Only known from the type. Endemic.	Hilliard, 1999.
Selago rigida Rolfe	Scrophulariaceae	Roggeveld, inland plateau of Roggeveld, and the Nuweveldberge. Cliffs and rocky areas. Endemic.	Hilliard, 1999.
Selago spectabilis Hilliard	Scrophulariaceae	Hantamberg. Endemic.	Hilliard, 1999.
Selago subspinosa Hilliard	Scrophulariaceae	Roggeveld, Klein-Roggeveld, Whitehill and Koedoesberge. Endemic.	Hilliard, 1999.
Sparaxis elegans (Sweet) Goldblatt	Iridaceae	Occurs on the Bokkeveld Plateau, on clay soils in renosterveld. Endemic.	Manning and Goldblatt, 2002.
Sparaxis pillansii L.Bolus	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Damp clay in dolerite outcrops. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Sparaxis tricolor (Schneev.) Ker Gawl.	Iridaceae	On the Bokkeveld Mountains in Nieuwoudtville Shale Renosterveld. Not an HRC Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Spiloxene sp. nov.	Iridaceae	Roggeveld. Known from about six previous collections. Endemic.	Snijman, pers. comm.
Stapelia villetiae C.A.Lückh.	Apocynaceae	Calvinia, Loeriesfontein and Nieuwoudtville area in Hantam Karoo. Endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Stomatium mustelinum (Haw.) Schwantes	Mesembryanthemaceae	Calvinia, on gentle slopes of fine Ecca shale. Endemic.	Hartmann, 2001b.
Stomatium resedolens L.Bolus	Mesembryanthemaceae	Sutherland. Endemic.	Hartmann, 2001b.

Stomatium sauveolens (Schwantes) Schwantes	Mesembryanthemaceae	In shallow pans and on edges. Fraserburg, Sutherland and Williston Districts (Nuweveld and Roggeveld). Endemic.	Hartmann, 2001b.
Stomatium villettii L.Bolus	Mesembryanthemaceae	Cited for Beaufort West (probably the Nuweveldberge) by Hartmann (2001b). Collected by the first author on the Roggeveld and Komsberg. Endemic.	Hartmann, 2001b.
Strumaria karooica (W.F.Barker) Snijman	Amaryllidaceae	Roggeveld Escarpment to Matjiesfontein. Endemic.	Manning et al., 2002.
Strumaria picta W.F.Barker	Thymelaceae	Lokenberg, in the Calvinia District, and the Bokkeveld Plateau. Occurs in Nieuwoudtville Shale Renosterveld. Endemic.	Barker et al., 1949; Manning et al., 2002; Mucina and Rutherford, 2006.
Trachyandra prolifera P.L.Perry	Anthericaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld on clay flats. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Troglophyton acocksianum Hilliard	Asteraceae	Hantamberg summit. Endemic.	Hilliard, 1983.
Ursinia sp. nov. *"roggeveldensis"*	Asteraceae	Roggeveldberge. Endemic.	Mucina, pers. comm.
Zaluzianskya acutiloba Hilliard	Scrophulariaceae	Hantamberge and Roggeveld. Endemic.	Hilliard, 1994.
Zaluzianskya cohabitans Hilliard	Scrophulariaceae	Hantamberg and Roggeveld in Hantam Karoo. Endemic.	Hilliard, 1994; Mucina and Rutherford, 2006.
Zaluzianskya inflata Diels	Scrophulariaceae	Hantamberge and Roggeveld in Hantam Karoo. Endemic.	Hilliard, 1994; Mucina and Rutherford, 2006.
Zaluzianskya marlothii Hilliard	Scrophulariaceae	Roggeveld – only known from two collections by Marloth near Sutherland. Endemic.	Hilliard, 1994.
Zaluzianskya minima (Hiern) Hilliard	Scrophulariaceae	Hantam Karoo, in gravelly clay. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Zaluzianskya mirabilis Hilliard	Scrophulariaceae	Middle Roggeveld. Endemic.	Hilliard, 1994.
Zaluzianskya sutherlandica Hilliard	Scrophulariaceae	Kruisrivier, Sutherland. Only known from the type. Endemic.	Hilliard, 1994.

Zaluzianskya violacea Schltr.	Scrophulariaceae	Roggeveld Shale Renosterveld, in gravelly clay and shale. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Zantedeschia odorata P.L.Perry	Araceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld. Damp places on dolerite outcrops. Endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
(B) Species near-endemic to the HRC.			
Antimima distans (L.Bolus) H.E.K.Hartmann	Mesembryanthemaceae	Hantam Karoo. Calvinia and Clanwilliam areas. Near-endemic.	Hartmann, 2001a; Mucina and Rutherford, 2006.
Babiana flabellifolia Harv. ex Klatt	Iridaceae	Namaqualand, Hantamberg, and to Laingsburg. Dolerite outcrops. Near-endemic.	Manning et al., 2002; Manning and Goldblatt, 2002, 2004.
Bulbinella elegans P.L.Perry	Asphodelaceae	Bokkeveld Escarpment and western Karoo to the Witteberg. Near-endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Corycium deflexum (Bolus) Rolfe	Orchidaceae	Calvinia, Roggeveld and Cederberg. Near-endemic.	Linder and Kurzweil, 1999; Mucina and Rutherford, 2006.
Cromidon austerum Hilliard	Scrophulariaceae	Hantam Karoo. Mostly around Calvinia – one record Victoria West. Near-endemic.	Hilliard, 1990; Mucina and Rutherford, 2006.
Cromidon decumbens (Thunb.) Hilliard	Scrophulariaceae	Hantamberge, Roggeveldberge, Nuweveldberge, Witteberg and mountains around Ceres. (Very similar plants occur on the Sneeuberg). Near-endemic.	Hilliard, 1990; Mucina and Rutherford, 2006.
Cromidon plantaginis (L.f.) Hilliard	Scrophulariaceae	Roggeveld, Kouebokkeveld and Cederberg. Near-endemic.	Hilliard, 1990; Mucina and Rutherford, 2006.
Drimia marginata (Thunb.) Jessop	Hyacinthaceae	Hantam plateau, between Loeriesfontein and Calvinia. Open clay flats in renosterveld. Also Hex River Mountains. Near-endemic.	Manning et al., 2002; Manning and Goldblatt, 2007.
Eriospermum erinum P.L.Perry	Hyacinthaceae	Dwyka clays, in Nieuwoudtville area. Nieuwoudtville Shale Renosterveld. Also the Bokkeveld Mountains. Near-endemic.	Perry, 1989; Manning et al., 2002; Mucina and Rutherford, 2006.
Eriospermum marginatum P.L.Perry	Hyacinthaceae	From Loeriesfontein to near Montagu. Near-endemic.	Perry, 1989, 1994; Mucina and Rutherford, 2006.

Euphorbia cylindrica A.C.White, R.A.Dyer & B.Sloane	Euphorbiaceae	Kubiskow mountains north of Loeriesfontein, Hantamberge, and northern slopes of the Bokkeveldberge. Near-endemic.	White et al., 1941; Van Wyk and Smith, 2001.
Euryops nodosus B.Nord.	Asteraceae	Komsberg, Eastern Nuweveldberge, and inland of Fraserburg. Near-endemic.	Nordenstam, 1969.
Gazania othonnites (Thunb.) Less.	Asteraceae	Roggeveld Karoo. Appears to be a near-endemic.	Mucina and Rutherford, 2006.
Gethyllis campanulata L.Bolus	Amaryllidaceae	Occurs on dolerite outcrops on the Bokkeveld Plateau near Nieuwoudtville. Also at Worcester, Montagu and Matjiesfontein. Near-endemic.	Manning et al., 2002; Manning and Goldblatt, 2002.
Gladiolus pritzelii Diels	Iridaceae	Hantamberg and Roggeveld in Roggeveld Karoo. According to Goldblatt and Manning (1998) also on the Kouebokkeveld and Cederberg. Near-endemic.	Goldblatt and Manning, 1998; Mucina and Rutherford, 2006.
Gladiolus splendens (Sweet) Herbert	Iridaceae	Moordenaars Karoo through the Roggeveld to north of Calvinia. Near-endemic.	Goldblatt and Manning, 1998.
Gladiolus uysiae G.J.Lewis	Iridaceae	Roggeveld Karoo. According to Goldblatt and Manning (1998) also on the Bokkeveld Escarpment south to Ceres. Near-endemic.	Goldblatt and Manning, 1998; Mucina and Rutherford, 2006.
Helictotrichon barbatum (Nees) Schweik.	Poaceae	Hantamberge and Kamiesberg. Near-endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001.
Heliophila pubescens Burch. ex Sond.	Brassicaceae	Roggeveld Karoo. According to Marais (1970) occurs from Clanwilliam area across to the Sneeuberg. Near-endemic.	Marais, 1970; Mucina and Rutherford, 2006.
Hemimeris centrodes Hiern	Scrophulariaceae	Hantam Karoo. Manning and Goldblatt (2002) state from western Karoo to Little Karoo. Heavy red clay in dolerite outcrops. Near-endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Hesperantha cucullata Klatt	Iridaceae	Roggeveld Karoo. Manning and Goldblatt (2002) state from Bokkeveld Escarpment and western Karoo to Biedouw Valley. Near-endemic.	Goldblatt, 1984; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Hesperantha pseudopilosa Goldblatt (=*H. pilosa* subsp. *latifolia* Goldblatt)	Iridaceae	On the Hantamberg, Kamiesberg, and Klein-Swartberg. Near-endemic.	Goldblatt, 1984, 1987b; Mucina and Rutherford, 2006.

Jamesbrittenia thunbergii (G.Don) Hilliard	Scrophulariaceae	Van Rhynsdorp, Calvinia, Ceres and Groot Swartberg. Near-endemic.	Hilliard, 1994; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Lotononis maximiliani Schltr. ex De Wildeman	Fabaceae	Van Rhynsdorp and Calvinia areas. Roggeveld Karoo. Near-endemic	Van Wyk, 1991; Mucina and Rutherford, 2006.
Merxmullera dura (Stapf) Conert	Poaceae	Calvinia and Carnavon Districts. Near-endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001.
Moraea bifida (L.Bolus) Goldblatt	Iridaceae	Eastern Namaqualand and western Karoo to Pakhuis Pass. Near-endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Moraea marlothii (L.Bolus) Goldblatt	Iridaceae	Bokkeveld Mountains and western Karoo. Near-endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Moraea pritzeliana Diels (= *Gynandriris pritzeliana* (Diels) Goldblatt)	Iridaceae	Bokkeveld Plateau and western Karoo in Hantam Karoo. Manning and Goldblatt (2002) state as also occurring on sandstone. Near-endemic?	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Pentaschistis aristifolia Schweik.	Poaceae	On heavier soils associated with Karoo sediments, in Roggeveld Karoo. Gibbs Russell et al. (1990) shows a wider distribution than the HRC however. Near-endemic?	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001; Mucina and Rutherford, 2006.
Polycarena aurea Benth.	Scrophulariaceae	Manning and Goldblatt (2002) state from the Bokkeveld Mountains, western Karoo south to the Hex River Mountains. Near-endemic.	Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Polyxena maughanii W.F.Barker	Hyacinthaceae	Western Karoo and Bokkeveld Mountains. Near-endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Quaqua aurea (C.A.Lückh.) Plowes	Apocynaceae	Above and below the Bokkeveld Escarpment. Near-endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Romulea membranacea M.P.de Vos	Iridaceae	Roggeveld, Hantam and the Bokkeveld Escarpment. Near-endemic.	De Vos, 1972; Manning et al., 2002; Mucina and Rutherford, 2006.
Romulea monadelpha (Sweet) Baker	Iridaceae	East of Nieuwoudtville, in Nieuwoudtville-Roggeveld Dolerite Renosterveld, on heavy dolerite clay. Manning et al. (2002) state also on Bokkeveld Escarpment, therefore possibly near-endemic.	Manning and Goldblatt, 2002; Manning et al., 2002; Mucina and Rutherford, 2006.

Romulea tetragona De Vos var. *tetragona*	Iridaceae	Clanwilliam, Ceres and Roggeveld plateau. Near-endemic.	De Vos, 1972; Mucina and Rutherford, 2006.
Stachys aurea Benth.	Lamiaceae	Southern Namaqualand and south-western Karoo. Near-endemic.	Codd, 1985; Mucina and Rutherford, 2006.
Stapelia surrecta N.E.Br.	Apocynaceae	Bloukrans Pass to Verlatenkloof, along the base of the Roggeveld Escarpment. Also near Karoo Poort. Near-endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
Strumaria discifera Snijman	Amaryllidaceae	*S.* subsp. *discifera* occurs on dolerite outcrops from the Bokkeveld Plateau to the Roggeveld, as well as below the Bokkeveld Escarpment. Near-endemic. *S.* subsp. *bulbifera* Snijman is endemic to the Nieuwoudtville area.	Snijman, 1992; Manning and Goldblatt, 2002.
Syringodea unifolia Goldblatt	Iridaceae	Western Karoo to Keeromsberg. Near-endemic.	Van Wyk and Smith, 2001; Manning et al., 2002; Mucina and Rutherford, 2006.
Tromotriche thudichumii (Pillans) L.C.Leach	Apocynaceae	Ceres and Tanqwa Karoos onto the Roggeveld. Near-endemic.	Bruyns, 2005; Mucina and Rutherford, 2006.
(C) Species purported to be HRC endemics or near-endemics in the literature but apparently neither.			
Alonsoa unilabiata (L.f.) Steud.	Scrophulariaceae	Clay soils in renosterveld, western Karoo. Fairly widespread. Not an HRC endemic.	Manning and Goldblatt, 2002.
Alyssum minutum Schltdl. ex DC.	Brassicaceae	Leliefontein, Calvinia, Roggeveld, Fraserburg. An introduced species from Europe. Not an HRC endemic.	Marais, 1970; Mucina and Rutherford, 2006.
Babiana pauciflora G.J.Lewis	Iridaceae	Nieuwoudtville Shale Renosterveld. Bokkeveld Escarpment. Not an HRC endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Bulbinella eburniflora P.L.Perry	Asphodelaceae	Bokkeveld Escarpment. Nieuwoudtville Shale Renosterveld. Gravelly clay. Not an HRC endemic.	Manning et al., 2002; Manning and Goldblatt, 2002; Mucina and Rutherford, 2006.
Cliffortia hantamensis Diels	Rosaceae	Wide distribution in the CFR (although rare) and onto the Hantam–Roggeveld. Not an HRC endemic.	Nordenstam, 1969; Van Wyk and Smith, 2001; Whitehouse, 2002.
Cromidon hamulosum (E.Mey.) Hilliard	Scrophulariaceae	Hilliard (1990) states only known from the type in northern Namaqualand. Not an HRC endemic.	Hilliard, 1990; Mucina and Rutherford, 2006.

Diascia insignis K.E. Steiner	Scrophulariaceae	Endemic to the Bokkeveld Escarpment, near Nieuwoudtville. Not an HRC endemic.	Steiner, 1992.
Dregeochloa calviniensis Conert	Poaceae	AFPD and Gibbs Russell et al. (1990) shows a distribution along the Orange River. Not an HRC endemic.	Gibbs Russell et al., 1990; Van Wyk and Smith, 2001.
Eriospermum glaciale P.L.Perry	Hyacinthaceae	Bokkeveld Escarpment. Clay soils, in an area south of Nieuwoudtville. Nieuwoudtville Shale Renosterveld. Not an HRC endemic?	Manning et al., 2002; Perry, 1994; Mucina and Rutherford, 2006.
Geissorhiza splendidissima Diels	Iridaceae	Bokkeveld Escarpment and western Karoo, in Nieuwoudtville Shale Renosterveld. Manning and Goldblatt (2002) state as endemic to Bokkeveld Mountains on stony clay flats in renosterveld. Either near-endemic or not an HRC endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Hesperantha marlothii Foster	Iridaceae	Roggeveld, Bokkeveld Escarpment and Kouebokkeveld. Not an HRC endemic.	Goldblatt, 1984; Mucina and Rutherford, 2006.
Moraea aspera Goldblatt	Iridaceae	Nieuwoudtville Shale Renosterveld. Bokkeveld Escarpment. Not an HRC endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.
Pelargonium articulatum (Cav.) Willd.	Geraniaceae	Namaqualand south to Worcester and east to Fraserburg. Not an HRC endemic.	Van der Walt et al., 1981; Mucina and Rutherford, 2006.
Romulea discifera J.C.Manning and Goldblatt	Iridaceae	Bokkeveld Mountains, in Nieuwoudtville Shale Renosterveld. Not an HRC endemic.	Manning et al., 2002; Mucina and Rutherford, 2006.

Appendix 5.2: A contribution to the flora of the Roggeveldberge.

Family	Species	Collectors/References
Pteridophytes		
Aspleniaceae	*Asplenium cordatum* (Thunb.) Sw.	Clark VR, Kelly C 167
Pteridaceae	*Cheilanthes capensis* (Thunb.) Sw.	Clark VR, Kelly C 158
Pteridaceae	*Cheilanthes hastata* (L.f.) Kunze	Clark VR, Kelly C 125
Pteridaceae	*Cheilanthes induta* Kunze	Clark VR, Kelly C 124
Pteridaceae	*Pellaea rufa* A.F.Tryon	Clark VR, Kelly C 137
Monocotyledons		
Alliaceae	*Allium dregeanum* Kunth	Clark VR, Kelly C 110
Amaryllidaceae	*Brunsvigia bosmaniae* F.M.Leighton	Manning et al., 2002
Amaryllidaceae	*Brunsvigia comptonii* W.F.Barker	Manning et al., 2002
Amaryllidaceae	*Gethyllis pectinata* D.M üller-Doblies	Manning et al., 2002
Amaryllidaceae	*Gethyllis roggeveldensis* D.M üller-Doblies	Manning et al., 2002
Amaryllidaceae	*Haemanthus barkerae* Snijman	Snijman, 1984
Amaryllidaceae	*Haemanthus coccineus* L.	Clark VR, O'Connor R 343
Amaryllidaceae	*Strumaria discifera* Marloth ex Snijman subsp. *discifera*	Snijman, 1992
Amaryllidaceae	*Strumaria karooica* (W.F.Barker) Snijman	Manning et al., 2002
Amaryllidaceae	*Strumaria picta* W.F.Barker	Manning et al., 2002
Anthericaceae	*Chlorophytum undulatum* (Jacq.) Oberm.	Clark VR, O'Connor R 333
Araceae	*Zantedeschia aethiopica* (L.) Spreng.	Clark VR 43
Asparagaceae	*Asparagus asparagoides* (L.) Druce	Clark VR, Kelly C 154
Asparagaceae	*Asparagus burchellii* Baker	Clark VR, Kelly C 66a
Asparagaceae	*Asparagus capensis* L. var. *capensis*	Clark VR, O'Connor R 297
Asparagaceae	*Asparagus declinatus* L.	Clark VR, O'Connor R 331
Asparagaceae	*Asparagus microraphis* (Kunth) Baker	Clark VR, O'Connor R 246
Asparagaceae	*Asparagus mollis* (Oberm.) Fellingham & N.L.Mey.	Clark VR, Kelly C 142
Asparagaceae	*Asparagus mucronatus* Jessop	Clark VR, Coombs G 982
Asparagaceae	*Asparagus retrofractus* L.	Clark VR, O'Connor R 319
Asparagaceae	*Asparagus rubicundis* P.J.Bergius	Clark VR, Kelly C 141, 289
Asparagaceae	*Asparagus exuvialis* Burch.	Clark VR, Kelly C 140
Asparagaceae	*Asparagus ferox* MS S.M.Burrows	Clark VR, Kelly C 66b
Asparagaceae	*Asparagus* sp. nov. (S. Burrrows, pers. comm.)	Clark VR, O'Connor R 156
Asphodelaceae	*Bulbine asphodeloides* (L.) Spreng.	Clark VR, Kelly C 100
Asphodelaceae	*Bulbine torta* N.E.Br.	Clark VR, O'Connor R 484
Asphodelaceae	*Bulbinella elegans* P.L.Perry	Clark VR, Kelly C 108
Asphodelaceae	*Bulbinella latifolia* (L.f.) Schult. & Schult.f. subsp. *latifolia*	Clark VR, O'Connor R 313
Asphodelaceae	*Bulbinella nutans* (Thunb.) T.Durand & Schinz	Clark VR, Kelly C 281
Asphodelaceae	*Haworthia semiviva* (Poelln.) M.B.Bayer	Bayer, 1982
Asphodelaceae	*Trachyandra thyrsoidea* (Baker) Oberm.	Clark VR, Kelly C 291
Colchicaceae	*Androcymbium crispum* Schinz	Manning et al., 2002
Colchicaceae	*Androcymbium cuspidatum* Baker	Clark VR, Kelly C 196
Colchicaceae	*Androcymbium hantamense* Engl.	Müller-Doblies and Müller-Doblies, 2002
Colchicaceae	*Androcymbium latifolium* Schinz	Manning et al., 2002
Colchicaceae	*Androcymbium praeirroratum* U.Müll.-Doblies & D.Müll.-Doblies	Müller-Doblies and Müller-Doblies, 2002
Colchicaceae	*Androcymbium pulchrum* Schltr. & Krause	Clark VR, Kelly C 106
Colchicaceae	*Wurmbea* cf. *variabilis* B.Nord. (Nordenstam, pers. comm.)	Clark VR, O'Connor R 258
Cyperaceae	*Carex acocksii* C.Archer	Van Wyk and Smith, 2001
Cyperaceae	*Carex divisa* Huds.	Clark VR, Kelly C 234

Cyperaceae	*Isolepis angelica* B.L.Burtt	Clark VR, Coombs G 797
Cyperaceae	*Isolepis costata* A.Rich.	Clark VR, Coombs G 835
Cyperaceae	*Pseudoschoenus inanis* (Thunb.) Oteng-Yeb.	Clark VR, Kelly C 223
Cyperaceae	*Scirpoides dioecus* (Kunth) Browning	Clark VR, Coombs G 836
Eriospermaceae	*Eriospermum lanimarginatum P.L.Perry*	Perry, 1989, 1994
Hyacinthaceae	*Albuca cooperi* Baker	Clark VR, O'Connor R 493
Hyacinthaceae	*Albuca namaquensis* Baker	Clark VR, Kelly C 215
Hyacinthaceae	*Albuca setosa* Jacq.	Clark VR, O'Connor R 371
Hyacinthaceae	*Albuca viscosa* L.f.	Clark VR 37
Hyacinthaceae	*Daubenya alba* A.M.van der Merwe	Van der Merwe and Marais, 2002
Hyacinthaceae	*Daubenya aurea* Lindl.	Manning et al., 2002
Hyacinthaceae	*Drimia marginata* (Thunb.) Jessop	Manning et al., 2002
Hyacinthaceae	*Drimia physodes* (Jacq.) Jessop	Clark VR 35
Hyacinthaceae	*Eucomis regia* (L.) L'Hér.	Clark VR, O'Connor R 424
Hyacinthaceae	*Lachenalia comptonii* W.F.Barker	Manning et al., 2002
Hyacinthaceae	*Lachenalia congesta* W.F.Barker	Clark VR, O'Connor R 473
Hyacinthaceae	*Lachenalia isopetala* Jacquin	Manning et al., 2002
Hyacinthaceae	*Lachenalia marlothii* W.F.Barker ex G.D.Duncan	Manning et al., 2002
Hyacinthaceae	*Lachenalia multiflora* W.F.Barker	Manning et al., 2002
Hyacinthaceae	*Lachenalia schelpei* W.Barker	Manning et al., 2002
Hyacinthaceae	*Lachenalia* sp. nov. (Duncan, pers. comm.)	Clark VR, Kelly C 105
Hyacinthaceae	*Lachenalia whitehillensis* W.F.Barker	Manning et al., 2002
Hyacinthaceae	*Massonia depressa* Houtt.	Clark VR, Kelly C 205
Hyacinthaceae	*Ornithogalum apertum* (Verdoorn) Oberm.	Obermeyer, 1978
Hyacinthaceae	*Ornithogalum corticatum* Mart.-Azorín	Martínez-Azorín M, Manning JC 96
Hyacinthaceae	*Ornithogalum hispidum* Hornem. subsp. *hispidum*	Clark VR, Coombs G 965
Hyacinthaceae	*Ornithogalum maculatum* Jacq.	Clark VR, Coombs G 967
Hyacinthaceae	*Ornithogalum niveum* Ait.	Obermeyer, 1978
Hyacinthaceae	*Ornithogalum pruinosum* F.M.Leighton	Manning et al., 2007
Hyacinthaceae	*Ornithogalum pullatum* F.M.Leighton	Leighton, 1945
Hyacinthaceae	*Ornithogalum rupestre* L.f.	Manning et al., 2007
Hyacinthaceae	*Ornithogalum sauveolens* Jacq.	Clark VR, O'Connor R 368
Hyacinthaceae	*Ornithogalum strictum* L.Bolus	Manning et al., 2007
Hyacinthaceae	*Polyxena longituba* A.M.van der Merwe	Manning et al., 2002
Hypoxidaceae	*Empodium plicatum* (Thunb.) Garside	Manning et al., 2002
Hypoxidaceae	*Saniella occidentalis* (Nel) B.L.Burtt	Clark VR, O'Connor R 405
Hypoxidaceae	*Spiloxene capensis* (L.) Garside	Clark VR, Kelly C 59
Hypoxidaceae	*Spiloxene serrata* (Thunb.) Garside	Clark VR, O'Connor R 354
Hypoxidaceae	*Spiloxene* sp. nov (Snijman, pers. comm.)	Clark VR, O'Connor R 259
Iridaceae	*Babiana flabellifolia* Harv. ex Klatt	Manning et al., 2002
Iridaceae	*Babiana praemorsa* Goldblatt & J.C.Manning	Goldblatt and Manning, 2004
Iridaceae	*Babiana spathacea* (L.f.) Ker Gawl	Clark VR, Coombs G 940
Iridaceae	*Babiana symmetrantha* Goldblatt & J.C.Manning	Goldblatt et al., 2008
Iridaceae	*Babiana virginea* Goldblatt	Manning et al., 2002
Iridaceae	*Devia xeromorpha* Goldblatt & J.C.Manning	Manning et al., 2002
Iridaceae	*Geissorhiza heterostyla* L.Bolus	Clark VR, Kelly C 58
Iridaceae	*Geissorhiza karooica* Goldblatt	Manning et al., 2002
Iridaceae	*Geissorhiza spiralis* (Burchell) M.P.de Vos ex Goldblatt	Manning et al., 2002
Iridaceae	*Gladiolus dolichosiphon*Goldblatt & J.C.Manning	Manning and Goldblatt, 2009
Iridaceae	*Gladiolus karooica*Goldblatt & J.C.Manning	Clark VR, Kelly C 102
Iridaceae	*Gladiolus marlothii* G.J.Lewis	Goldblatt and Manning, 1998
Iridaceae	*Gladiolus orchidiflorus* Andrews	Clark VR 55
Iridaceae	*Gladiolus pritzelii* Diels	Clark VR, O'Connor R 263

Iridaceae	*Gladiolus splendens* (Sweet) Herb.	Clark VR, Kelly C 92
Iridaceae	*Gladiolus venustus* G.J.Lewis	Clark VR, Kelly C 103
Iridaceae	*Hesperantha acuta* (Licht. ex Roem. & Schult.) Ker Gawl.	Clark VR, Coombs G 812
Iridaceae	*Hesperantha bachmannii* Baker	Clark VR, Kelly C 237
Iridaceae	*Hesperantha ciliolata* Goldblatt	Goldblatt, 1984
Iridaceae	*Hesperantha cucullata* Klatt	Clark VR, Kelly C 257
Iridaceae	*Hesperantha hantamensis* Schltr. ex R.C.Foster	Goldblatt, 1984
Iridaceae	*Hesperantha humilis* Baker	Clark VR, O'Connor R 128
Iridaceae	*Hesperantha karroica* Goldblatt	Goldblatt and Manning, 2007
Iridaceae	*Hesperantha marlothii* Foster	Clark VR, O'Connor R 386
Iridaceae	*Hesperantha pseudopilosa* Goldblatt	Clark VR, O'Connor R 252
Iridaceae	*Hesperantha purpurea* Goldblatt	Goldblatt, 1984
Iridaceae	*Hesperantha quadrangula* Goldblatt	Goldblatt, 1984
Iridaceae	*Hesperantha radiata* (Jacq.) Ker Gawl.	Clark VR, Kelly C 109
Iridaceae	*Hesperantha teretifolia* Goldblatt	Goldblatt, 1987b
Iridaceae	*Ixia amethystina* J.C.Manning & Goldblatt	Manning and Goldblatt, 2006
Iridaceae	*Ixia brevituba* G.J.Lewis	Clark VR, Coombs G 880
Iridaceae	*Ixia curvata* G.J.Lewis	Lewis, 1962
Iridaceae	*Ixia marginifolia* (Salisb.) G.J.Lewis	Clark VR, Coombs G 811
Iridaceae	*Ixia rapunculoides* Delile	Goldblatt and Manning, 2008
Iridaceae	*Ixia rivulicola* Goldblatt & J.C.Manning	Goldblatt and Manning, 2008
Iridaceae	*Ixia sobolifera* Goldblatt & J.C.Manning subsp. *sobolifera*	Clark VR, Kelly C 60
Iridaceae	*Ixia thomasiae* Goldblatt	Goldblatt, 1979b
Iridaceae	*Ixia trifolia* G.J.Lewis	Clark VR, Kelly C 91
Iridaceae	*Lapeirousia montana* Klatt	Clark VR, Kelly C 182
Iridaceae	*Lapeirousia oreogena* Goldblatt	Manning et al., 2002
Iridaceae	*Melasphaerula ramosa* (L.) N.E.Br.	Clark VR, O'Connor R 189
Iridaceae	*Moraea ciliata* (L.f.) Ker Gawl	Clark VR, Kelly C 195
Iridaceae	*Moraea cookii* (L.Bolus) Goldblatt	Clark VR, Coombs G 764
Iridaceae	*Moraea fistulosa* (Goldblatt) Goldblatt	Manning and Goldblatt, 2006
Iridaceae	*Moraea marginata* J.C.Manning & Goldblatt	Manning and Goldblatt, 2006
Iridaceae	*Moraea miniata* Andrews	Clark VR, Kelly C 8
Iridaceae	*Moraea pritzeliana* diels	Clark VR, Kelly C 104
Iridaceae	*Moraea reflexa* Goldblatt	Manning et al., 2002
Iridaceae	*Moraea tripelata* (L.f.) Ker Gawl.	Clark VR, O'Connor R 286
Iridaceae	*Moraea virgata* subsp. *karooica* (Goldblatt) Goldblatt	Goldblatt, 1987
Iridaceae	*Romulea alba* J.C.Manning & P.Golblatt	Goldblatt et al., 2002a
Iridaceae	*Romulea albiflora* Goldblatt & J.C.Manning	Manning et al., 2002a
Iridaceae	*Romulea atrandra* G.J. Lewis	Clark VR, O'Connor R 256
Iridaceae	*Romulea diversiformis* M.P.de Vos	Clark VR, O'Connor R 352
Iridaceae	*Romulea diversiformis* x *komsbergensis*	Clark VR, Coombs G 802
Iridaceae	*Romulea hallii* M.P.de Vos	Manning et al., 2002
Iridaceae	*Romulea hantamensis* (Diels) Goldblatt	Goldblatt et al., 2002a
Iridaceae	*Romulea komsbergensis* M.P.de Vos	Clark VR, Kelly C 187
Iridaceae	*Romulea luteoflora* (M.P.de Vos) M.P.de Vos	Goldblatt et al., 2002a
Iridaceae	*Romulea membranacea* M.P.de Vos	Manning et al., 2002
Iridaceae	*Romulea monadelpha* (Sweet) Baker	Goldblatt et al., 2002a
Iridaceae	*Romulea multifida* M.P.de Vos	De Vos, 1972
Iridaceae	*Romulea subfistulosa* M.P.de Vos	Goldblatt et al., 2002a
Iridaceae	*Romulea syringodeoflora* M.P.de Vos	Clark VR, Kelly C 188
Iridaceae	*Romulea tetragona* De Vos var. *tetragona*	Clark VR, O'Connor R 82
Iridaceae	*Romulea tortuosa* (Licht. ex Roem. & Schult.) Baker	Clark VR, Kelly C 68
Iridaceae	*Romulea unifolia* M.P.de Vos	Manning et al., 2002

Iridaceae	*Xenoscapa fistulosa* (Spreng. ex Klatt) Goldblatt & J.C.Manning	Clark VR, Coombs G 961
Orchidaceae	*Corycium deflexum* (Bolus) Rolfe	Clark VR, Kelly C 282
Orchidaceae	*Disperis purpurata* Rchb.f.	Clark VR, Kelly C 261
Orchidaceae	*Pterygodium hallii* (Schelpe) Kurzweil & H.P.Linder	Clark VR, Coombs G 871
Orchidaceae	*Pterygodium schelpei* H.P.Linder	Clark VR, O'Connor R 336
Poaceae	*Aristida adscensionis* L.	Clark VR, O'Connor R 196
Poaceae	*Avena barbata* Pott ex Link*	Clark VR, Kelly C 24
Poaceae	*Bromus diandrus* Roth*	Clark VR 24, 42
Poaceae	*Bromus pectinatus* Thunb.	Clark VR, Kelly C 13
Poaceae	*Bromus tectorum* L.*	Clark VR, Kelly C 115
Poaceae	*Cenchrus ciliaris* L.	Clark VR, Coombs G 922
Poaceae	*Chaetobromus involucratus* subsp. *dregeanus* (Nees) Verboom	Clark VR, Kelly C 131
Poaceae	*Ehrharta calycina* J.E.Sm.	Clark VR, O'Connor R 250
Poaceae	*Ehrharta delicatula* Stapf	Clark VR, Kelly C 132
Poaceae	*Ehrharta eburnea* Gibbs Russell	Gibbs Russell et al., 1990
Poaceae	*Ehrharta longiflora* Sm.	Clark VR, O'Connor R 206
Poaceae	*Ehrharta melicoides* Thunb.	Clark VR, Kelly C 37
Poaceae	*Ehrharta triandra* Nees ex Trin.	Clark VR, Coombs G 925
Poaceae	*Enneapogon scaber* Lehm.	Clark VR, Coombs G 920
Poaceae	*Festuca scabra* Vahl	Clark VR, Kelly C 266
Poaceae	*Fingerhuthia africana* Lehm.	Clark VR, O'Connor R 199
Poaceae	*Helictotrichon barbatum* (Nees) Schweik.	Gibbs Russell et al., 1990
Poaceae	*Helictotrichon namaquense* (Stapf) Schweick.	Gibbs Russell et al., 1990
Poaceae	*Hordeum murinum* subsp. *glaucum* (Steud.) Tzvelev*	Clark VR, Kelly C 23
Poaceae	*Hordeum murinum* subsp. *leporinum* (Link) Arcang.*	Clark VR, Coombs G 740
Poaceae	*Hyparrhenia hirta* (L.) Stapf.	Clark VR, Coombs G 906
Poaceae	*Karroochloa purpurea* (L.f.) Conert & Tuerpe	Clark VR, Kelly C 70
Poaceae	*Lolium temulentum* L. var. *temulentum**	Clark VR 45
Poaceae	*Merxmuellera dura* (Stapf) Conert	Clark VR, O'Connor R 302
Poaceae	*Merxmuellera stricta* (Schrad.) Conert	Clark VR, Kelly C 113
Poaceae	*Pentaschistis airoides* (Nees) Stapf subsp. *airoides*	Clark VR, Kelly C 235a
Poaceae	*Pentaschistis aristifolia* Schweick.	Clark VR, Kelly C 138
Poaceae	*Pentaschistis triseta* (Thunb.) Stapf	Clark VR, Kelly C 235b
Poaceae	*Phragmites australis* subsp. *altissimus* (Benth.) Clayton	Clark VR, Coombs G 949
Poaceae	*Poa bulbosa* L.	Clark VR, Kelly C 44
Poaceae	*Polypogon monspeliensis* (L.) Desf.*	Clark VR, Coombs G 848
Poaceae	*Schismus barbatus* (Loefl. ex L.) Thell.	Clark VR, Kelly C 130
Poaceae	*Schismus scaberrimus* Nees	Clark VR, Kelly C 22
Poaceae	*Secale africanum* Stapf	Gibbs Russell et al., 1990
Poaceae	*Stipagrostis namaquensis* (Nees) De Winter	Clark VR, O'Connor R 425
Poaceae	*Themeda triandra* Forssk.	Clark VR, O'Connor R 499
Poaceae	*Tribolium hispidum* (Thunb.) Desv.	Clark VR, Kelly C 193
Poaceae	*Vulpia myuros* (L.) C.Gmel.*	Clark VR, O'Connor R 261
Restionaceae	*Ischyrolepis distracta* (Mast.) H.P.Linder	Clark VR, O'Connor R 421
Restionaceae	*Ischyrolepis laniger* (Kunth) H.P.Linder	Clark VR, O'Connor R 390
Tecophilaeaceae	*Cyanella hyacinthoides* L.	Clark VR 6
Tecophilaeaceae	*Cyanella lutea* L.f.	Clark VR, Kelly C 220
Dicotyledons		
Acanthaceae	*Monechma spartioides* (T.Anderson) C.B.Clarke	Clark VR 60
Aizoaceae	*Galenia africana* L.	Clark VR, Kelly C 11
Aizoaceae	*Galenia sarcophylla* Fenzl.	Adamson, 1956
Aizoaceae	*Tetragonia spicata* L.f.	Clark VR, Coombs G 976

Anacardiaceae	*Searsia lancea* (L.f.) F.A.Barkley	Clark VR, Kelly C 219
Apiaceae	*Anginon fruticosum* I.Allison & B.-E.van Wyk	Clark VR 15
Apiaceae	*Conium sphaerocarpum* Hilliard & B.L.Burtt	Clark VR, Kelly C 239
Apiaceae	*Torilis arvensis* (Huds.) Link*	Clark VR, O'Connor R 191
Apocynaceae	*Gomphocarpus cancellatus* (Burm.f.) Bruyns	Clark VR, O'Connor R 230
Apocynaceae	*Hoodia gordonii* (Masson) Sweet ex Decne.	Clark VR, Coombs G 966
Apocynaceae	*Huernia humilis* (Masson) Haw.	Bruyns, 2005
Apocynaceae	*Microloma sagittatum* (L.) R.Br.	Clark VR, O'Connor R 279
Apocynaceae	*Pectinaria articulata* (Aiton) Haw. subsp. *articulata*	Bruyns, 2005
Apocynaceae	*Pectinaria longipes* (N.E.Br.) Bruyns subsp. *longipes*	Bruyns, 2005
Apocynaceae	*Quaqua arenicola* subsp. *pilifera* (N.E.Br.) Plowes	Bruyns, 2005
Apocynaceae	*Stapelia surrecta* N.E.Br.	Bruyns, 2005
Apocynaceae	*Tromotriche thudichumii* (Pillans) L.C.Leach	Bruyns, 2005
Asteraceae	*Amellus strigosus* (Thunb.) Less.	Clark VR, O'Connor R 163
Asteraceae	*Arctotheca calendula* (L.) Levyns	Clark VR, O'Connor R 184
Asteraceae	*Arctotis acaulis* L.	Clark VR, Kelly C 19
Asteraceae	*Arctotis arctotoides* (L.f.) O.Hoffm.	Clark VR, Kelly C 231
Asteraceae	*Arctotis diffusa* Thunb.	Clark VR, O'Connor R 103
Asteraceae	*Arctotis erosa* (Harv.) Beauverd	Clark VR, O'Connor R 205
Asteraceae	*Arctotheca prostrata* (Salisb.) Britten	Clark VR 56
Asteraceae	*Arctotis sulcocarpa* K.Lewin	Clark VR, O'Connor R 71
Asteraceae	*Aster squamatus* (Spreng.) Hieron.*	Clark VR 5
Asteraceae	*Berkheya cardopatifolia* (DC.) Roessler	Clark VR, Coombs G 981
Asteraceae	*Berkheya carlinifolia* (DC.) Roessler	Clark VR, Kelly C 96
Asteraceae	*Berkheya spinosa* (L.f.) Druce	Clark VR, Kelly C 6, 210
Asteraceae	*Berkheya spinosissima* (Thunb.) Willd.	Clark VR, Coombs G 919
Asteraceae	*Bolandia* cf. *pedunculosa* (DC.) Cron (Cron, pers. comm.)	Clark VR, O'Connor R 396
Asteraceae	*Chrysanthemoides incana* (Burm.f.) Norl.	Clark VR, O'Connor R 292
Asteraceae	*Chrysocoma ciliata* L.	Clark VR, Kelly C 21
Asteraceae	*Cineraria alchemilloides* DC. *alchemilloides*	Clark VR 38
Asteraceae	*Cineraria vallis-pacis* Dinter ex Merxm.	Clark VR, Kelly C 277
Asteraceae	*Conyza scabrida* DC.	Clark VR, Kelly C 97
Asteraceae	*Cotula coronopifolia* L.	Clark VR, Kelly C 89
Asteraceae	*Cotula microglossa* (DC.) O.Hoffm. & Kuntze ex Kuntze	Clark VR, Kelly C 175
Asteraceae	*Dicerothamnus rhinocerotis* (L.f.) Koekemoer	Clark VR, Kelly C 53
Asteraceae	*Dimorphotheca cuneata* (Thunb.) Less.	Clark VR, Kelly C 20
Asteraceae	*Eriocephalus ericoides* (L.f.) Druce subsp. *ericoides*	Clark VR, Kelly C 78
Asteraceae	*Eriocephalus eximius* DC.	Clark VR, O'Connor R 129
Asteraceae	*Eriocephalus purpureus* Burch.	Müller et al., 2001
Asteraceae	*Euryops imbricatus* (Thunb.) DC.	Clark VR, O'Connor R 453
Asteraceae	*Euryops lateriflorus* (L.f.) DC.	Clark VR, Kelly C 12
Asteraceae	*Euryops marlothii* B.Nord.	Clark VR, Kelly C 268
Asteraceae	*Euryops* sp. nov. (Nordenstam, pers. comm.)	Clark VR, O'Connor R 394
Asteraceae	*Euryops trifidus* (L.f.) DC.	Clark VR, O'Connor R 78
Asteraceae	*Felicia australis* (Alston) E.Phillips	Clark VR, O'Connor R 66
Asteraceae	*Felicia filifolia* (Vent.) Burtt Davy	Clark VR, Kelly C 14
Asteraceae	*Felicia hirsuta* DC.	Clark VR, Kelly C 73
Asteraceae	*Felicia macrorrhiza* (Thunb.) DC.	Clark VR, Kelly C 204
Asteraceae	*Felicia ovata* (Thunb.) Compton	Clark VR, O'Connor R 471
Asteraceae	*Felicia scabrida* (DC.) Range	Clark VR, O'Connor R 296
Asteraceae	*Galeomma oculus-cati* (L.f.) Rauschert	Clark VR, Coombs G 725
Asteraceae	*Gazania serrata* DC.	Clark VR, O'Connor R 118
Asteraceae	*Helichrysum hamulosum* E.Mey. ex DC.	Clark VR, Kelly C 54, 171

Asteraceae	*Helichrysum revolutum* (Thunb.) Less.	Clark VR, Kelly C 121
Asteraceae	*Helichrysum trilineatum* DC.	Clark VR, Kelly C 168
Asteraceae	*Helichrysum* cf. *tysonii* Hilliard	Clark VR, Kelly C 180
Asteraceae	*Hirpicium alienatum* (Thunb.) Druce	Clark VR, Kelly C 218
Asteraceae	*Ifloga decumbens* (Thunb.) Schltr.	Clark VR, Coombs G 822
Asteraceae	*Lasiospermum pedunculare* Lag.	Clark VR, O'Connor R 63
Asteraceae	*Lasiospermum poterioides* Hutch.	Müller et al., 2001
Asteraceae	*Leysera gnaphalodes* (L.) L.	Clark VR, Kelly C 41
Asteraceae	*Leysera tenella* DC.	Clark VR, O'Connor R 70
Asteraceae	*Oedera genistifolia* (L.) Anderb. & K.Bremer	Clark VR, O'Connor R 291
Asteraceae	*Oncosiphon piluliferum* (L.f.) Källersjö	Clark VR, Coombs G 861
Asteraceae	*Oncosiphon suffruticosum* (L.) Källersjö	Clark VR, O'Connor R 165
Asteraceae	*Osteospermum rigidum* Aiton	Clark VR, O'Connor R 72
Asteraceae	*Tripteris aghillana* DC. var. *aghillana*	Clark VR, Kelly C 77
Asteraceae	*Osteospermum sinuatum* (DC.) Norl.	Clark VR, O'Connor R 345
Asteraceae	*Osteospermum spinescens* Thunb.	Clark VR, Kelly C 211
Asteraceae	*Othonna arbuscula* (Thunb.) Sch.Bip.	Clark VR, Kelly C 297
Asteraceae	*Pentzia incana* (Thunb.) Kuntze	Clark VR, Kelly C 149
Asteraceae	*Pentzia spinescens* Less.	Clark VR, Coombs G 821
Asteraceae	*Pseudognaphalium luteo-album* (L.) Hilliard & B.L.Burtt subsp. *luteo-album*	Clark VR, Kelly C 93
Asteraceae	*Pteronia divaricata* (P.J.Bergius) Less.	Clark VR, Coombs G 928
Asteraceae	*Pteronia glomerata* L.f.	Clark VR, O'Connor R 155
Asteraceae	*Pteronia incana* (Burm.) DC.	Clark VR, O'Connor R 171
Asteraceae	*Pteronia pallens* L.f.	Clark VR, O'Connor R 369
Asteraceae	*Pteronia quinqueflora* DC.	Clark VR, Coombs G 716
Asteraceae	*Rosenia glandulosa* Thunb.	Clark VR, O'Connor R 93
Asteraceae	*Rosenia oppositifolia* (DC.) K.Bremer	Clark VR, Kelly C 151
Asteraceae	*Rosenia spinescens* DC.	Clark VR, O'Connor R 312
Asteraceae	*Senecio burchellii* DC.	Clark VR, Kelly C 120
Asteraceae	*Senecio cinerascens* Aiton	Clark VR, O'Connor R 349
Asteraceae	*Senecio hastatus* L.	Clark VR, O'Connor R 376
Asteraceae	*Senecio radicans* (L.f.) Sch.Bip.	Clark VR, Kelly C 304
Asteraceae	*Senecio scapiflorus* (L'Hér.) C.A.Sm.	Clark VR, Kelly C 34
Asteraceae	*Sonchus asper* (L.) Hill subsp. *asper**	Clark VR, Coombs G 855
Asteraceae	*Stilpnogyne bellidioides DC.*	Clark VR, Kelly C 162
Asteraceae	*Troglophyton acocksianum* Hilliard	Hilliard, 1983
Asteraceae	*Troglophyton capillaceum* (Thunb.) Hilliard & B.L.Burtt subsp. *capillaceum*	Clark VR, Kelly C 229
Asteraceae	*Ursinia* sp. nov. "*roggeveldensis"* (Mucina, pers. comm.)	Clark VR, O'Connor R 325
Asteraceae	*Vellereophyton dealbatum* (Thunb.) Hilliard & B.L.Burtt	Clark VR, Kelly C 155
Boraginaceae	*Amsinckia retrorsa* Suksd.*	Clark VR, Kelly C 247
Boraginaceae	*Codon royenii* L.	Clark VR 47
Boraginaceae	*Lithospermum scabrum* Thunb.	Clark VR, O'Connor R 497
Boraginaceae	*Lobostemon echioides* Lehm.	Clark VR, O'Connor R 233
Brassicaceae	*Alyssum minutum* Schltdl. ex DC.*	Clark VR, Kelly C 57
Brassicaceae	*Capsella bursa-pastoris* (L.) Medik.*	Clark VR, Kelly C 213
Brassicaceae	*Heliophila carnosa* (Thunb.) Steud.	Clark VR, Kelly C 71
Brassicaceae	*Heliophila latisiliqua* E.Mey. ex Sond.	Clark VR, Kelly C 79
Brassicaceae	*Heliophila pectinata* Burch. ex DC.	Clark VR, Kelly C 144
Brassicaceae	*Heliophila pubescens* Burch. ex Sond.	Clark VR, Kelly C 62
Brassicaceae	*Heliophila suavissima* Burch. ex DC.	Clark VR, Kelly C 264
Brassicaceae	*Heliophila suborbicularis* Al-Shehbaz & Mummenhoff	Clark VR, Kelly C 33
Brassicaceae	*Lepidium transvaalense* Marais	Clark VR, Kelly C 75
Buddlejaceae	*Gomphostigma incomptum* (L.f.) N.E.Br.	Verdoorn, 1963

Buddlejaceae	*Gomphostigma virgatum* (L.f.) Baill.	Clark VR, Coombs G 914
Campanulaceae	*Wahlenbergia nodosa* (H.Buek) Lammers	Clark VR, O'Connor R 467
Caryophyllaceae	*Cerastium capense* Sond.	Clark VR, Kelly C 245
Caryophyllaceae	*Dianthus laingsburgensis* S.S.Hooper	Clark VR, Coombs G 950
Caryophyllaceae	*Silene cretica* L.	Clark VR, Kelly C 287
Caryophyllaceae	*Stellaria media* (L.) Vill.*	Clark VR, Coombs G 789
Chenopodiaceae	*Chenopodium album* L.*	Clark VR, O'Connor R 362
Chenopodiaceae	*Chenopodium murale* L.*	Clark VR, Coombs G 933
Chenopodiaceae	*Salsola kali* L.*	Clark VR, O'Connor R 211
Crassulaceae	*Cotyledon orbiculata* L.	Clark VR, O'Connor R 221
Crassulaceae	*Crassula corallina* Thunb.	Clark VR, O'Connor R 85
Crassulaceae	*Crassula cultrata* L.	Clark VR, O'Connor R 215
Crassulaceae	*Crassula dependens* Bolus	Clark VR, O'Connor R 440
Crassulaceae	*Crassula natans* Thunb. var. *natans*	Clark VR, O'Connor R 201
Crassulaceae	*Crassula nemorosa* (Eckl. & Zeyh.) Endl. ex Walp.	Clark VR, Coombs G 977
Crassulaceae	*Crassula roggeveldii* Schonl.	Tölken, 1977
Crassulaceae	*Crassula sarcocaulis* Eckl. & Zeyh. subsp. *sarcocaulis*	Clark VR, Kelly C 88
Crassulaceae	*Crassula vestita* Thunb.	Tölken, 1977
Crassulaceae	*Tylecodon paniculatus* (L.f.) Tölken	Clark VR, O'Connor R 224
Crassulaceae	*Tylecodon ventricosus* (Burm.f.) Tölken	Clark VR, Coombs G 905
Ebenaceae	*Diospyros austro-africana* De Winter var. *austro-africana*	Clark VR, Kelly C 18
Euphorbiaceae	*Euphorbia aspericaulis* Pax	White et al., 1941
Euphorbiaceae	*Euphorbia cylindrica* A.C.White, R.A.Dyer & B.Sloane	White et al., 1941
Euphorbiaceae	*Euphorbia eustacei* N.E.Br.	Clark VR, Kelly C 80
Euphorbiaceae	*Euphorbia mauritanica* L. var. *mauritanica*	Clark VR, Kelly C 190
Fabaceae	*Acacia karroo* Hayne	Clark VR, O'Connor R 360
Fabaceae	*Aspalathus acicularis* E.Mey. subsp. *acicularis*	Dahlgren, 1988
Fabaceae	*Indigofera meyeriana* Eckl. & Zeyh.	Clark VR, Kelly C 241
Fabaceae	*Indigofera* sp. E (Schrire, pers. comm.)	Schrire, pers. comm.
Fabaceae	*Lotononis pungens* Eckl. & Zeyh.	Clark VR, O'Connor R 491
Fabaceae	*Lotononis venosa* B.-E.van Wyk	Van Wyk, 1990b, 1991
Fabaceae	*Medicago polymorpha* L.*	Clark VR, Kelly C 86
Fabaceae	*Melolobium candicans* (E.Mey.) Eckl. & Zeyh.	Clark VR, Kelly C 65
Fabaceae	*Otholobium striatum* (Thunb.) C.H.Stirt.	Clark VR, O'Connor R 329
Fabaceae	*Polhillia involucrata* (Thunb.) Van Wyk & Schutte	Clark VR 49
Fabaceae	*Sutherlandia frutescens* (L.) R.Br.	Clark VR, Kelly C 9
Fabaceae	*Wiborgia sericea* Thunb.	Clark VR 59
Fumariaceae	*Cysticapnos vesicaria* (L.) Fedde	Clark VR, Coombs G 932
Geraniaceae	*Erodium cicutarium* (L.) L'Hér.*	Clark VR, Kelly C 25
Geraniaceae	*Pelargonium abrotanifolium* (L.f.) Jacq.	Clark VR, Kelly C 278
Geraniaceae	*Pelargonium crithmifolium* Sm.	Clark VR, Coombs G 980
Geraniaceae	*Pelargonium githagineum* E.M.Marais	Marais, 1998
Geraniaceae	*Pelargonium magenteum* J.J.A.van der Walt	Clark VR, O'Connor R 210
Geraniaceae	*Pelargonium punctatum* (Andrews) Willd.	Clark VR, Coombs G 970
Geraniaceae	*Pelargonium torulosum* E.M.Marais	Marais, 1990
Geraniaceae	*Sarcocaulon crassicaule* Rehm	Clark VR, Coombs G 983
Geraniaceae	*Sarcocaulon salmoniflorum* Moffett	Moffett, 1979
Illecebraceae	*Scleranthus annuus* L.*	Clark VR, Kelly C 179
Lamiaceae	*Ballota africana* (L.) Benth.	Clark VR, O'Connor R 172
Lamiaceae	*Mentha longifolia* (L.) Huds.	Clark VR, Kelly C 98
Lamiaceae	*Stachys aurea* Benth.	Clark VR, Kelly C 112
Lamiaceae	*Stachys lamarckii* Benth.	Clark VR, Coombs G 815
Lamiaceae	*Stachys linearis* Burch. ex Benth.	Clark VR, Kelly C 17

Lamiaceae	*Stachys rugosa* Aiton	Clark VR, O'Connor R 307
Loranthaceae	*Septulina glauca* (Thunb.) Tiegh.	Clark VR, Kelly C 225
Malvaceae	*Anisodontea triloba* (Thunb.) Bates	Clark VR, O'Connor R 351
Melianthaceae	*Melianthus major* L.	Clark VR, Kelly C 95
Mesembryanthemaceae	*Aethephyllum pinnatifidum* (L.f.) N.E.Br.	Clark VR, Coombs G 742A
Mesembryanthemaceae	*Aloinopsis malherbei* (L.Bolus) L.Bolus	Hartmann, 2001a
Mesembryanthemaceae	*Aloinopsis spathulata* (Thunberg) L.Bolus	Hartmann, 2001a
Mesembryanthemaceae	*Antimima androsacea* (Marloth & Schwantes) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima dekenahi* (N.E.Br.) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima distans* (L.Bolus) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima emarcescens* (L.Bolus) H.E.K.Hartmann	Clark VR, Kelly C 294
Mesembryanthemaceae	*Antimima ivori* (N.E.Br.) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima* cf. *loganii* (L.Bolus) H.E.K.Hartmann	Clark VR, O'Connor R 96
Mesembryanthemaceae	*Antimima lokenbergensis* (L.Bolus) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima prolongata* (L.Bolus) H.E.K.Hartmann	Hartmann, 2001a
Mesembryanthemaceae	*Antimima subtruncata* (L.Bolus) H.E.K.Hartmann	Clark VR, Kelly C 192
Mesembryanthemaceae	*Antimima viatorum* (L.Bolus) Klak	Clark VR, O'Connor R 310
Mesembryanthemaceae	*Cheiradopsis namaquensis* (Sond.) H.E.K.Hartmann	Clark VR, O'Connor R 509
Mesembryanthemaceae	*Cleretum lyratifolium* Ihlenf. & Struck	Clark VR, Kelly C 116
Mesembryanthemaceae	*Cleretum papulosum* (L.f.) L.Bolus subsp. *papulosum*	Clark VR, O'Connor R 200
Mesembryanthemaceae	*Delosperma acocksii* L.Bolus	Clark VR, Coombs G 947
Mesembryanthemaceae	*Delosperma sphalmantoides* S.A.Hammer	Clark VR, O'Connor R 77
Mesembryanthemaceae	*Delosperma subincanum* (Haw.) Schwantes	Clark VR 9
Mesembryanthemaceae	*Dorotheanthus booysenii* L.Bolus	Hartmann, 2001a
Mesembryanthemaceae	*Dorothoreanthus bellidiformis* (Burman) N.E.Br. subsp. *bellidiformis*	Clark VR, O'Connor R 409
Mesembryanthemaceae	*Drosanthemum eburneum* L.Bolus	Clark VR, O'Connor R 374
Mesembryanthemaceae	*Drosanthemum floribundum* (Haw.) Schwantes	Clark VR, O'Connor R 347
Mesembryanthemaceae	*Drosanthemum hispidum* (L.) Schwantes	Clark VR, Coombs G 926
Mesembryanthemaceae	*Hammeria gracilis* Burgoyne	Hartmann, 2001b
Mesembryanthemaceae	*Hammeria meleagris* (L.Bolus) Klak	Clark VR 20
Mesembryanthemaceae	*Leipoldtia schultzei* (Schlechter & Diels) Friedrich	Clark VR, O'Connor R 155
Mesembryanthemaceae	*Malephora crassa* (L.Bolus) H.Jacobsen & Schwantes	Clark VR, O'Connor R 366
Mesembryanthemaceae	*Mesembryanthemum crystallinum* L.	Clark VR, O'Connor R 370
Mesembryanthemaceae	*Phyllobolus amabilis* Gerbaulet & Struck	Hartmann, 2001b
Mesembryanthemaceae	*Psilocaulon granulicaule* (Haw.) Schwantes	Clark VR 27
Mesembryanthemaceae	*Ruschia acocksii* L.Bolus	Hartmann, 2001b
Mesembryanthemaceae	*Ruschia altigena* (L.Bolus) L.Bolus	Clark VR, Kelly C 170
Mesembryanthemaceae	*Ruschia campestris* (Burchell) Schwantes	Hartmann, 2001b
Mesembryanthemaceae	*Ruschia centrocapsula* H.E.K.Hartmann & Stüber	Clark VR, Kelly C 5
Mesembryanthemaceae	*Ruschia divaricata* L.Bolus	Clark VR, O'Connor R 477
Mesembryanthemaceae	*Ruschia hamata* (L.Bolus) Schwantes	Clark VR, Coombs G 890
Mesembryanthemaceae	*Ruschia nana* L.Bolus	Clark VR, O'Connor R 130
Mesembryanthemaceae	*Ruschia putterillii* (L.Bolus) L.Bolus	Clark VR, Kelly C 143
Mesembryanthemaceae	*Ruschia spinosa* (L.) Dehn	Clark VR, Kelly C 147
Mesembryanthemaceae	*Stomatium resedolens* L.Bolus	Hartmann, 2001b
Mesembryanthemaceae	*Stomatium villettii* L.Bolus	Clark VR, Kelly C 99
Mesembryanthemaceae	*Trichodiadema setuliferum* (N.E.Br.) Schwantes	Clark VR, Coombs G 943
Molluginaceae	*Pharnaceum aurantium* (DC.) Druce	Clark VR, Kelly C 198
Molluginaceae	*Pharnaceum incanum* L.	Clark VR, O'Connor R 482
Montiniaceae	*Montinia caryophyllacea* Thunb.	Clark VR, Coombs G 921
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H.Raven	Goldblatt and Raven, 1997
Oxalidaceae	*Oxalis heterophylla* DC.	Clark VR, O'Connor R 74
Oxalidaceae	*Oxalis hirsuta* Sond.	Salter, 1944

Oxalidaceae	*Oxalis marlothii* Schltr.	Clark VR, O'Connor R 335a
Oxalidaceae	*Oxalis melanosticta* Sond.	Clark VR, Kelly C 118
Oxalidaceae	*Oxalis neglecta* Knuth	Salter, 1944
Oxalidaceae	*Oxalis obtusa* Jacq.	Clark VR, Kelly C 26
Oxalidaceae	*Oxalis odorata* J.C.Manning & Goldblatt	Clark VR, O'Connor R 416
Oxalidaceae	*Oxalis palmifrons* Salter	Clark VR, O'Connor R 420
Oxalidaceae	*Oxalis pes-caprae* L. var. *pes-caprae*	Clark VR, O'Connor R 198
Oxalidaceae	*Oxalis pocockiae* L.Bolus	Clark VR, O'Connor R 79
Oxalidaceae	*Oxalis purpurea* L.	Salter, 1944
Oxalidaceae	*Oxalis* sp. aff. *strigosa* Salter (Oberlander, pers. comm.)	Clark VR, O'Connor R 257
Oxalidaceae	*Oxalis* sp. no. 1 (Oberlander, pers. comm.)	Clark VR, Kelly C 117
Plantaginaceae	*Plantago cafra* Decne.	Clark VR, Coombs G 841
Polygalaceae	*Muraltia horrida* Diels	Clark VR, O'Connor R 383
Polygalaceae	*Polygala* cf. *ephedroides* Burch. (Balkwill, pers. comm.)	Clark VR, Kelly C 293
Polygonaceae	*Rumex cordatus* Poir.	Clark VR, Kelly C 185
Ranunculaceae	*Ranunculus aquatilis* L.	Clark VR, Coombs G 849
Ranunculaceae	*Ranunculus multifidus* Forssk.	Clark VR, O'Connor R 240
Rosaceae	*Cliffortia arborea* Marloth	Clark VR, O'Connor R 447
Rosaceae	*Cliffortia hantamensis* Diels	Whitehouse, 2002
Rosaceae	*Cliffortia ramosissima* Schltr.	Clark VR, Kelly C 227
Rubiaceae	*Anthospermum monticola* Puff	Clark VR, O'Connor R 305
Rubiaceae	*Anthospermum spathulatum* Spreng. subsp. *spathulatum*	Clark VR, O'Connor R 502
Rubiaceae	*Galium spurium* subsp. *africanum* Verdc.	Clark VR, Kelly C 238
Rubiaceae	*Nenax cinerea* (Thunb.) Puff	Clark VR 46
Rubiaceae	*Nenax microphylla* (Sond.) T.M.Salter	Clark VR, Kelly C 296
Rutaceae	*Agathosma* sp. nov."*roggeveldensis*" (Trinder-Smith, pers. comm.)	Clark VR, O'Connor R 501
Santalaceae	*Thesium imbricatum* Thunb.	Clark VR, O'Connor R 154
Santalaceae	*Thesium lineatum* L.f.	Clark VR, Coombs G 931
Sapindaceae	*Dodonaea viscosa* Jacq. var. *angustifolia* (L.f.) Benth.	Clark VR, O'Connor R 234
Scrophulariaceae	*Alonsoa unilabiata* (L.f.) Steud.	Clark VR, O'Connor R 281
Scrophulariaceae	*Aptosimum indivisum* Burch. ex Benth.	Clark VR, O'Connor R 465
Scrophulariaceae	*Cromidon austerum* Hilliard	Clark VR, Kelly C 197b
Scrophulariaceae	*Cromidon corrigioloides* (Rolfe) Compton	Clark VR, Kelly C 197a
Scrophulariaceae	*Cromidon decumbens* (Thunb.) Hilliard	Clark VR, O'Connor R 272
Scrophulariaceae	*Cromidon minutum* (Rolfe) Hilliard	Clark VR, O'Connor R 99
Scrophulariaceae	*Cromidon plantaginis* (L.f.) Hilliard	Hilliard, 1990
Scrophulariaceae	*Cromidon varicalyx* Hilliard	Hilliard, 1990
Scrophulariaceae	*Diascia cardiosepala* Hiern	Clark VR, Kelly C 83
Scrophulariaceae	*Diascia dissimulans* Hilliard & Burtt	Hilliard and Burtt, 1984
Scrophulariaceae	*Diascia floribunda* MS. (Steiner, pers. comm.)	Clark VR, Coombs G 900
Scrophulariaceae	*Diascia lewisiae* K.E.Steiner	Steiner, 1992
Scrophulariaceae	*Diascia macrophylla* (Thunb.) Spreng.	Clark VR, Kelly C 82
Scrophulariaceae	*Diascia nana* Schltr.	Clark VR, Coombs G 726
Scrophulariaceae	*Diascia parviflora* Benth.	Clark VR, Kelly C 161
Scrophulariaceae	*Hemimeris centrodes* Hiern	Clark VR, Coombs G 722
Scrophulariaceae	*Hemimeris racemosa* (Houtt.) Merr.	Clark VR, Kelly C 61, 164
Scrophulariaceae	*Hemimeris sabulosa* L.f.	Clark VR, Coombs G 736
Scrophulariaceae	*Hyobanche glabrata* Hiern	Clark VR, O'Connor R 463
Scrophulariaceae	*Hyobanche rubra* N.E.Br.	Clark VR, Kelly C 134
Scrophulariaceae	*Hyobanche sanguinea* L.	Clark VR, Kelly C 230
Scrophulariaceae	*Jamesbrittenia incisa* (Thunb.) Hilliard	Hilliard, 1994
Scrophulariaceae	*Lyperia tristis* (L.f.) Benth.	Clark VR, Kelly C 47
Scrophulariaceae	*Manulea diandra* Hilliard	Clark VR, Kelly C 183

Scrophulariaceae	*Manulea incana* Thunb.	Hilliard, 1994
Scrophulariaceae	*Nemesia azurea* Diels	Clark VR, Kelly C 181
Scrophulariaceae	*Nemesia platysepala* Diels	Grant DAL 4892
Scrophulariaceae	*Polycarena aurea* Benth.	Clark VR, Kelly C 246
Scrophulariaceae	*Reyemia chasmanthiflora* Hilliard	Hilliard, 1994
Scrophulariaceae	*Reyemia nemesioides* (Diels) Hilliard	Hilliard, 1994
Scrophulariaceae	*Selago florifera* Hilliard	Hilliard, 1999
Scrophulariaceae	*Selago pinguicula* E.Mey.	Hilliard, 1999
Scrophulariaceae	*Selago polygala* S.Moore	Hilliard, 1999
Scrophulariaceae	*Selago spectabilis* Hilliard	Hilliard, 1999
Scrophulariaceae	*Selago subspinosa* Hilliard	Hilliard, 1999
Scrophulariaceae	*Sutera violacea* (Schltr.) Hiern	Clark VR, Kelly C 123
Scrophulariaceae	*Veronica anagallis-aquatica* L.	Clark VR, Coombs G 939
Scrophulariaceae	*Zaluzianskya acutiloba* Hilliard	Hilliard, 1994
Scrophulariaceae	*Zaluzianskya bella* Hilliard	Clark VR, Kelly C 178
Scrophulariaceae	*Zaluzianskya capensis* (L.) Welp.	Clark VR, O'Connor R 469
Scrophulariaceae	*Zaluzianskya cohabitans* Hilliard	Hilliard, 1994
Scrophulariaceae	*Zaluzianskya inflata* Diels	Clark VR, Coombs G 896
Scrophulariaceae	*Zaluzianskya marlothii* Hilliard	Hilliard, 1994
Scrophulariaceae	*Zaluzianskya minima* (Hiern) Hilliard	Clark VR, Coombs G 782
Scrophulariaceae	*Zaluzianskya peduncularis* (Benth.) Walp.	Clark VR, Kelly C 177
Scrophulariaceae	*Zaluzianskya sutherlandica* Hilliard	Hilliard, 1994
Solanaceae	*Lycium amoenum* Dammer	Clark VR, O'Connor R 175
Solanaceae	*Lycium cinereum* Thunb.	Clark VR, Kelly C 169
Solanaceae	*Lycium horridum* Thunb.	Clark VR, Kelly C 226
Solanaceae	*Lycium oxycarpum* Dunal	Clark VR, Kelly C 136
Solanaceae	*Lycium pilifolium* C.H.Wright	Clark VR, Coombs G 721a
Solanaceae	*Solanum tomentosum* L. var. *coccineum* (Jacq.) Willd.	Clark VR, Kelly C 129
Sterculiaceae	*Hermannia althaeifolia* L.	Clark VR, O'Connor R 372
Sterculiaceae	*Hermannia cernua* Thunb.	Clark VR, Kelly C 284
Sterculiaceae	*Hermannia coccocarpa* (Eckl. & Zeyh.) Kuntze	Clark VR, Coombs G 851
Sterculiaceae	*Hermannia cuneifolia* Jacq. var. *glabrescens* (Harv.) I.Verd.	Clark VR, Kelly C 55
Sterculiaceae	*Hermannia grandiflora* Aiton	Clark VR, O'Connor R 365
Sterculiaceae	*Hermannia jacobeifolia* (Turcz.) R.A.Dyer	Clark VR, O'Connor R 445
Sterculiaceae	*Hermannia johanssenii* N.E.Br.	Clark VR, Kelly C 133
Urticaceae	*Forsskaolea candida* L.f.	Clark VR 44
Urticaceae	*Urtica lobulata* Blume	Clark VR, Kelly C 153
Viscaceae	*Viscum hoolei* (Wiens) Polhill & Wiens	Clark VR, O'Connor R 320
Zygophyllaceae	*Zygophyllum pygmaeum* Eckl. & Zeyh.	Clark VR, Kelly C 38

Chapter 6: Endemism, connectivity and disjunction along the southern Great Escarpment.

6.1. Introduction

The Great Escarpment in southern Africa has often been cited as a biological corridor and/or refugium for moist, temperate and montane species in southern Africa (Levyns, 1952, 1964; Van Wyk and Smith, 2001). Areas in Africa currently with such a flora comprise White's (1983) Afromontane phytochorion and are a series of phytogeographically-related montane islands that span a region extending from the CFR northwards along the eastern mountain ranges of southern Africa and up through east Africa to Ethiopia, with outliers in Angola, Cameroon and West Africa (Linder, 1990; Meadows and Linder, 1993; Carbutt and Edwards, 2001; Galley et al., 2007). The moist eastern Great Escarpment in southern Africa – especially the DAC (Linder, 1990; Van Wyk and Smith, 2001; Galley et al., 2007) – forms a key component in this archipelago, while the southern and western sections of the Great Escarpment are largely arid and inhospitable to many Cape and Afromontane elements (Weimarck, 1941). Numerous Cape clades are found in the Afromontane region, providing grounds for much speculation on the source of the large-scale scatter of these clades (Galley et al., 2007). In southern Africa it has been postulated that the southern Great Escarpment may have at one time been a corridor connecting Cape and Afromontane elements between the CFR and the DAC (Weimarck, 1941; Levyns, 1952, 1964; Van Wyk and Smith, 2001; Bergh et al., 2007; Clark et al., 2009).

The purpose of this chapter is to use the floristic data gathered and discussed in Chapters 2–5 to explore the nature of the southern Great Escarpment as a biogeographical corridor linking the CFR and the DAC, as well as a series of montane interglacial refugia. The direction of migration between the CFR and DAC (Galley et al., 2007) is not as much a concern in this chapter as is the assessment of the actual connectivity and putative occurrence of refugia along this largely more arid series of mountains.

6.2. The Southern Great Escarpment

6.2.1. Geomorphology and Intervals

The southern Great Escarpment constitutes, from west to east, the Hantamberge, Roggeveldberge and Komsberg (hereafter referred to as the Hantam–Roggeveld), the Nuweveldberge, the Sneeuberg, the Great Winterberg–Amatolas and the Stormberg (Fig. 6.1). The geology of the southern Great Escarpment is fairly uniform, comprising Beaufort Series shales and sandstones of the Karoo Supergroup heavily intruded by dolerites (Rubin and Palmer, 1996; Woodford and Chevallier, 2002; Clark et al., 2009), with Molteno and Clarens Formation sandstones and Drakensberg basalts occurring on the Stormberg (Department of Mineral and Energy Affairs, 1982; Bester, 1998; Hoare and Bredenkamp, 2001). Geomorphologically, the southern

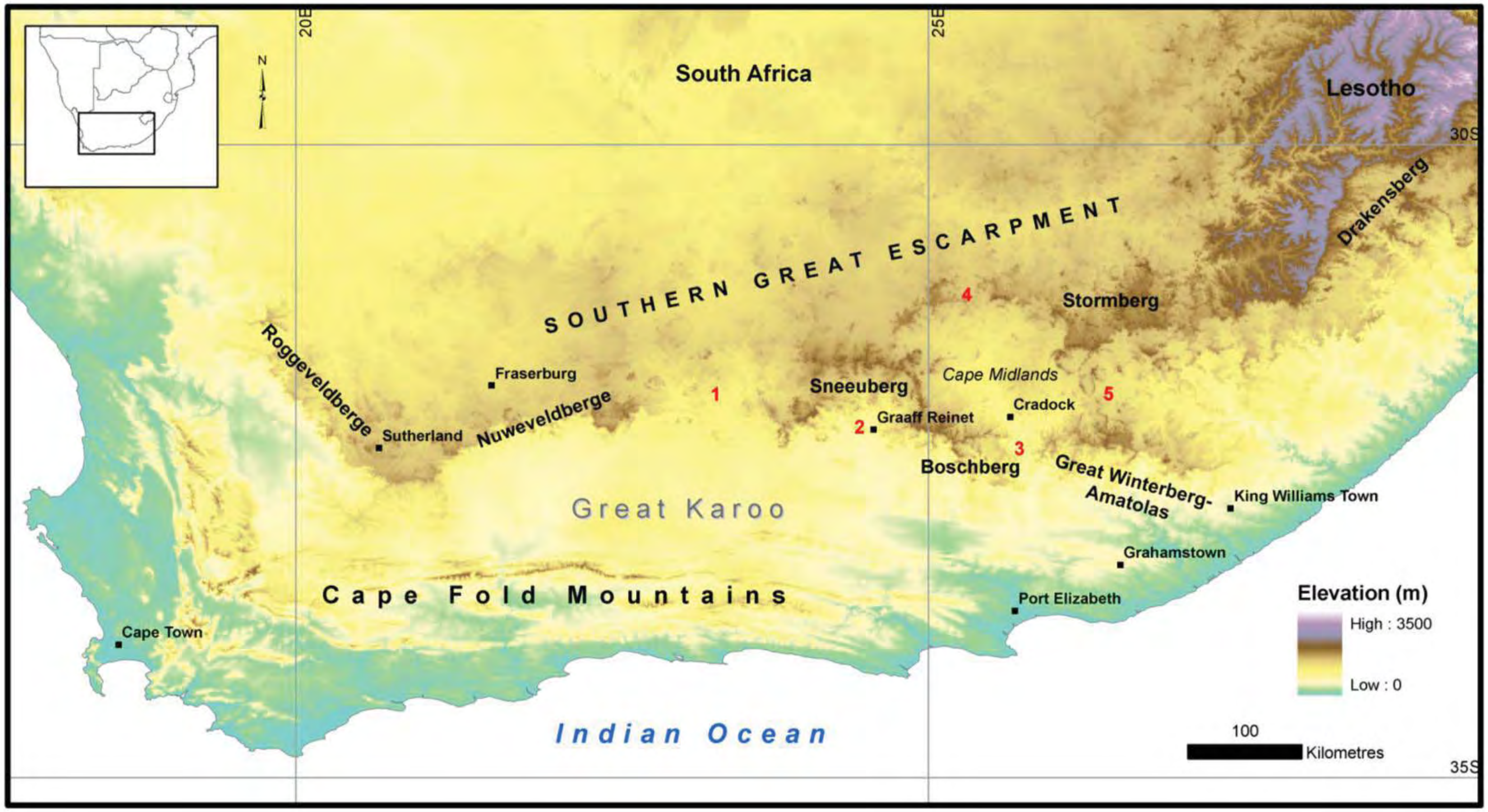


Figure 6.1: The southern Great Escarpment, South Africa, showing principal orographic components and intervals. 1 = Nelspoort Interval, 2 = Sundays River Interval, 3 = Great Fish River Interval, 4 = Macassarfontein Interval, 5 = Queenstown Interval. Base-map generated by G. Keevey (Department of Botany) using data elevation data sourced from Geo Community (2009).

Great Escarpment is the perhaps the most complex component of the Great Escarpment in southern Africa, considering the extent of fragmentation by fluvial erosion and the formation of the Cape Midlands basin (Fig. 6.1; see Chapters 1 and 2). What used to be a continuous Escarpment between the Roggeveld and DAC has been fragmented into the Hantam–Roggeveld–Nuweveld Escarpment, the Sneeuberg Escarpment, the Great Winterberg–Amatolas Escarpment, and Stormberg (part of the Main Drakensberg Escarpment) (Fig. 6.1; see also Chapter 1).

Of the numerous intervals defined along the Great Escarpment in Chapter 1, three minor intervals – the Nelspoort, Sundays River and Great Fish River Intervals (Table 6.1; Fig. 6.1) – occur along the southern Great Escarpment. The Macassarfontein and Queenstown Intervals, which do not qualify as major or minor intervals in Chapter 1, are here recognised as local intervals (Table 6.1; Fig. 6.1). The most significant of these southern Great Escarpment intervals biogeographically is the Nelspoort Interval, separating the Hantam–Roggeveld–Nuweveld Escarpment from the Sneeuberg Escarpment (Nordenstam, 1969; Clark et al., 2009) as it forms a clear geomorphological break between the Hantam–Roggeveld Centre of Endemism (HRC), or "Western Upper Karoo Centre" in the west, from the Sneeuberg or "Sneeuwbergen" Centre in the east (Nordenstam, 1969; Hilliard, 1994; Van Wyk and Smith, 2001; Clark et al., 2009). There is no interval between the Hantam–Roggeveld and the Nuweveldberge, hence Nordenstam's (1969) and Hilliard's (1994) "Western Upper Karoo Centre" incorporating the Hantam–Roggeveld–Nuweveldberg Escarpment. The Sneeuberg is separated from the Great Winterberg–Amatolas and the Stormberg by the Great Fish River and Macassarfontein Intervals respectively, and the Great Winterberg–Amatolas from the Stormberg by the Queenstown Interval (Table 6.1 and Fig. 6.1). While geomorphological fragmentation and landscape dissection is, together with the interval nature of Cape Midlands basin, unequivocal, the influence of local intervals along the southern Great Escarpment on the local floras is equivocal, being apparent barriers to some species (e.g. local endemics) but not so for many others (e.g. regional endemics and more widespread Great Escarpment species). Some of the answer may lie in historical under-collecting: a case in point is four of the Sneeuberg endemics now also known from the Nuweveldberge (see Chapter 4).

6.2.2. Climate

The climate of the southern Great Escarpment ranges from humid in the east (with a summer rainfall regime) to arid in the west (with a winter rainfall regime; Figs 6.2–6.4). Walter-Leith diagrams, as provided by Mucina and Rutherford (2006) for the vegetation units that characterise the plains below the southern Great Escarpment, the scarp/crest, and the summit plateau, illustrate this transition along the southern Great Escarpment from east to west and south to north (Fig. 6.2A–D). In all instances, the MAP is lowest on the plains below the Great Escarpment and highest on the scarp/crest itself, except on the Sneeuberg (Fig. 6.2B), where the MAP is highest on the summit plateau rather than on the scarp/crest. Of the scarp/crest weather

Table 6.1: Intervals along the southern Great Escarpment. Interval numbers correspond with Fig. 6.1.

Interval	Width (at 1500 m-contour)	Comments
1. Nelspoort Interval.	105 km (from Skipberg in the Nuweveldberge to Goewermentsberg in the Onder-Sneeuberg; 32°12'S 22°37'E and 32°07'S 23°45'E respectively).	The largest break along the southern Great Escarpment. Separates Nordenstam's (1969) "Western Mountain Karoo Centre" (Hantam – Roggeveld– Nuweveld Escarpment) from his "Sneeuwbergen Centre" (Sneeuberg, Stormberg and Great Winterberg–Amatolas). Perhaps the most significant biogeographical interval along the southern Great Escarpment. See also Chapter 4.
2. Sundays River Interval.	Difficult to provide a definite width due to the highly dissected nature of the terrain, and the many isolated peaks exceeding 1 500 m. The distance between the continuous plateau on each side of the Interval is 61 km however (from near Bakenskop in the west to Platberg in the east; 32°15'S 24°6'E and 32°15'S 24°50'E respectively).	An incision into the Sneeuberg mountain complex, separating it into eastern and western components. Each of these sections has its own set of endemics, but they also share many endemics and are connected around the north via the Compassberg.
3. Great Fish River Interval.	25 km (from the Bloemfonteinberge in the Sneeuberg to Aasvoëlkop in the Great Winterberg–Amatolas; 32°25'S 25°36'E and 32°26'S 25°53'E respectively).	Separates the Sneeuberg in the east from the Great Winterberg–Amatolas in the west. Not a significant interval as many species are shared between the Boschberg and the Great Winterberg–Amatolas, including several endemics. See also Chapters 2 and 3.
4. Macassarfontein Interval.	3 km (from the Grootbrilberg plateau to Ysterberg; 31°10'S 25°20'S 31°10'S 25°24'E respectively). This Interval doesn't qualify as a major or minor interval in terms of the criteria used in Chapter 1.	Separates the Kikvorsberge (part of the Sneeuberg) in the west from the Suurberg (part of the Stormberg) in the east. Located at the watershed between the Orange and Great Fish River systems. This Interval is the narrowest in the southern Great Escarpment. There is however a broad basin encircled by the Sneeuberg, Great Winterberg–Amatola and Stormberg and which comprises the Cape Midlands. This forms a large basin interval in its own right.
5. Queenstown Interval.	Difficult to provide a definite width due to the highly dissected nature of the terrain, and many isolated peaks exceeding 1 500 m and several 2 000 m. The width between the continuous plateau on each side of the Interval is approximately 65 km (from the Bamboesberge and Hangklip in the north to the northern edge of the Great Winterberg plateau). This Interval doesn't qualify as a major or minor interval in terms of the criteria used in Chapter 1.	Separates the Great Winterberg–Amatolas in the south from the Stormberg mountain complex in the north. A complex Interval due to the abundance of high altitude but narrow dolerite intrusions present in the Interval and which have probably encouraged both connectivity and speciation.

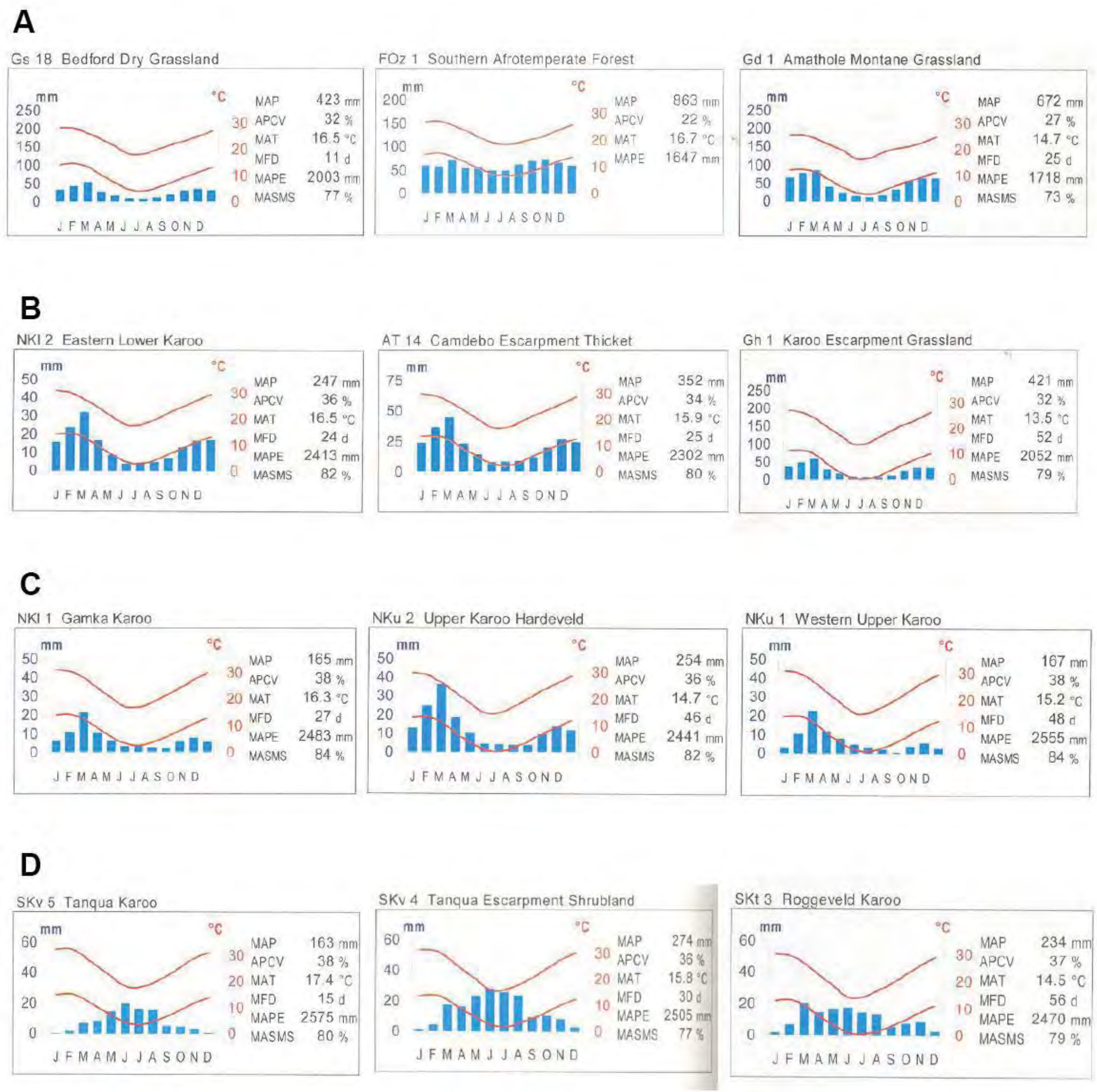


Figure 6.2: Walter-Leith diagrams for the southern Great Escarpment, indicating climatic transitions from east to west (vertically in the Figure), and from south to north (horizontally across the Figure): (A) Great Winterberg–Amatolas; (B) Sneeuberg; (C) Nuweveldberge; (D) Roggeveldberge. Abbreviations: MAP = Mean Annual Precipitation, APCV = Annual Co-efficient of Variation, MAT = Mean Annual Temperature, MFD = Mean Frost Days, MAPE = Mean Annual Potential Evaporation, MASMS = Mean Annual Soil Moisture Stress. From Mucina and Rutherford (2006).

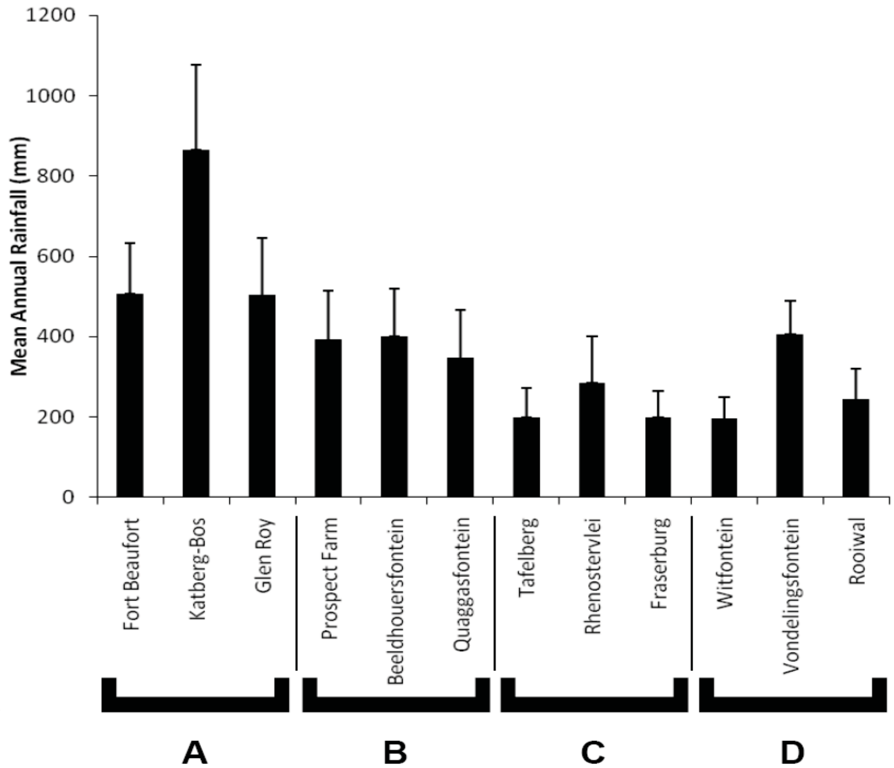


Figure 6.3: Mean annual precipitation with standard deviation for the southern Great Escarpment: (A) Great Winterberg–Amatolas; (B) Sneeuberg; (C) Nuweveldberge; (D) Roggeveldberge. Data supplied by the South African Weather Service (2010) for 1980–2009.

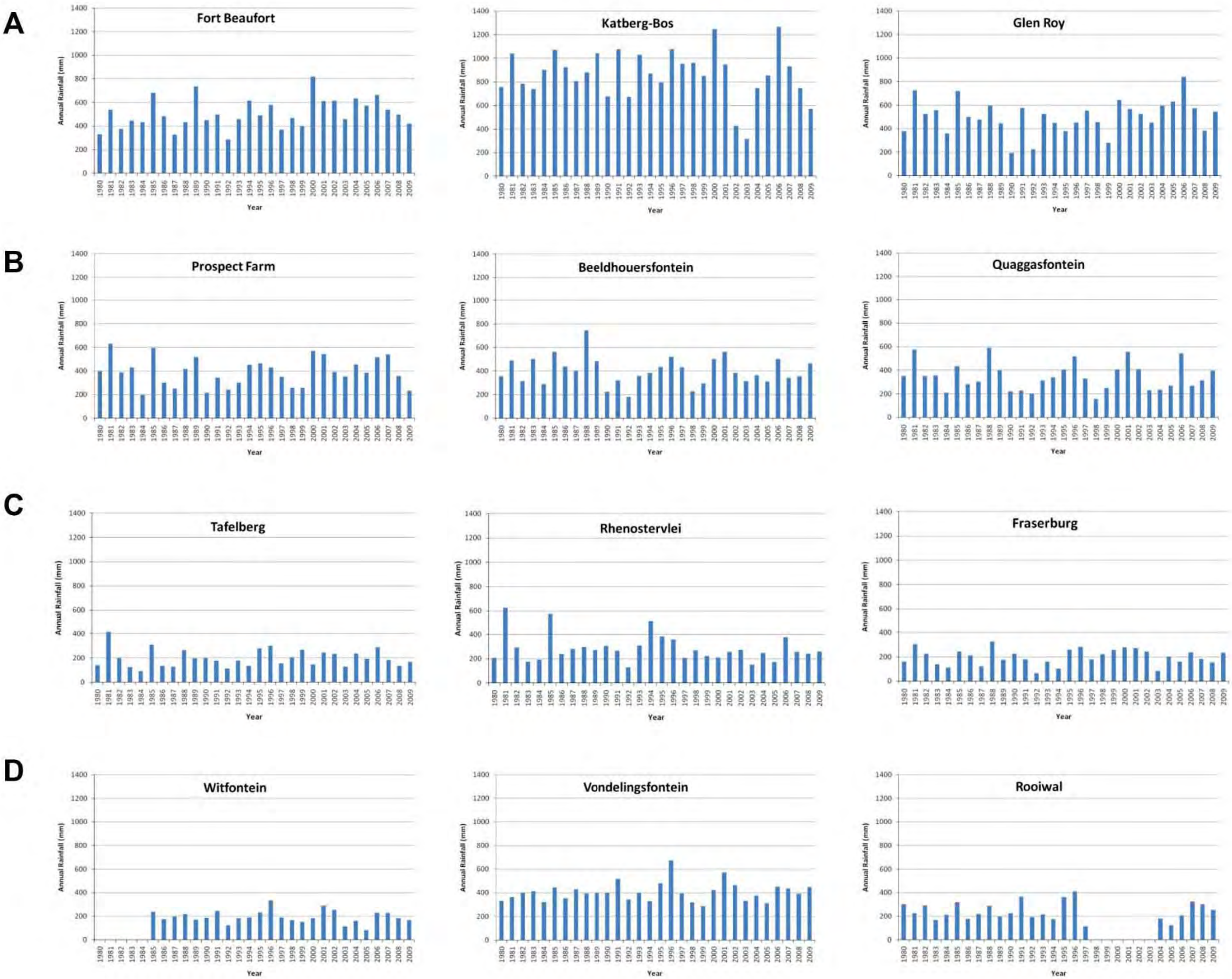


Figure 6.4: Mean annual precipitation (1980–2009) for the southern Great Escarpment: (A) Great Winterberg–Amatolas; (B) Sneeuberg; (C) Nuweveldberge; (D) Roggeveldberge. From left to right: the foot of the Great Escarpment, the scarp/crest, and the summit plateau/inland margin. Data supplied by the South African Weather Service (2010). Note that data was unavailable for Witfontein from 1980–1984 and for Rooiwal from 1998–2003.

sites, the Great Winterberg–Amatolas has the most consistent rainfall through the year (Fig. 6.2A), while the Nuweveldberge scarp/crest has the lowest MAP and the least consistent rainfall during the year (Fig. 6.2B). West of the Nuweveldberge there is a clear change to a winter-rainfall regime on the Roggeveldberge (Fig. 6.2D).

The actual MAP for specific weather-recording sites along the southern Great Escarpment (from 1980–2009; Fig. 6.3; and not simply the averages for the more widespread vegetation units used in Fig. 6.2) generally supports the trends in Fig. 6.2, but with some differences. Most noticeable of these is the MAP of 407 mm for the Roggeveld scarp/crest (Vondelingsfontein; Fig. 6.3D), which is substantially higher than the MAP of 274 mm in Fig. 6.2D. Similarly the Nuweveldberge rainfall figures in Fig. 6.3C are all on or over 200 mm, compared to Fig. 6.2C where only the scarp/crest exceeds 200 mm. Interestingly enough, the Sneeuberg in Fig. 6.3B has an almost consistent MAP across the Great Escarpment from south to north, compared to the almost 200 mm-difference between the base of the Great Escarpment and the summit plateau in Fig. 6.2B. These differences are probably due to the use here of specific weather site data compared to the vegetation unit averages in Fig. 6.2B.

A look at the inter-annual rainfall data for three decades from 1980–2009 (Fig. 6.4A–D) provides insight into the standard deviations indicated in Fig. 6.3. Interestingly enough, standard deviation is highest for the Great Winterberg–Amatola scarp/crest than for the rest of the southern Great Escarpment (Fig. 6.3A). This is the result of the very varying inter-annual rainfall figures, ranging from very wet years (>1 000 mm) to periodic dry years (<700 mm), the most recent being an apparent severe drought in 2002 and 2003, although this is not corroborated in the Fort Beaufort and Glen Roy data (Fig. 6.4A). Standard deviation for the other two Great Winterberg–Amatolas sites and for the Sneeuberg are similar (Fig. 6.3A and B), with significant inter-annual rainfall variability being evident (6.4A and B). Standard deviation on the Nuweveldberg scarp/crest (Fig. 6.3C) is similar to that of the Sneeuberg (Fig. 6.3B), but lower for the base of the Great Escarpment and the inland plains, these being more comparable with the standard deviations for the Roggeveldberge (Fig. 6.3D). The Roggeveldberge has the lowest standard deviations of the southern Great Escarpment, probably due to the more reliable winter-rainfall regime. What is evident overall from Fig. 6.4 is the obvious inter-annual rainfall variability across the entire southern Great Escarpment.

6.2.3. Vegetation

Studies on the vegetation of the various montane components of the southern Great Escarpment have been sketchy (Meadows and Linder, 1993) and until this study (Chapters 2–5) there has been no comprehensive treatment of any of these components. There is little known floristic work for Stormberg, and the Great

Winterberg–Amatolas, although having been patchily studied, still await a holistic phytogeographical investigation.

6.2.4. Connections with the CFR

Three purported connections between the southern Great Escarpment and the CFR were postulated by Weimarck (1941): the NW connection, the Matjiesfontein connection and the SE connection (Fig. 6.5). The NW connection is the link between NW Centre mountains (e.g. the Cederberg and Bokkeveld mountains) and the Hantam–Roggeveldberge, while the Matjiesfontein connection is the connection between the KM Centre mountains (e.g. the Witteberge, Swartberge and Anysberge) via the Klein-Roggeveldberge and Koedoesberge onto the Roggeveldberge and Komsberg. The SE connection is the link between the SE Centre mountains (e.g. Groot-Winterhoekberge and Zuurberg) onto the Sneeuberg–Boschberg and Great Winterberg–Amatolas.

The aim of this Chapter is to determine floristic connectivity along the southern Great Escarpment and between the CFR and the southern Great Escarpment. Two numerical methods to analyse the floristic data were used, namely the clustering technique Unweighted Pair-Group Method Using Arithmetic Averages (UPGMA) (Sokal and Sneath, 1963; Krebs, 1999; McGarigal et al., 2000), based on Jaccard's Similarity Co-efficient as a resemblance measure, and Parsimony Analysis of Endemicity (PAE) (Rosen, 1988). In addition, what is here termed a “connectivity analysis”, was also undertaken where sister-taxa/area relationships of Great Escarpment species are assessed based on available phylogenies.

6.3. Methods

6.3.1. Data Sources

Floristic data for the southern Great Escarpment (Great Winterberg–Amatolas, Sneeuberg, Nuweveldberge and Roggeveldberge), the DAC, and Weimarck’s (1941) five CFR centres of endemism (SW, NW, Langeberg (LB), KM, Knysna Region (KR), SE) as well as the Agulhas Plain (AP) Centre, were collected from numerous sources (Table 6.2). The data was organised in a spreadsheet, and plant names standardised and synonyms merged using the African Flowering Plants Database (2009) and Germishuizen and Meyer (2003). Taxa were coded for their presence (1) or absence (0) in each of the 13 areas. The final data matrix of 11 765 taxa is attached as Appendix 6.1 (on the enclosed compact disc). In this Chapter, reference to the Sneeuberg includes the Boschberg (unless otherwise stated) and is synonymous with the Sneeuberg Centre. Reference to the Roggeveldberge includes the Komsberg, while Hantam–Roggeveld and HRC are referred to

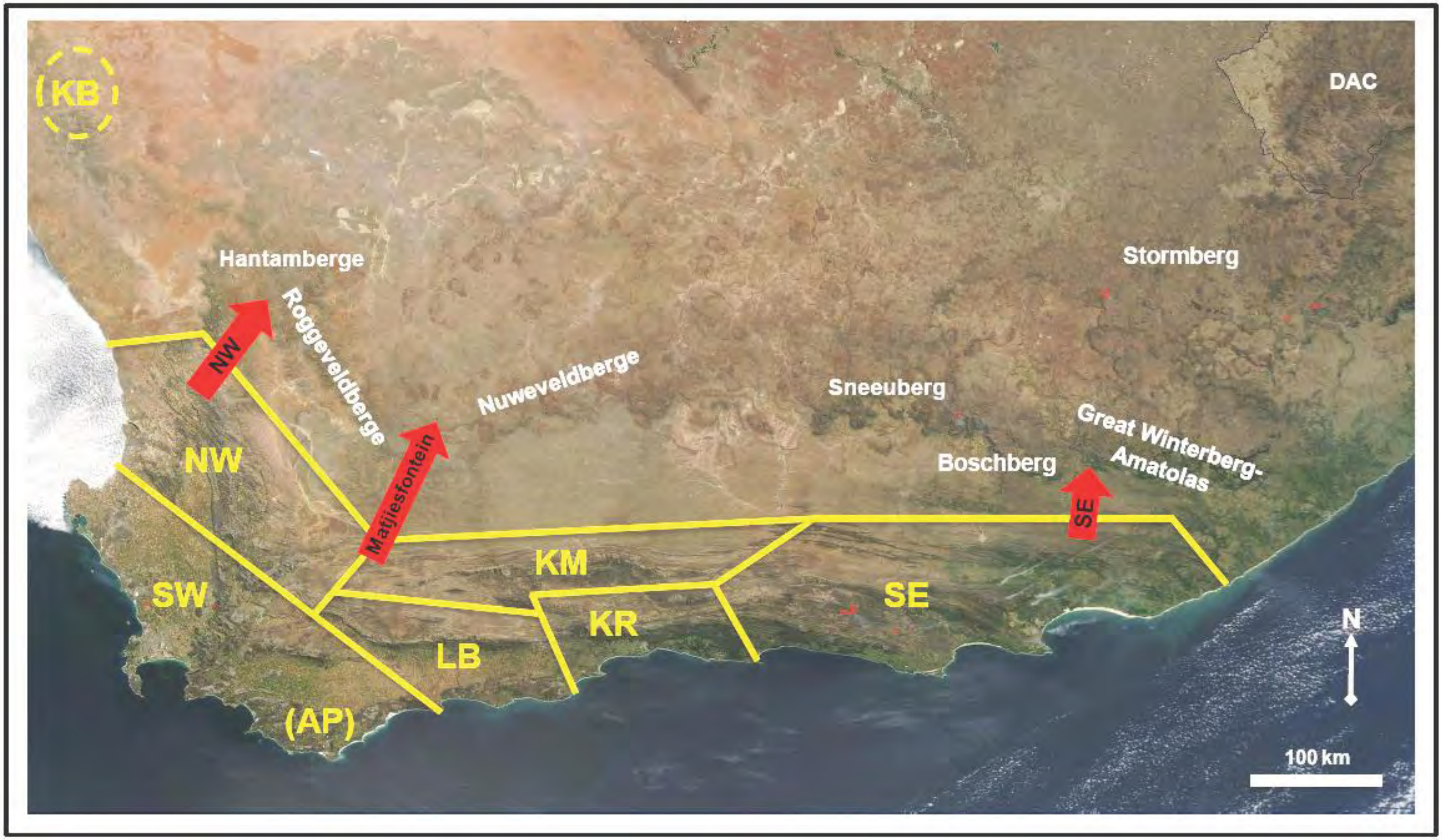


Figure 6.5: The three putative connections between the CFR and the southern Great Escarpment (red arrows). CFR Centres of Endemism based on Weimarck (1941): SW = South West Centre, NW = North West Centre, KM = Karoo Mountain Centre, LB = Langeberg Centre, KR = Knysna Region, SE = South East Centre, KB = Kamiesberg Centre. AP = Agulhas Plain (additional centre not in Weimarck, 1941). DAC = Drakensberg Alpine Centre. Satellite imagery from NASA (2008).

Table 6.2: References and sources of floristic data for the southern Great Escarpment. The Stormberg and Hantamberge have been excluded due to a paucity of data.

Mountain Range/Section	Floristic Data Sources
Drakensberg Alpine Centre.	Bester (1998), Pooley (2003), Carbutt and Edwards (2004), AfriDev (1996). The dataset is considered to be reasonably complete given a total of 2 035 taxa out of a flora of 2 818 taxa as given by Carbutt and Edwards (2004).
Great Winterberg–Amatolas.	Story (1952a, b; Keiskammahoek), Phillipson (1987; Amatolas), PRECIS, taxonomic revisions. The dataset of 1 518 taxa is considered to be reasonably complete and is one of the most robust for the southern Great Escarpment, although with future work on the Great Winterberg component the total flora may exceed 2 000 taxa.
Sneeuberg.	Appendix 2 in Chapter 2 (from Clark et al., 2009), Appendix 3 in Chapter 3. The dataset of 1 366 taxa is considered to be reasonably to nearly complete.
Nuweveldberge.	Rubin and Palmer (1996), Rubin et al. (2001; Karoo National Park), Appendix 4 in Chapter 4. The dataset of 1 116 taxa is considered to be reasonably complete.
Roggeveldberge/Hantam–Roggeveldberge/HRC.	Appendix 5.2 in Chapter 5. Data for the total HRC is sourced from Van Wyk and Smith (2001). The dataset of 513 taxa is not complete, and the total Roggeveld Escarpment flora is probably closer to 1 500 species.
CFR.	PRECIS. The dataset is considered to be reasonably complete given a total of ca. 7 500 taxa out of a flora of 8 600 taxa.
Baviaanskloof.	Archer and Van Wyk (1993). It is not known how complete this dataset is.
Cockscomb.	Fieldtrip collections (March 2006 – Clark VR, Dold AP, Weston P – housed in GRA). Not complete – a complete flora of Cockscomb would require a dedicated collecting effort which is beyond the scope of this study.
Zuurberg.	Van Wyk et al. (1988). The dataset of 1 011 taxa is considered to be reasonably to substantially complete.

specifically when the Hantam component and the entire HRC are considered respectively. The Stormberg has been excluded due to a paucity of floristic data.

6.3.2. Floristic comparisons

Species richness on the various components of the southern Great Escarpment and the DAC were calculated together with family richness, percent endemism, rainfall reliability, species–area and endemic–area relationships, proportion endemics per the main endemic-rich families, and the top ten families occurring on each orographic entity. For the CFR, total floras were calculated for the NW and KM Centres and the Baviaanskloof–Cockscomb and Zuurberg components of the SE Centre using the floristic database in Appendix 6.1, these being the CFR–components in closest proximity to the southern Great Escarpment. The proportion of shared species between these CFR components and the southern Great Escarpment and the DAC were also calculated. Species–area and endemic–area analyses were undertaken for the southern Great Escarpment, the DAC, the CFR and four other Great Escarpment centres of endemism (Chimanimani–Nyanga, Kamiesberg, Soutpansberg and Wolkberg Centres), the data for which was obtained from Van Wyk and Smith (2001). All of this data was then converted into graphics using Microsoft Office Excel 2007 and Microsoft PowerPoint 2007.

6.3.3. Multivariate Analysis

a) Unweighted pair-group method using arithmetic mean (UPGMA)

The floristic relationships between the 13 areas was analysed using the phenetic clustering technique UPGMA (Sokal and Sneath, 1963; Krebs, 1999; McGarigal et al., 2000), based on Jaccard's Similarity Co-efficient as a resemblance measure (Linder, 2001). This approach has the advantage of being more readily repeatable as opposed to manual methods such as the intuitive inspection of distribution maps and tabulation (Ramdhani et al., 2008). The clustering analysis was undertaken using NT-SYS version 2.0 (Rholf, 1998). An advantage of Jaccard's Similarity Co-efficient is that shared absences are ignored thus making absences from under-collecting less problematic in biogeographic analyses (Linder and Mann, 1998; Ramdhani et al., 2008).

b) Parsimony Analysis of Endemicity

A PAE (Rosen, 1988) was applied to the same data matrix as outlined in 6.3.1.(a) above. PAE is useful as it can generate cladograms using species distribution data without phylogenetic studies of the taxa in question being necessary (Bisconti et al, 2001; Mota et al., 2002; Manrique et al., 2003). PAE groups areas by their shared taxa and represents a version of the historical relationships between the areas in question (Brooks and Van Veller, 2003). A drawback of PAE, however, is that it is only considered accurate for historical biogeographical analysis if the dominant speciation process was vicariance (Brooks and Van Veller, 2003). Speciation in the 13 areas in the analysis is probably a combination of vicariance and long-distance dispersal, but perhaps primarily climatic vicariance. The dataset was analysed using PAUP* 4.0b10 (Swofford, 2002), applying the following settings: heuristic search with tree bisection-reconnection (TBR) branch-swapping and 1 000 random addition replicates, saving all best trees. A second heuristic search was performed using the best trees from the initial search as starting trees. In both cases, the same single most parsimonious tree was retrieved.

6.3.4. Connectivity analysis using phylogenies

As stated by Lovett et al. (2005, p. 207), "*History is reflected in the genetic composition of centres of biodiversity*", and phylogenetic/phylogeographic analyses may be key in disentangling montane species relationships (Jetz et al., 2004; Barraclough, 2006; Hawkins, 2006; Bergh et al., 2007; Holderegger and Thiel-Egenter, 2009). This may be especially important in trying to gain an indication of relationships between relatively localised (relict?) montane floras compared to the coarse palaeoclimatic data (Holderegger and Thiel-Egenter, 2009) for the southern African sub-region (Bergh et al., 2007). Phylogeographic analyses may also be useful in bringing clarity to discrepancies from palaeoclimatic results, especially as the presence of micro-refugia is virtually undetectable by palaeo-ecological analysis (Bergh et al., 2007; Rull, 2009).

In order to discern if the southern Great Escarpment has been a palaeo-corridor for Cape elements from either the NW, Matjiesfontein or SE connections (or all of these), reasonably well-sampled phylogenies of genera with CFR, DAC and Great Escarpment species were obtained. The distribution of each Great Escarpment species and its sister taxon (or taxa/co-taxa in each clade) was then noted in terms of Weimarck's (1941) Cape centres of endemism (including the Kamiesberg Centre). The sources of phylogenetic and geographical distributional data are provided in Table 6.3. Some of the distributions indicated in the African Flowering Plants Database (2009) are problematic and this source has been used cautiously. For the sake of space only taxa relevant to the clades which include Great Escarpment taxa have been indicated on the phylogenies (Appendix 6.2).

Several limitations to this approach must be noted: (1) Phylogenies of some key Afromontane groups have low resolution or exhibit questionable monophyly at species level, such as *Kniphofia* (Ramdhani et al., 2009) and *Conium* (Stratton, pers. comm.). This may be due to low genetic variability and possible recent speciation of such groups on African mountains (Gehrke, 2008; Ramdhani et al., 2009). For this reason they were not considered in this analysis. (2) Caution is required given persistent uncertainties in the reconstruction of phylogenies (Linder, 2006). (3) There is sometimes conflict between apparent morphological similarities and phylogenetic results (such as Nordenstam et al., 2009; Devos et al., 2010). (4) The phylogenies used here are Cape-biased and often incompletely sampled. Many southern Great Escarpment endemics that would provide interesting insights into the origins of the montane floras (e.g. *Cliffortia bolusii*, *Euryops dentatus*) are thus often absent from these phylogenies. (5) There are no phylogenies available as yet for some key groups with strong Great Escarpment significance. Examples (some in preparation) are *Asparagus, Carex, Cromidon, Eriocephalus*, *Otholobium, Psoralea*, *Pentzia*, *Selago*, *Sutera*, *Tetraria* and *Thesium*. (6) Finally, there is often contradiction between nuclear and chloroplast trees (e.g. *Cliffortia* and *Euryops*; Whitehouse, 2002; Nordenstam et al., 2009; Devos et al., 2010), and many of the phylogenies represent “gene trees” rather than robust, multi-gene phylogenies.

Table 6.3: Phylogenies used, together with their sources and that of the species distributions.

Genus	Phylogeny Source	Geographic Distribution Source
Alepidea (Apiaceae)	Calviño and Downie, 2007.	African Flowering Plants Database, 2009.
Anginon and other Apiaceae	Calviño et al., 2006.	African Flowering Plants Database, 2009.
Berkehya (Asteraceae)	Phaliso, pers. comm.	African Flowering Plants Database, 2009.
Brassicaceae (Cape)	Mummenhoff et al., 2005.	Marais, 1970.
Cliffortia (Rosaceae)	Whitehouse, 2002.	Weimarck, 1934, 1948; Oliver and Fellingham, 1991; Fellingham, 1995, 2003; Whitehouse, 2002; Whitehouse and Fellingham, 2007; Whitehouse, pers. comm.
Disa (Orchidaceae)	Bytebier et al., 2007.	Linder and Kurzweil, 1999.
Ehrharta (Poaceae)	Verboom et al., 2004.	Gibbs Russell et al., 1990.
Euryops (Asteraceae)	Nordenstam et al., 2009.	Nordenstam, 1969.
Gazania (Asteraceae)	Howis et al., 2009.	Howis et al., 2009.
Indigofera (Fabaceae)	Schrire et al., 2009.	African Flowering Plants Database, 2009.
Melianthus (Melianthaceae)	Linder et al., 2006.	African Flowering Plants Database, 2009.
Melolobium (Fabaceae)	Moteetee and Van Wyk, 2006.	Moteetee and Van Wyk, 2006.
Moraea (Iridaceae)	Goldblatt et al., 2002b.	Goldblatt and Anderson, 1986.
Muraltia (Polygalaceae)	Forest et al., 2007.	Levyns, 1954.
Nemesia (Scrophulariaceae)	Datson et al., 2008.	African Flowering Plants Database, 2009.
Orchidaceae (*Corycium*, *Pterygodium*, *Disperis*)	Waterman et al., 2009.	Linder and Kurzweil, 1999.
Pelargonium (Geraniaceae)	Bakker et al., 2004.	Van der Walt and Ward-Hilhorst, 1977; Van der Walt et al., 1981, 1988.
Pentaschistis and *Prionanthum* (Poaceae)	Galley and Linder, 2007.	Linder and Ellis, 1990.
Zaluzianskya (Scrophulariaceae)	Archibald et al., 2005.	Hilliard, 1994.

6.4. Results

6.4.1. Floristic comparisons

a) Diversity, dominance and endemism

The DAC and HRC have the highest number of species, with the Great Winterberg–Amatolas, Sneeuberg and Nuweveldberge having comparable species richness (Fig. 6.6A). The high number of HRC species is misleading as it includes a wider area than the Hantam–Roggeveldberge. This montane component of the HRC may have a total flora of ca. 1 500 species but a comprehensive flora is currently unavailable. The very high number of DAC species is no doubt a result of higher rainfall predictability, a high MAP on the windward side of the Main Drakensberg Escarpment (2 000 mm; Van Wyk and Smith, 2001), as well as habitat heterogeneity and steep climatic gradients (as outlined by Thuiller et al., 2006).

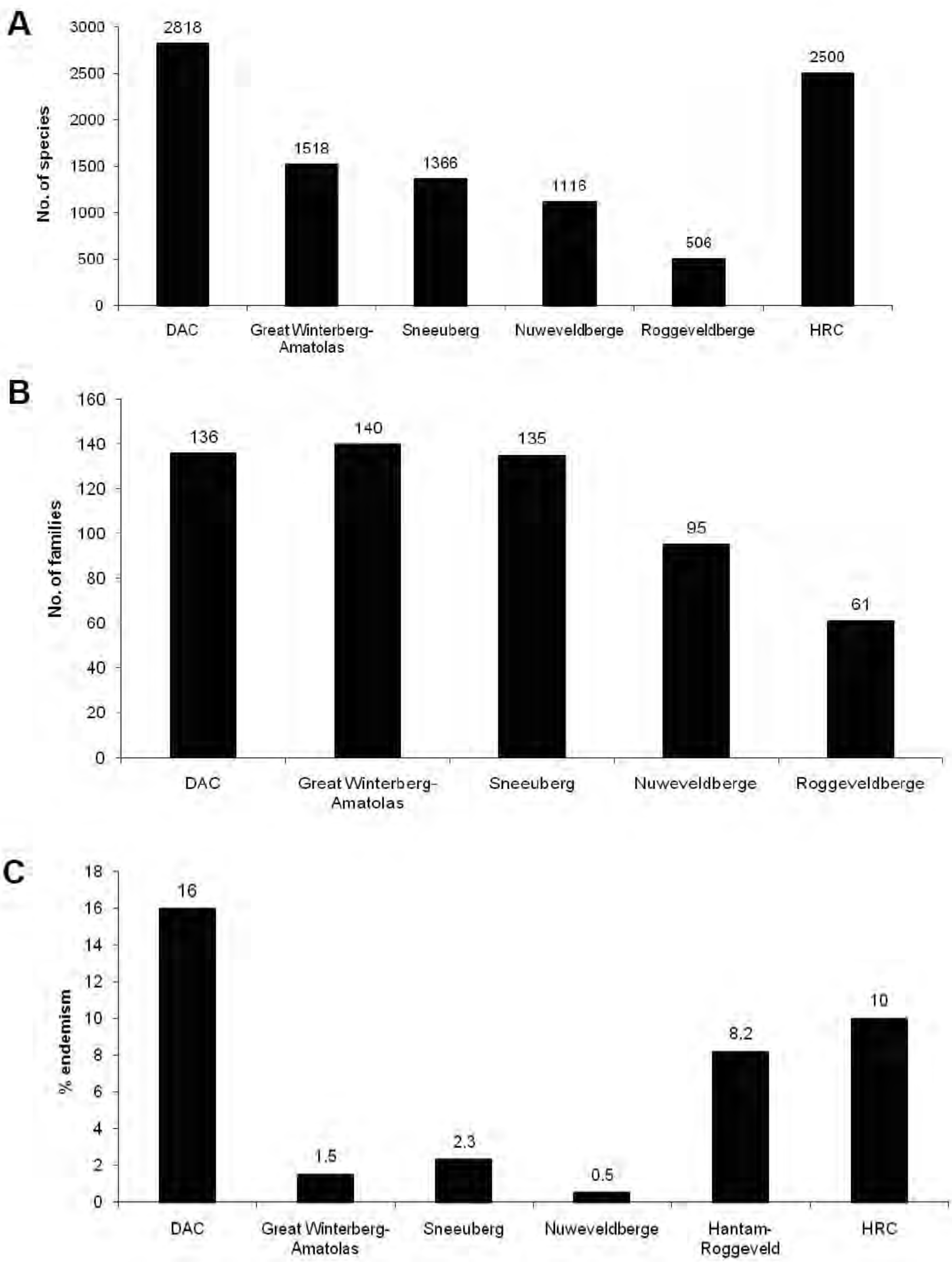


Figure 6.6: Floristic comparisons along the southern Great Escarpment and Drakensberg Alpine Centre (DAC): (A) Species richness; (B) Family-level diversity. Hantam–Roggeveld Centre (HRC) data not available; (C) Levels of endemism.

Family-level diversity is consistent from the DAC to the Sneeuberg but tapers off to the west on the Nuweveldberge and Roggeveldberge (Fig. 6.6B). While the Nuweveld family tally is considered reliable, the Roggeveld is again a factor of a still poorly-known flora and may approach or (probably) exceed that of the Nuweveldberge. As in species–richness, lower family diversity in the Nuweveldberge may be a factor of aridity, with many moist Cape- and eastern-centred families being absent, although it may also be due to dominance by a few Cape families.

Local endemism along the southern Great Escarpment and DAC shows a very strong endemicity gradient, with very high endemism in the DAC and HRC, and lower endemism in the centre (Fig. 6.6C). Although the Sneeuberg and Great Winterberg–Amatolas both have much lower levels of endemism than the DAC and HRC, their percentage endemisms are comparable to other montane centres of endemism on the eastern Great Escarpment (Van Wyk and Smith, 2001; see also Chapter 2). It can also be noted that endemism in the Great Winterberg–Amatolas will likely equal or exceed Sneeuberg endemism following detailed future research on those mountains. The Nuweveldberge has the lowest endemism. Figure 6.7 suggests very strongly that endemism on the southern Great Escarpment is correlated to rainfall reliability. Rainfall reliability has been calculated taking the standard deviations for the scarp/crest weather stations in Fig. 6.3 and dividing this by their MAPs. This is then expressed as an inverse percentage in order to get rainfall reliability, rather than rainfall unreliability (i.e. 100 – (SD/MAP x100)) and graphed against total endemism (Fig. 6.7A) and percent endemism (Fig. 6.7B). The results in Figs 6.7A and B are basically identical: the Nuweveldberge exhibits the lowest rainfall reliability and the lowest endemism, while the Hantam–Roggeveld exhibits the highest rainfall reliability and highest endemism. The DAC likely mirrors this scenario too, although climatic data needs to be obtained to confirm this. The Sneeuberg and Great Winterberg–Amatolas exhibit intermediate rainfall reliability and intermediate endemism, and – as stated above – future research on the Great Winterberg–Amatolas will probably place its endemism on a par with the Sneeuberg or exceed it. What is interesting is that this trend is evident in both the summer (Sneeuberg and Great Winterberg–Amatolas) and winter (Hantam–Roggeveld) rainfall regime, one on either side of the Nuweveldberge. The winter-rainfall regime – known for having higher rainfall reliability than the summer rainfall regime (Chase and Meadows, 2007) – has the highest number of endemics on the southern Great Escarpment (excluding the DAC). While rainfall reliability has been considered as an ecological factor by various authors (such as Cowling et al., 2005), there has been no attempt to define this numerically within southern Africa, and certainly not along the Great Escarpment, although climatic stability on the Great Escarpment is recognised as a key factor in the high species richness and endemism along the Great Escarpment (Thuiller et al., 2006). This approach is hence novel but requires inclusion of additional sections of the Great Escarpment, particularly the DAC.

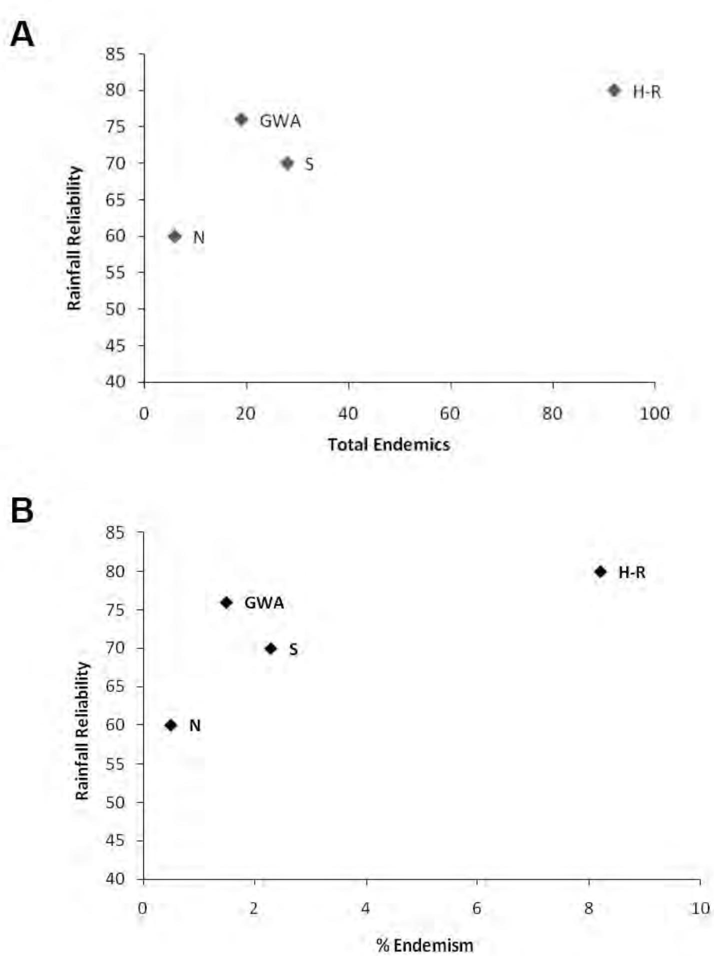


Figure 6.7: The relationship between rainfall reliability (standard deviation expressed as a percentage of the MAP, and subtracted from 100) and endemism on the southern Great Escarpment: (A) total endemism; (B) percentage endemism. GWA = Great Winterberg–Amatolas, H–R = Hantam–Roggeveldberge, N= Nuweveldberge, S = Sneeuberg. Data from Chapters 2–5 and Fig. 6.3.

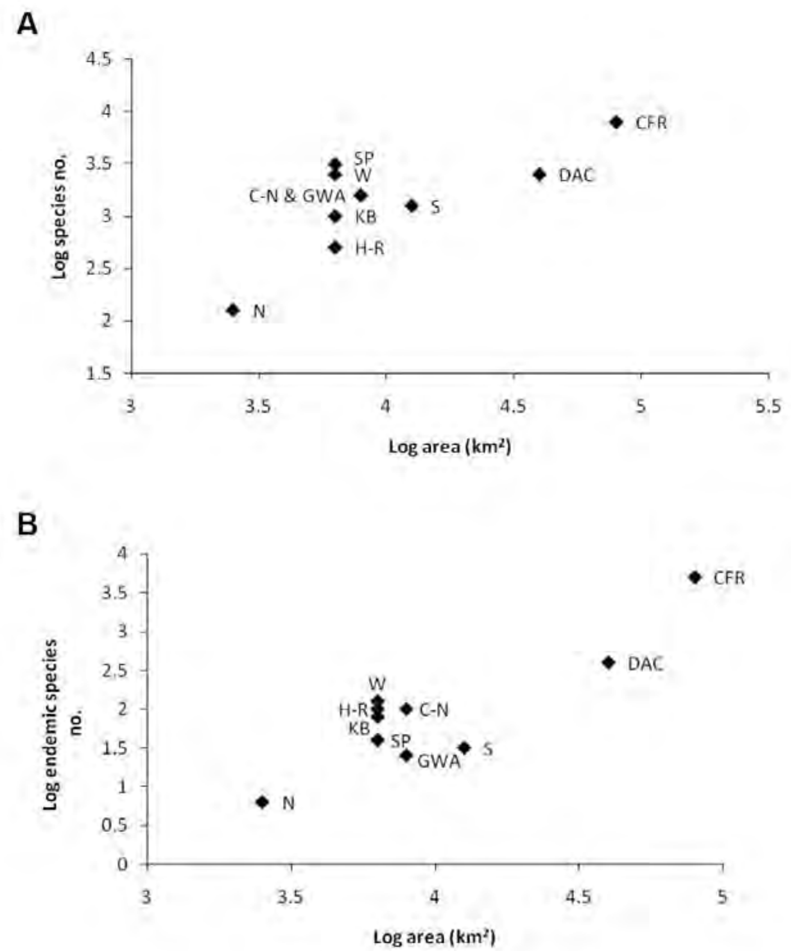


Figure 6.8: Species–area relationships (A) and endemic–area relationships (B) for selected Great Escarpment centres of endemism, together with the Soutpansberg Centre and the CFR. C–N = Chimanimani–Nyanga, DAC = Drakensberg Alpine Centre, GWA = Great Winterberg–Amatolas, H–R = Hantam–Roggeveldberge, KB = Kamiesberg, N = Nuweveldberge, S = Sneeuberg, SP = Soutpansberg, W = Wolkberg. Data from Van Wyk and Smith (2001) and Chapters 2–5.

A species–area analysis of the southern Great Escarpment, other selected centres of endemism on the Great Escarpment, and the Soutpansberg Centre and CFR (Fig. 6.8A), indicates that the Nuweveldberge is the smallest orographic entity and has the lowest species richness, while the CFR is the largest and most diverse entity. With the exception of the DAC (which is the largest centre here other than the CFR) the other orographic entities/centres are similar in terms of area, but there is a general trend of increasing diversity from west to east/north-east. Exceptions to this are the Kamiesberg, which comes out stronger than the Hantam–Roggeveld, although the latter – with a possible flora of 1 500 species – would no doubt come out stronger in terms of diversity. The endemics-area analysis in Fig. 6.8B generally mirrors that of Fig. 6.8A, but with the Sneeuberg and Great Winterberg–Amatolas exhibiting lower endemic diversity than the other centres with comparable size.

It is worth considering what proportions of endemics occur in which plant families per orographic entity – for example, what proportion of the DAC endemics are Asteraceae, Iridaceae etc.. From Fig. 6.9 it can be seen that there is a great variation in this regard. The only families in Fig. 6.9 which have endemics represented on all five orographic entities are Asteraceae, Fabaceae and Mesembryanthemaceae, with a general decrease in their proportions per orographic entity from east to west for Asteraceae, and an uneven pattern for both Fabaceae and Mesembryanthemaceae. Endemic Iridaceae occur on all five orographic entities except for the Nuweveldberge, suggesting that the unreliable rainfall is unsuitable for this family. The Hantam–Roggeveldberge has the highest proportion of Iridaceae endemics out of all the families considered, suggesting that the reliable winter rainfall regime is conducive to this family. Proportions of endemics in the other families represented in Fig. 6.9 is more patchy across the southern Great Escarpment and DAC, with local endemics in these families being absent from several of the orographic entities.

An analysis of the top ten families on each orographic entity indicates that Asteraceae are the dominant family from the DAC right across to the HRC (Fig. 6.10). This largely mirrors Koekemoer (1996), who indicates that the Great Escarpment hosts five of eight putative centres of Asteraceae diversity in South Africa, Lesotho and Swaziland. In terms of the regions being considered in this Chapter these are effectively the HRC, Sneeuberg Centre, and the DAC. Although the Asteraceae diversity in each region is consistently high, the tribal composition in each region varies along the Great Escarpment (Koekemoer, 1996). Asteraceae in the DAC, for instance, is dominated by Gnaphalieae and Senecioneae whereas these are minor in the Sneeuberg (Koekemoer, 1996). What is surprising is that the Nuweveldberge – which has the highest proportion of Asteraceae (Fig. 6.10D) – did not feature in Koekemoer (1996). Inversely, while Asteraceae prominence in the Roggeveldberge did not come out strongly (Fig. 6.10E) the adjacent Hantamberg was recorded by Koekemoer (1996) as the centre with the highest Asteraceae component. Poaceae and Fabaceae are strong families from the DAC westwards to the Sneeuberg, reflecting the prevailing higher and summer rainfall regime on these sections of Great Escarpment and a dominance of the Grassland Biome. The higher

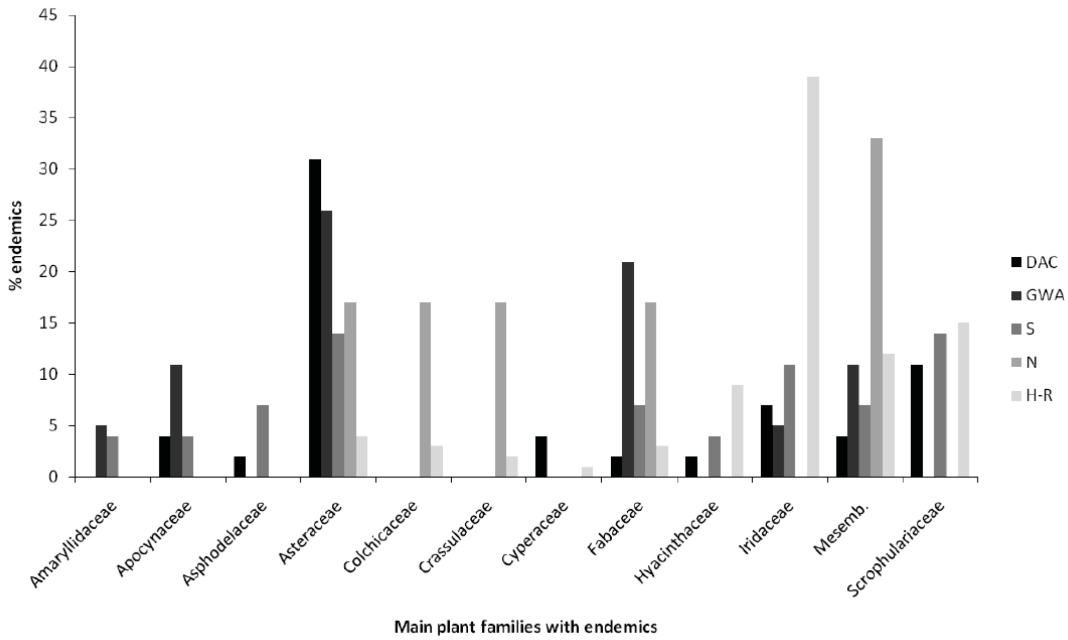
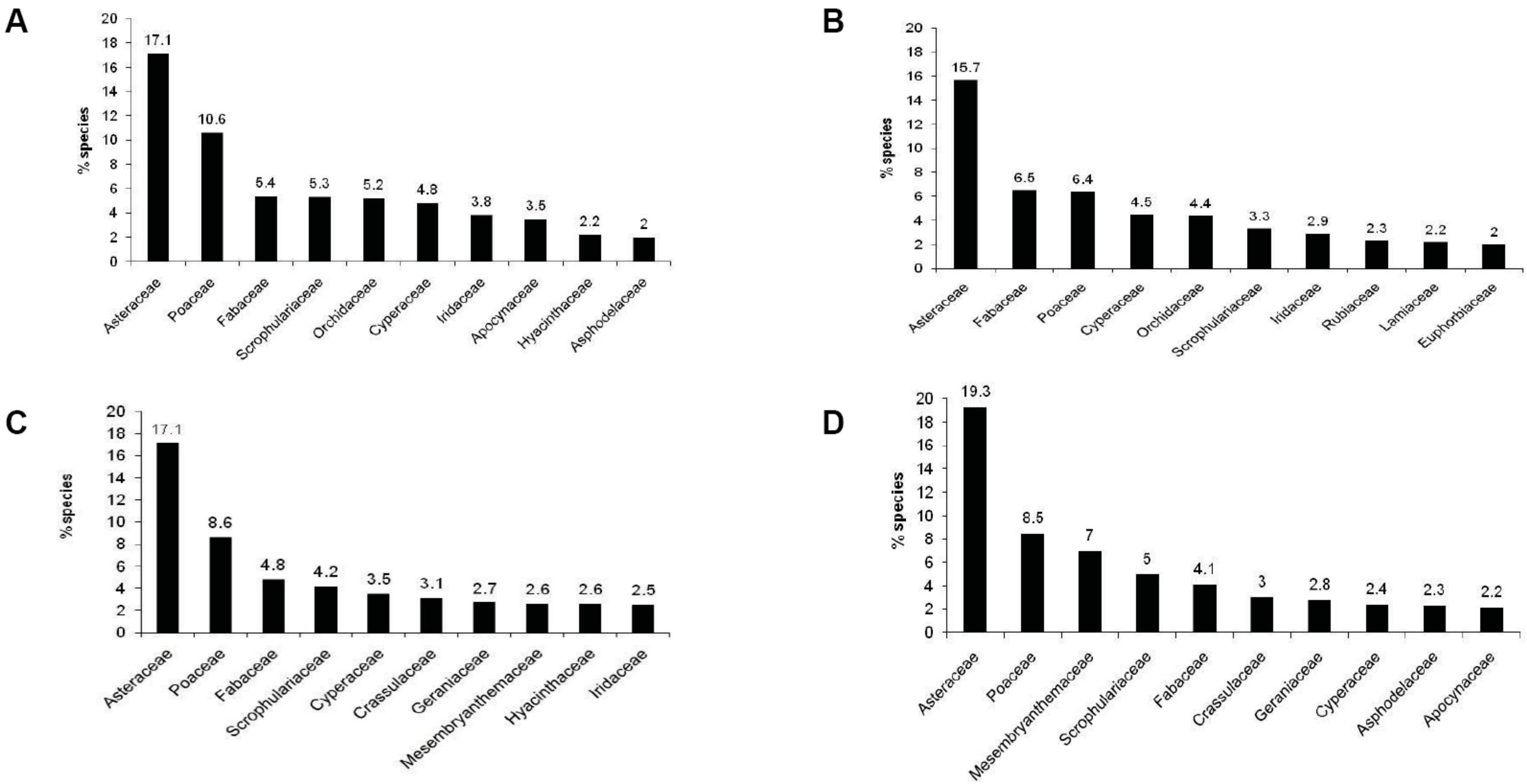


Figure 6.9: Proportion of endemics out of total endemism in the twelve most endemic-rich families for the Drakensberg Alpine Centre (DAC) and the southern Great Escarpment (GWA = Great Winterberg–Amatolas, S = Sneeuberg, N = Nuweveldberge, H–R = Hantam–Roggeveldberge).

rainfall regime in the east is supported by the presence of the Orchidaceae in the DAC and in the Great Winterberg–Amatola's top-ten families; Orchidaceae does not feature in the top-ten families west of the Great Winterberg–Amatolas. The presence of Mesembryanthemaceae as the third-largest family on the Nuweveldberge (Fig. 6.10E) reflects a change towards a drier climate and a dominance of Nama-Karoo and Succulent Karoo vegetation west of the Sneeuberg. The Sneeuberg is perhaps intermediate here, with Mesembryanthemaceae featuring as number seven, but absent in the top-ten families in the Great Winterberg–Amatola and DAC. On the Roggeveldberge, Iridaceae is the dominant family after Asteraceae, indicating the influence of Cape elements on the flora and the dominance of a winter rainfall regime. Scrophulariaceae, being the third-largest family, represents the high diversity of annual species present on the Roggeveldberge in this family, and which have proliferated in this region. Succulent Karoo elements on the Roggeveldberge are also evident, with Mesembryanthemaceae being the fourth-largest family. Poaceae and Fabaceae, so visible on the remainder of the southern Great Escarpment and the DAC, take much lower places on the Roggeveldberge, indicating a weaker presence of summer-rainfall vegetation and a dominance of winter-rainfall vegetation.



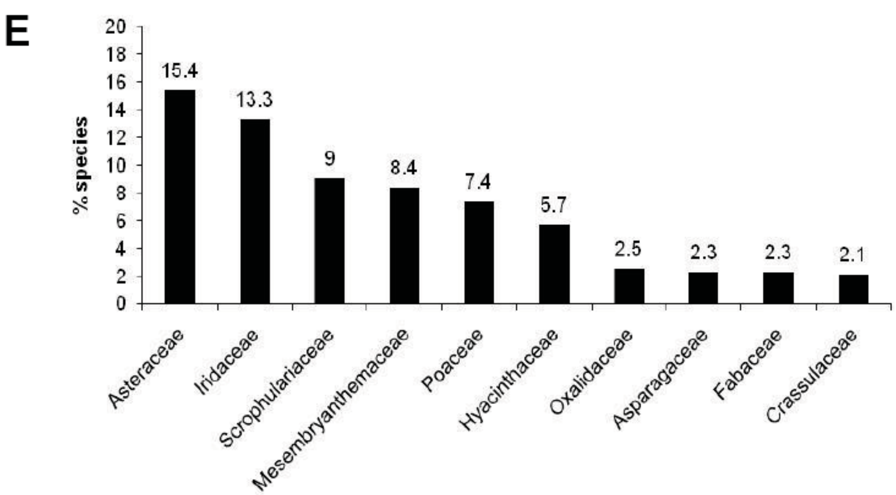


Figure 6.10: The top ten families with percent species in each for the Drakensberg Alpine Centre (DAC) and southern Great Escarpment: (A) DAC; (B) Great Winterberg–Amatolas; (C) Sneeuberg; (D) Nuweveldberge; (E) Roggeveldberge.

b) Floristic connectivity

Species-sharing between the components of the southern Great Escarpment is highest between the Sneeuberg and Nuweveldberge (with a slight majority of Sneeuberg species on the Nuweveldberge) and between the Sneeuberg and Great Winterberg–Amatolas (almost equal sharing of species; Fig. 6.11). The latter adds support to strong floristic connections between the Sneeuberg and Great Winterberg–Amatolas and for a weaker Great Fish River Interval – thus supporting Nordenstam's (1969) original "Sneeuwbergen Centre". The former supports strong floristic connections between the Sneeuberg and Nuweveldberge and motivates for a weaker Nelspoort Interval (thus there is overlap between Nordenstam's, 1969, "Western Upper Karoo" and "Sneeuwbergen" Centres). It is possible that some of the shared taxa between the Great Winterberg–Amatolas, Sneeuberg and Nuweveldberge are a result of the ubiquitous Karoo flora found on the drier slopes of the Sneeuberg and Great Winterberg–Amatolas as well as on much of the Nuweveldberge. While drier components no doubt contribute to this there is nevertheless also a significant level of sharing of moister, higher-altitude species (see Chapters 2–4). The high proportion of species shared between the Sneeuberg and Great Winterberg–Amatolas and the Sneeuberg and the Nuweveldberge suggests that the Sneeuberg is a hub between these sections of the Great Escarpment.

Given the high DAC flora, it is not surprising that the proportion of DAC species found on adjacent sections of the Great Escarpment is higher than vice versa. The most shared DAC species are found on the Great Winterberg–Amatolas: this reflects the Great Winterberg–Amatolas having a climate most comparable to the DAC than to the rest of the southern Great Escarpment. The number of DAC species on the Sneeuberg is also high, supporting connectivity between the DAC and the southern Great Escarpment as far west as the Sneeuberg. West of the Sneeuberg the number of DAC species on the southern Great Escarpment tapers off dramatically, and can be attributed to much more arid conditions west of the Sneeuberg as well as a major shift in rainfall regime from summer to winter rainfall.

In terms of connectivity between the southern Great Escarpment and the CFR, in the west and centre the proportion of taxa is biased from the CFR to the southern Great Escarpment, being highest from the NW Centre to the Roggeveldberge. The proportion direction changes in the east, where the scenario is reversed and the Sneeuberg and Great Winterberg–Amatolas each have a higher proportion of taxa on the Zuurberg than vice versa respectively. This is likewise for the Sneeuberg and the Baviaanskloof–Cockscomb. This reverse in sharing may represent shared Albany Thicket, Nama-Karoo and Afromontane forest taxa rather than shared fynbos or high-altitude Afromontane grassland taxa, and this is supported by the low number of Baviaanskloof–Cockscomb species on the KM Centre, which has no (or very few) Albany Thicket or Afromontane forest taxa. What is interesting is the closer proportion of shared species between the Baviaanskloof–Cockscomb and Zuurberg than between any of the other CFR centres considered here.

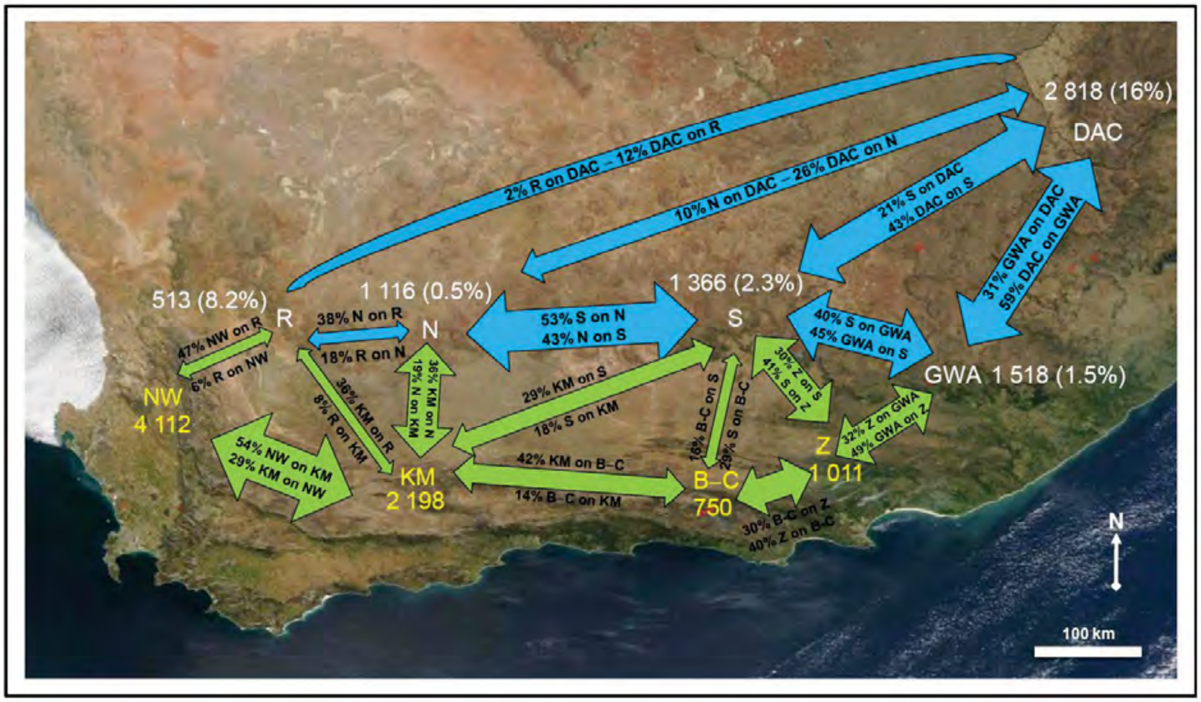


Figure 6.11: Floristic links along the southern Great Escarpment and with the DAC and CFR. The arrows indicate the proportion of shared taxa. Green figures are those shared between the CFR and the southern Great Escarpment, blue for those shared along the southern Great Escarpment and with the DAC. Yellow text represents CFR centres of endemism (NW = North West, KM = Karoo Mountain) and mountains (B–C = Baviaanskloof and Cockscomb, Z = Zuurberg). White text represents the components of the southern Great Escarpment and DAC, with floras and percent endemism (R = Roggeveldberge, N = Nuweveldberge, S = Sneeuberg, GWA = Great Winterberg–Amatolas, DAC = Drakensberg Alpine Centre). Satellite imagery from NASA (2008).

Again this may be the result of shared Albany Thicket, Nama-Karoo and Afromontane forest taxa between these two CFR centres versus the high local fynbos endemicity of the KM and NW Centres.

6.4.2. Floristic relationships from the UPGMA analysis

The multivariate results are shown in Fig. 6.12. The Great Winterberg–Amatolas clusters with the DAC, no doubt a result of the similar moisture conditions and gadients. This is followed by the Sneeuberg–Nuweveldberge cluster, which – as for the floristic comparisons above – suggests that the Nelspoort Interval is more of a token interval than an actual floristic disjunction. Again this may be a factor of shared lower-altitude Karoo elements. Reasonable connectivity between the summer rainfall components of the southern Great Escarpment and with the DAC is suggested by the clustering of the Nuweveldberge, Sneeuberg, Great Winterberg–Amatolas and DAC. This generally complements the floristic analysis above.

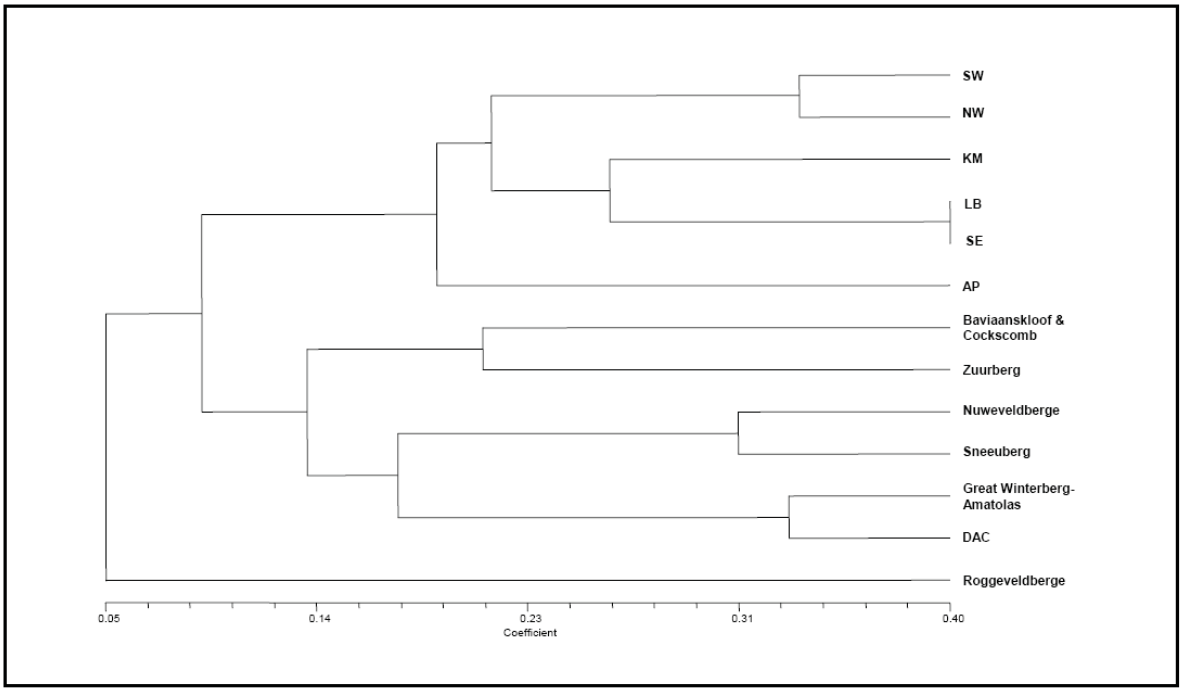


Figure 6.12: Floristic similarity among components of the southern Great Escarpment, DAC and the CFR using Jaccard's Co-efficient. Abbreviations (from top to bottom): SW = South West Centre, NW = North-West Centre, KM = Karoo Mountain Centre, LB = Langeberg Centre, SE = South East Centre, AP = Agulhas Plain Centre, DAC = Drakensberg Alpine Centre.

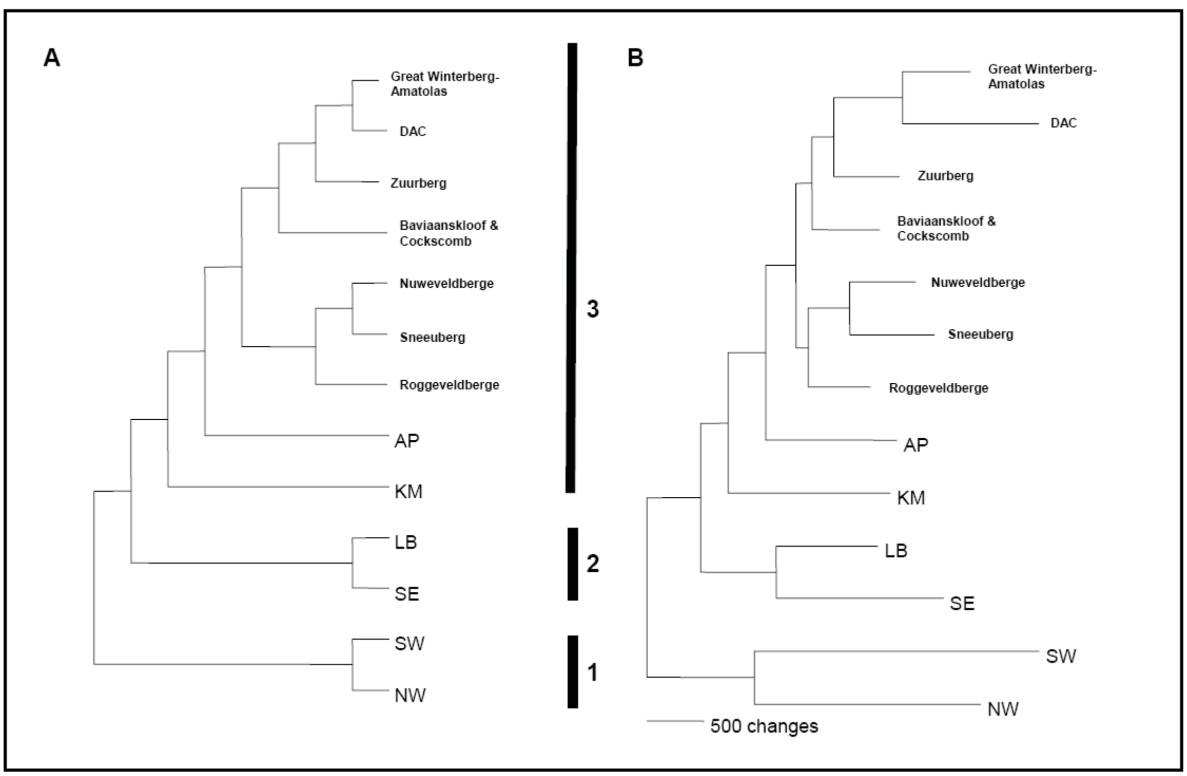


Figure 6.13: Parsimony Analysis of Endemism results for the southern Great Escarpment, the Drakensberg Alpine Centre, and the Cape Floristic Region. (A) Cladogram with mid-point rooting. (B) Phylogram with mid-point rooting. All characters used (i.e. autapomorphies included).

The Zuurberg and the Baviaanskloof–Cockscomb cluster is sister to the clusters discussed. This suggests some commonality between them with the entire southern Great Escarpment and DAC (but excluding the Roggeveld) and offers some support for Weimarck's (1941) SE connection. These taxa may however represent lower-altitude Albany Thicket, Nama-Karoo and Afromontane forest taxa shared with the southern Great Escarpment rather than shared fynbos or high-altitude Afromontane grassland taxa.

The most surprising result is that the Roggeveldberge does not cluster with any of the other Great Escarpment components or with the NW or KM Centres as might have been expected. The floristic data for this section of Great Escarpment is however limited and an increase in data may change the results considerably. It is postulated that there may be stronger links with the Nuweveldberge, with both the NW and KM centres, also possibly with the Kamiesberg.

6.4.3. Parsimony Analysis of Endemicity

The PAE results are shown in Fig. 6.13, represented as a cladogram and phylogram, with mid-point rooting. Fig. 6.11A indicates three clades: a SW–NW Centres clade (Clade 1), a SE–LB Centres clade (Clade 2), and a "mixed" clade (Clade 3) comprising the KM and AP Centres, the Baviaanskloof–Cockscomb and Zuurberg, and the southern Great Escarpment and DAC. The presence of the Baviaanskloof–Cockscomb and Zuurberg basal to the Great Winterberg–Amatolas and the DAC supports the SE connection but – as for the UPGMA results above – may also be due to the numerous Albany Thicket, Nama-Karoo, Fynbos and Afromontane forest taxa shared between and which largely bypass the comparatively arid Sneeuberg, Nuweveldberge and Roggeveld. Within this "mixed" clade, the Sneeuberg, Nuweveldberge and Roggeveld resolve well as a sub-clade, with the Roggeveld basal to the other two. This suggests that there is some commonality between these regions and supports the southern Great Escarpment track.

The phylogram in Fig. 6.13B indicates (by means of relative branch length) shared and unique taxa. Unsurprisingly the CFR Centres and the DAC came out with a highest numbers of unique taxa, as based on branch length. This is expected considering the high levels of local endemism in the CFR (Midgley et al., 2005; Verboom, et al., 2009) and DAC (Van Wyk and Smith, 2001). It is surprising that the Roggeveldberge did not come out with a longer branch length given the high number of local endemics.

In terms of the UPGMA and the PAE results, the PAE results support the expected scenario of a SE connection via the Baviaanskloof–Cockscomb and Zuurberg onto the southern Great Escarpment at the Great Winterberg–Amatolas and through to the DAC. Although this concept is also present in the UPGMA results, the connection includes a larger section of the Great Escarpment (i.e. also the Sneeuberg and Nuweveldberge) – this may suggest an expansion of species both westwards and eastwards on the Great

Escarpment from the SE connection however. The grouping of the southern Great Escarpment into a sub-clade in the PAE is also more credible than the Roggeveld being basal to the entire CFR and Great Escarpment as indicated in the UPGMA results.

6.4.4. Connectivity analysis based on phylogenetic relationships

The phylogenetic trees with geographical distributional data for taxa relevant to the southern Great Escarpment and DAC, and their sister taxa/related clades, are given in Appendix 6.2. However, not all the phylogenies are well resolved (e.g. *Pelargonium*). Some others, such as *Melolobium* and *Melianthus* – which are well resolved – do not provide any obvious indication of phylogenetic relationship between taxa from the southern Great Escarpment and the CFR. However several phylogenies show very clear relationships between taxa from the southern Great Escarpment/DAC and the CFR, similar patterns being repeated in several different phylogenies. It is difficult to quantify these relationships into totalled number of "sister taxa", as in some instances (such as in *Pentaschistis, Moraea* and in the Orchidaceae) there appears to have been multiple genetic exchanges between particularly the CFR and DAC. This has often resulted in one species from the one area being basal to whole clades from another area, or even basal to other sections of the Great Escarpment or elsewhere. Because of these complex phylogenetic relationships, an attempt is here made to discuss the relationships evident from the phylogenies with emphasis on the CFR–Great Escarpment connections (NW, Matjiesfontein and SE), the southern Great Escarpment track, and other Great Escarpment connections. In some instances more than one of the connections could have been used, and these instances are discussed separately. (In the results below, the same abbreviations used for the geographic distributions in Appendix 6.2 are used in reference to the species mentioned.)

a) NW and Matjiesfontein Connections

The NW connection is supported by the sister relationship in *Prionanthum*, with *P. dentatum* (a Hantam–Roggeveld (HR) endemic) sister to *P. ecklonii* (W. Coast; bootstrap value 100%). Similarly, *Cliffortia arborea* (HR, Nuweveldberge (N)) is sister to *C. dichotoma* (NW); support values not provided. Apart from these, none of the other phylogenies used here indicate support for the NW connection and the Hantam–Roggeveldberge, although complete phylogenies of the Cape geophytes which are abundant (and with many local endemics) on the Hantam–Roggeveldberge (e.g. *Hesperantha*) would possibly contradict this pattern. Many species, however, occur in the NW Centre and on the Hantam–Roggeveldberge, as well as often also on the KM Centre. This is no doubt due to the Bokkeveld mountains (NW) and the Hantam–Roggeveldberge being relatively well-connected by the Bokkeveld Plateau and the proximity of the Klein-Roggeveldberge to the NW and KM Centre mountains (see Chapter 4). This may also explain the paucity of sister taxa between the NW and KM Centres and the Hantam–Roggeveldberge in these phylogenies, as many of the species may be able to continue genetic contact along the NW and

Matjiesfontein connections and thus have not speciated. Examples of such species in the phylogenies are *Cliffortia hantamensis*, *Corycium deflexum*, *Heliophila acuminata*, *H. arenaria*, *H. descurva*, *H. suborbicularis* (=*Thlaspeocarpa capensis* in the Cape Brassicaceae phylogeny), *Moraea tripetala*, *Muraltia horrida*, *M. macrocarpa*, *Pelargonium coronopifolium*, *P. magenteum*, *Polycarena aurea*, *Zaluzianskya minima*. Many other examples can be listed among the geophytes (Van Wyk and Smith, 2001; Mucina and Rutherford, 2006).

b) SE Connection

The SE connection is the best supported CFR–Great Escarpment connection of the three, and lends further weight to the results of the UPGMA and PAE. On a sister-taxa scale, *Pentaschistis ampla* (NW, KM, SE) is sister to *P. exserta* (DAC; bootstrap value 55%, posterior probability 0.99), *P. aurea* subsp. *pilosogluma* (DAC) is sister to *P. aurea* subsp. *aurea* (NW, KM, SE, Namaqualand; the southern Great Escarpment track may also have been involved here – see below; bootstrap value 100%). Likewise *Cliffortia filicaulis* (CFR) is sister to *C. filicauloides* (DAC; support values not provided). At small-clade level, *Euryops acraeus* (DAC) is basal to a clade that includes two other DAC and Eastern Cape Great Escarpment taxa (*E. candollei*, *E. tysonii*) and two CFR taxa (*E. algoënsis*, *E. virginius*; posterior probability 1.0), while *Muraltia flanaganii* (DAC and northwards) is basal to *M. bondii* and *M. juniperifolia* (both KM, SE; bootstrap value 98%). *M. pubescens* (SW) is basal to a clade of two other CFR species (*M. ciliaris*, *M. squarrosa*), one Great Escarpment species (*M. saxicola*; SC, Great Winterberg–Amatola (GWA), DAC), and one eastern southern African species (*M. lancifolia*; E. Cape, KZN; bootstrap value 100%). On a coarser scale, *Pentaschistis basutorum* (DAC) is basal to most of *Pentaschistis* (posterior probability 0.96), which is primarily a CFR species (Galley and Linder, 2007). Similarly, *P. tysonii* (DAC) is basal to *Pentameris* (bootstrap value 75%; posterior probability 1.0), which is a CFR genus.

As for the NW route, species that have used the SE connection without speciating are numerous. Those present in the phylogenies include *Cliffortia eriocephalina*, *C. linearifolia*, *C. paucistaminea*, *C. repens*, *Disa cornuta*, *D. tysonii*, *D. lugens*, *Disperis lindleyana*, *D. macowanii*, *Indigofera alpina*, *I. porrecta*, *Pelargonium laevigatum*, *P. graveolens*, *P. schizopetalum*, *Pentaschistis glandulosa*, *Rhodocoma capensis*, *R. fruticosa*, *Satyrium membranaceum*, *Moraea spathulata*, *Muraltia alopecuroides* and *Nemesia affinis*. This route can also be used to explain several faunal CFR–DAC disjunctions (Clark et al., 2009; see Chapter 2).

A variation of the SE connection is from the SE Centre along the eastern seaboard into Pondoland (e.g. *Euryops brachypodus*), or via the SE connection onto the Great Winterberg–Amatolas and then back onto the Wild Coast north of East London (Hughes et al., 2005). Examples of species present in the phylogenies that exhibit this latter version of the SE connection are *Cliffortia odorata*, *Disa sagittalis* and *Pelargonium schizopetalum*.

c) Southern Great Escarpment Track

Phylogenetic relationships between the moist eastern and arid western components of the Great Escarpment are perhaps the most surprising, but consistent, result from the phylogenies. These results also compliment the PAE results. *Pentaschistis airoides* subsp. *jugorum* (Sneeuberg Centre (SC), GWA, Stormberg (ST), DAC) is basal to *P. veneta*, *P. pseudopallescens* and *P. capillaris* (NW, W. Coast; bootstrap value 77%), and *Corycium flanaganii* (SC, DAC) is basal to *Pterygodium hallii* (SW, NW, HRC, Namaqualand) and *P. inversum* (SW, NW; posterior probability 1.0). Similarly, *Pterygodium cooperi* (DAC) is sister to *P. schelpei* (SW to Richtersveld; posterior probability 0.86), while *Gazania caespitosa* (SC) is sister to *G. ciliaris* (SW, NW, Namaqualand; bootstrap value 98%). (This *Gazania* distribution pattern matches *Senecio arenarius*, also a West Coast species with a very similar species – if not the same – occurring on the Sneeuberg; Clark et al., 2009). *Melianthus insignis* (KZN Escarpment) is sister to *M. dregeanus* (Great Karoo (GK), E. Cape; bootstrap value 100%), and *Melolobium obcordatum* (DAC, E. Cape) is sister to *M. aethiopicum* (SW, NW, Namaqualand; support values not provided). *Ehrharta longigluma* (N, SC, DAC) is sister to *E. melicoides* (NW, Namaqualand; bootstrap value 77%), and *Nemesia leipoldtii* (NW) comes out in a clade of moist eastern Great Escarpment taxa with the exception of *Nemesia "foetens"* (a widespread species of apparently still uncertain taxonomic status; support values not provided). *Euryops multifidus* (NW, Namaqualand) forms a separate clade with two DAC species (*E. montanus* and *E. decumbens*; posterior probability 0.99), and *E. proteoides* (SC) is basal to a clade of three CFR/Namaqualand species (*E. hebecarpus*, *E. linifolius* and *E. tenuissimus*; posterior probability 0.77). *Zaluzianskya mirabilis* (HR) is basal to a clade of the primarily eastern Great Escarpment and East Coast species Z. *microsiphon*, *Z. angustifolia* and *Z. maritima* (bootstrap value 75%). Finally, most southern Great Escarpment *Heliophila* species belong to Mummenhoff et al.'s (2005) Clade C, centred in the Richtersveld and the Roggeveld, with outliers in the Sneeuberg and DAC. All of these suggest that there is a historical phylogenetic relationship between taxa of the western Great Escarpment (and NW Centre – see the discussion below) and the eastern Great Escarpment, particularly the Sneeuberg and DAC.

Numerous species occur right along the southern Great Escarpment without evidence of speciation. Examples of such species occurring in the phylogenies include *Berkheya cardopatifolia*, *Cliffortia ramosissima*, *Indigofera burchellii*, *Moraea unguiculata*, *Euryops annae*, *E. empetrifolius*, *E. petraeus*, *Zaluzianskya capensis* and *Z. ovata.*

d) The western and eastern components of the Great Escarpment

The phylogenies reveal patterns of connectivity and local speciation along the western and eastern components of the Great Escarpment respectively. On the western Great Escarpment (HR to the Richtersveld) many species' geographical distribution ranges extend from the SW and NW Centres up through the HRC and Namaqualand to the Richtersveld. Examples are *Melolobium aethiopicum, Ehrharta brevifolia* and *E. longiflora*. Connectivity is also emphasised by relationships such as *Berkheya coriacea*

(AP) being basal to at least three species ranging from Namaqualand to the Sperrgebiet in southern Namibia, and *Melianthus gariepinus* (Namaqualand, Richtersveld) being sister to *M. elongatus* (SW, Namaqualand). There are also strong links between the SW and NW Centres and Namaqualand in *Heliophila*, *Moraea*, *Nemesia* and *Zaluzianskya*. Local endemism on the Hantam–Roggeveldberge, Kamiesberg and Namaqualand Escarpment (including the Richtersveld) is primarily within these western Great Escarpment clades.

Similarly, strong connections along, and speciation, on the eastern Great Escarpment is evident in genera such as *Alepidea*, *Berkheya*, *Moraea*, *Nemesia*, *Polemannia* and *Zaluzianskya* as well as in the Orchidaceae. Minor eastern Great Escarpment clades in predominantly CFR genera such as *Cliffortia* (e.g. the *C. dracomontana* clade) also occur, and in the Cape clade of *Indigofera*. Local endemism on the Sneeuberg, Great Winterberg–Amatolas and in the DAC is primarily within the eastern Great Escarpment clades. Several phylogenies indicate reliable evidence of connectivity from the eastern Great Escarpment onto the Chimanimani–Nyanga Escarpment, and in often northwards onto the mountains of tropical Africa (*Berkheya*, *Disa*, *Moraea* and *Pentaschistis*). There is also evidence of connectivity between the eastern Great Escarpment and adjacent highlands such as the KZN Midlands and the mountain ridges in Gauteng/Limpopo Provinces (such as the Magaliesberg and Waterberg; see Chapter 1). Examples of this occur in *Melianthus* and *Berkheya*.

e) Multiple and vague connections

In some instances more than one connection may have been used. Numerous relationships appear to have resulted from a combination of the southern Great Escarpment track in combination with the NW or Matjiesfontein connections. Examples of these are *Moraea verecunda* (NW) and *M. alpina* (DAC), and *Ehrharta melicoides* (NW, Namaqualand) and *E. longigluma* (N, SC, DAC). Similarly, *Cliffortia micrantha* (NW) is basal to a clade with two DAC species and one tropical African species. *Conium sphaerocarpum* (NW, HR, Kamiesberg (KB)) is sister to the *C. fontanum* complex (Stratton, pers. comm.; tree unpublished and not included in Appendix 6.2). This latter group includes *C. chaerophylloides* and *C.* spp. no.'s 3 and 4, and occurs throughout the CFR and eastern South Africa. This suggests that the NW or SE connections as well as the southern Great Escarpment track may have been involved. A similar scenario is suggested by *Pentaschistis chippindalliae* (Mpumalanga–Limpopo (M–L) Escarpment) being sister to *P. densifolia* (NW, KM), with either the southern Great Escarpment track or the SE connection having been used. This is mirrored by *Cliffortia browniana* (M–L Escarpment) being sister to *C. densa* (LB), and *Pentaschistis aurea* subsp. *aurea* (NW, KM, Namaqualand) sister to *P. aurea* subsp. *pilosogluma* (E. Cape mountains).

Several CFR taxa from the KM Centre – such as *Otholobium macradenium*, *Disa harveiana* subsp. *harveiana*, *Cliffortia montana*, *Acmadenia* sp. aff. *sheilae* – are also known from the Sneeuberg (Clark et al., 2009), but without any apparent connection via the NW, Matjiesfontein or SE connections. They may have become locally extinct along an old migration route (e.g. the now arid Nuweveldberge), or represent a few isolated dispersal events to the Sneeuberg. Other unusual distributions without clear migrations routes are found in *Berkheya rigida* and *Indigofera ionii* (both SW, DAC).

6.5. Palaeoclimate Considerations

Although the connections between the CFR and southern Great Escarpment are strongly supported by the phylogenies and current species distributions, the phylogenetic disjunction between the western and eastern components of the Great Escarpment requires further consideration, especially given the evidence of current connectivity along the southern Great Escarpment. The possible role of palaeoclimatic oscillations (Tyson, 1999a, b), and particularly climate change from the Last Glacial Maximum (LGM) to the present (Van Zinderen Bakker, 1962), must be considered as a possible driving force for this fascinating series of parallel disjunctions.

The Great Escarpment (and the southern components of the Afromontane region in general; Meadows and Linder, 1993) has not been thoroughly investigated in terms of palaeoclimatic data, one reason possibly being the lack of suitable habitat for palaeoclimate records (Sugden, 1989; Meadows, 2001). However, sites in the Great Winterberg (Meadows and Linder, 1993), Kikvorsberge (Scott and Nyakale, 2002; Scott et al., 2005), Compassberg (Sugden, 1989), Stormberg (Thomas et al., 2002) and eastern Nuweveldberge (Sugden, 1989) have been investigated over the past 25 years, the dating depths ranging from 5 000–16 000 BP. It is also possible to corroborate these sites with well-known locations further afield, such as Equus Cave, Tswaing Crater, Wonderkrater, Boomplaas, the Cederberg and Cango Caves etc. (Van Zinderen Bakker, 1983; Scott, 1989, 1993, 2002; Johnson et al., 1997; Partridge et al., 1999; Tyson, 1999a; Meadows, 2001; Scott and Lee-Thorpe, 2004), and with other sections of the Great Escarpment, such as Braamhoek Wetland (Norström et al., 2009), the Malutis–Drakensberg (Tusenius, 1989; Grab et al., 2005; Lewis, 2005), Elim in the eastern Free State (Scott, 1989) and Afromontane/alpine mountains elsewhere in Africa (e.g. Mount Kenya; Mahaney, 2004). Although comparison of data is not easy due to seasonal and moisture gradients over large distances (Scott and Nyakale, 2002) and diverse topographic suites in South Africa (Grab and Simpson, 2000), sites at altitude in generally drier areas – such as Blydefontein – are comparable with sites in moister areas, such as Florisbad and Wonderkrater to the north due to comparable current MAP (Scott and Nyakale, 2002).

Difficulties in using palaeoclimatic reconstructions are numerous:

(1) Such reconstructions are often largely macroscale in interpretation (typical examples are Partridge et al., 1999, and Chase and Meadows, 2007). The relatively minor surface area covered by the southern

Great Escarpment, with its rapid south-north climatic gradient (Phillipson, 1987, for the Amatolas), is easily overlooked (Grab and Simpson, 2000), and conditions on the Great Escarpment may have always been different to conditions below it (Tusenius, 1989).

(2) Similarly, sites used as proxy data may not have been repositories for microrefugia harbouring key taxa (Rull, 2009).

(3) The rapid change in vegetation over short time periods (decades) suggests that palaeoenvironmental reconstructions are not necessarily representative for broader time periods (Grab et al., 2005).

(4) Reliable radiocarbon dating in palynological studies has been a problem, limiting the detail in palaeo-environmental chronologies (Scott, 1989).

(5) There is a variety of interpretations for rainfall over southern Africa during the LGM and the resultant distribution of biomes (compare Van Zinderen Bakker, 1962, Shi et al., 1998 and Partridge et al., 1999).

(6) Finally, many potential sites along the Great Escarpment suitable for palaeoclimatic interpretation have yet to be investigated (Thomas et al., 2002). The summary of the issue is that there is only sufficient data to make tentative reconstructions for the southern Great Escarpment, and these are detailed in Table 6.4.

6.5.1. Climate oscillation in southern Africa and the southern Great Escarpment track

The main factors affecting climatic oscillations in southern Africa are: (1) Mega-oscillations over long time periods such as from the ca. 100 000-year changes in the earth's orbital eccentricity (a Milankovitch forcing) resulting in the periods of glaciation and inter-glaciation (Huntley and Webb, 1989; Tyson, 1999a; Dynesius and Jansson, 2000; Partridge et al., 2004; Norström et al., 2009). (2) The ca. 23 000-year equinoctial precession, resulting in changing times of perihelion and aphelion (Huntley and Webb, 1989; Tyson, 1999a; Meadows, 2001). (3) Cycles of ca. 100–200 years (perhaps ca. 450 years), possibly from lunar tidal effect or solar variability (Tyson, 1999a; Scott and Lee-Thorpe, 2004). (4) Smaller cycles e.g. the ca. decadal wet-dry oscillations that occur in southern Africa's current climatic regime (Meadows, 2001; Carr et al., 2006). The generally accepted attributes of the mega-oscillations are of cooler, drier periods during glaciations outside of the CFR (Meadows and Linder, 1993; Tyson, 1999a) with warmer, wetter interglacials (Tyson, 1999a). The climate of the Southern Hemisphere is characterised by a tension between the sub-Antarctic westerlies and the sub-tropical easterlies (Iriondo, 1999; Scott and Lee-Thorp, 2004; Norström et al., 2009). This tension between the temperate westerlies and sub-tropical easterlies may have also characterised the climate oscillations of the Pleistocene cycles (Van Zinderen Bakker, 1962; Tyson, 1999b; Carr et al., 2006), although not causal to the oscillations themselves. During glacial periods the westerlies dominated due to a latitudinal shift to the north of 5–10^{o} (Iriondo, 1999), and a winter-rainfall regime prevailed with interior conditions usually being dryer (Tyson, 1999a). During warmer, interglacial periods the easterlies dominated and a summer-rainfall regime prevailed, and rainfall was generally higher (Tyson, 1999a).

Table 6.4: Climatic variation in southern Africa over the past 125 000 years, with notes on the effect on the climate and vegetation of the southern Great Escarpment: Sources: Tidmarsh, 1948; Van Zinderen Bakker, 1962, 1983; Scott, 1989, 1993, 2002; Sugden, 1989; Meadows and Linder, 1993; Tyson, 1999a, b; Bredenkamp et al., 2002; Scott and Nyakale, 2002; Partridge et al., 1999, 2004; Scott and Lee-Thorpe, 2004; Lewis, 2005; Scott et al., 2005; Bergh et al. 2007.

Date	**Period**	**General Effect**	**Weather Systems**	**Effect on Southern Great Escarpment**	**Effect Elsewhere on the Escarpment**
125 000 BP	Eemian Interglacial (precessional low).	Generally much wetter and hotter. Biomes shifted south (Miombo to ca. 27°S; central Free State much grassier with Hippopotamus and Lechwe; forests widespread from 40 000–75 000 BP). Agulhas current warmer.	Rainfall similar to present, perhaps up to 10% higher in places.		
21 000–18 000 BP	Last Glacial Maximum.	Cold and dry at the maximum glacial. Temperature depressed by 5°C below current temperatures, except in the SW, where may have been less than 2°C. Rainfall decreased by 40%, but less so in east. Windspead accelerated by 17%. Karroid vegetation in the west; upland grassland (C3) with low fynbos scrub in central regions; mesic ericaceous vegetation in the east. Grassland favoured over forest. C3 grasses spread to expense of C4 grasses. Upland Ericaceous grassland expanded. Afromontane forests fragmented and restricted to refugia. Vegetation belts depressed by 700–1 000 m.	The winter rainfall band more extensive (westerlies dominant). Weather dominated by westerlies over much of southern Africa. Fynbos extended up the west coast as far as southern Nambian highlands.	Marked expansion of C3 grassland in southern Karoo.	At Elim, ericaceous grassland present suggesting down-shift in this vegetation belt from c. 23 000-20 000 BP. Climate cooler and moister, with evenly distributed seasonal moisture. At the Glacial maximum at c. 19 000 BP, climate locally harsher and drier. No vegetation above 3 000 m in the DAC. Montane forests retreated.
16 000–11 000 BP	Late Glacial times.	Waming, wetter.			Wet in western Lesotho up to c. 12 200 BP; localised wet conditions. Moister conditions along the Caledon River before 12 000 to 10 000 BP. Moister and possibly cooler conditions in SE Main Drakensberg Escarpment before 10

Date	Period	General Effect	Weather Systems	Effect on Southern Great Escarpment	Effect Elsewhere on the Escarpment
					000 BP.
11 800–7 000 BP	Early Holocene.	Sudden cooling. General aridity except in the south-western Cape.		Dry conditions at Blydefontein from 11 850–5 400 BP; low rainfall in summer and winter; shrubby Asteraceae vegetation. Probable climatic variation.	Drier conditions in Aliwal North c. 11 000 BP; spread to upper Caledon River by c. 9 000 BP. Cooler, wetter conditions in Lesotho 9 000-8 000 BP (including *Podocarpus*). Driest at c. 8 500 BP in Lesotho. Cool conditions at 10, 9.5 and 8 000 BP (C3 grasses dominant) interspersed with warm conditions in E. Free State and Lesotho.
7 000–4 500 BP (8 000–6 000 BP)	Holocene antithermal (less from precessional effect than in the Eemian interglacial; possibly more a result of solar output fluctuations).	Temperatures higher than at present, with increased rainfall in various areas. Considerable regional variation: the west wetter, and the east drier. Apparantly also much fluctuation in rainfall abundance, with dry-wet cycles (perhaps much like the present).	Sub-tropical, easterly (summer) rainfall systems dominant. This regime moved progessively south and reached the southern coast by 3 500 BP. Less rainfall by 10-20%.	Later arrival of summer rainfall regime at Blydefontein than further north; remained dry for longer.	Wetter conditions in Lesotho 6 900–5 000 BP. Drier period 5 600 BP in Lesotho. Aridity resulted in fragmentation of the Great Escarpment floras, with steppe and fynbos surviving on the highest mountains only.
4 700–4 200 BP		Major cool events.		Grassy phase at Blydefontein (c. 4 500–4 000 BP; after 5 370 BP by Scott et al., 2005); summer rainfall dominant; wetter. Great Winterberg also wetter during this time.	Warm/wet episode in Lesotho 4 500–3 900 BP, with pockets of Afromontane forest.
4 200–3 200 BP		Mild.		Possible cooling at c. 3 590 BP at Compassberg evidenced by increased Ericaceous pollen. General decrease in grass to karroid shrubs from 3 590 to present; marsh environment has stayed relatively stable; fynbos	

Date	Period	General Effect	Weather Systems	Effect on Southern Great Escarpment	Effect Elsewhere on the Escarpment
				elements decline gradually to present. Dry conditions at Blydefontein after 4 000BP to 2 000 BP. Great Winterberg: moister conditions and richer vegetation cover at 4 200 BP. Afromontane forest extent roughly the same as today. General drying out of the Nuweveldberge from 4 000 BP to present.	
3 200–2 500 BP	Neoglacial	Major cool event.		Cooling or more winter moisture (or both) at Blydefontein (c. 3000 BP); more grassy. Sugden refers to a drier period in the Great Winterberg sometime after 4 200 BP, but it is not dated. Possibly this time. Conditions more like current Nuweveldberg and Sneeuberg; Afromontane decreased. Followed by moister conditions again.	
2 300–2 000 BP (300–0 BC)		Cooler.			
2 000–1 800 BP (0–200 AD)		Warmer.		Dry (Karoo) conditions at Blydefontein.	
1 900–1 750 BP (100–250 AD)		Cooler.			
1 750–1 400 BP (250–600 AD)		Warmer.			
1400–1100 BP		Cooler.		Grass component declined at	

Date	Period	General Effect	Weather Systems	Effect on Southern Great Escarpment	Effect Elsewhere on the Escarpment
(600–900 AD)				Blydefontein since 1 360 BP.	
1 100–700 BP (900–1300 AD)	Medieval Warm Epoch	Warmer, wetter		Blydefontein indicated to have either a dry, warm event or to be grassy (900-1500 AD).	
700–500 BP (1300–1500 AD)	Little Ice Age (I)	Cooler, drier, more major flooding		Stable vlei environment on the Eastern Nuweveldberge from 760 BP till present. Fluctuations in the surrounding environment from moister (increased *Cliffortia arborea*, *Salix*, Campanulaceae).	
500–325 BP (1500–1675 AD)		Warmer			
300–150 BP (1700–1850 AD)	Little Ice Age (II)	Cooler		Increase in the Karoo element at Blydefontein, indicating lower summer rainfall.	
150 BP – present (1850–2009 AD)	Global Warming	Warming	Current climate of cyclic drought-wet periods; possible diminished overall rainfall in the Great Escarpment since ca. 1890.	Forest favoured except for anthropogenic use of fire.	Note: Afromontane forest generally favoured in Holocene than grassland, grassland being favoured in the LGM.

It appears that the current winter and summer conditions over the southern African subcontinent are a seasonal-scale version of the long-term climatic oscillations. Westerlies dominate in winter, with colder, drier conditions prevailing except in the south-west, which is wet (Cowling and Lombard, 2002), while easterlies dominate during summer, with warmer, wetter conditions except in the south-west, which remains dry (Van Zinderen Bakker, 1962, 1983). The same pattern follows for drought periods in the interior of southern Africa: the south-west receives unusual summer rain from stronger westerlies while the interior suffers summer drought. This is usually linked to the Southern Ocean Oscillation System and to the strengthening of the Kalahari High Pressure system over the interior, and a similar scenario over a much longer time period may have contributed/be attributed to the mega-oscillations (Tyson, 1999b).

Under the current climate regime, the western Great Escarpment falls under the reliable winter rainfall regime while the eastern Great Escarpment falls primarily under the less reliable summer rainfall regime (Scott and Lee-Thorpe, 2004; Chase and Meadows, 2007; Fig. 6.14). The Nuweveldberge however falls into the “all-year rainfall” regime (Sugden, 1989; Chase and Meadows, 2007; Fig. 6.14), which in the Great Karoo is a bimodal rainfall regime. Rainfall in this Nama-Karoo region can be unpredictable (Venter et al., 1986; Cowling and Lombard, 2002; Burgess et al., 2004; Esler et al., 2006), is highly sensitive to declines in summer rainfall (Scott and Lee-Thorpe, 2004), and lacks the ameliorating effect of the Indian Ocean (Mucina and Rutherford, 2006). (It can be noted that the KR is also an all-year rainfall area, although much wetter than the Nuweveldberge; it is also a floristic disjunction, possibly for similar reasons as the Nuweveldberge; Weimarck, 1941; Cowling and Lombard, 2002; Cowling et al., 2005). This rainfall unpredictability on the Nuweveldberge may be the cause of the phylogenetic disjunctions between the western and eastern components of the Great Escarpment, the “Nuweveld corridor” between them having been “broken” since the LGM.

The following scenario of the evolution of the Nuweveld disjunction is proposed:

During the LGM, the vegetation of the Hantam–Roggeveld was able to migrate eastwards along a wetter and colder Nuweveldberge Escarpment to the Sneeuberg and DAC (Van Zinderen Bakker, 1962, p. 28, his Map IV). A depression (a shift of borders of vegetation zones to lower altitudes) of vegetation belts (Van Zinderen Bakker, 1962, 1983) would have rendered the Nelspoort Interval trivial, as it would the current gaps that in the LGM would constitute the NW, Matjiesfontein and SE connections. Meadows and Baxter (1999), for instance, indicate a depression in vegetation belts on the Cederberg, which is part of the NW Centre and adjacent to the HRC. The vegetation in the LGM was possibly much more fynbos-dominated on the Hantam–Roggeveld than today (for instance Bergh

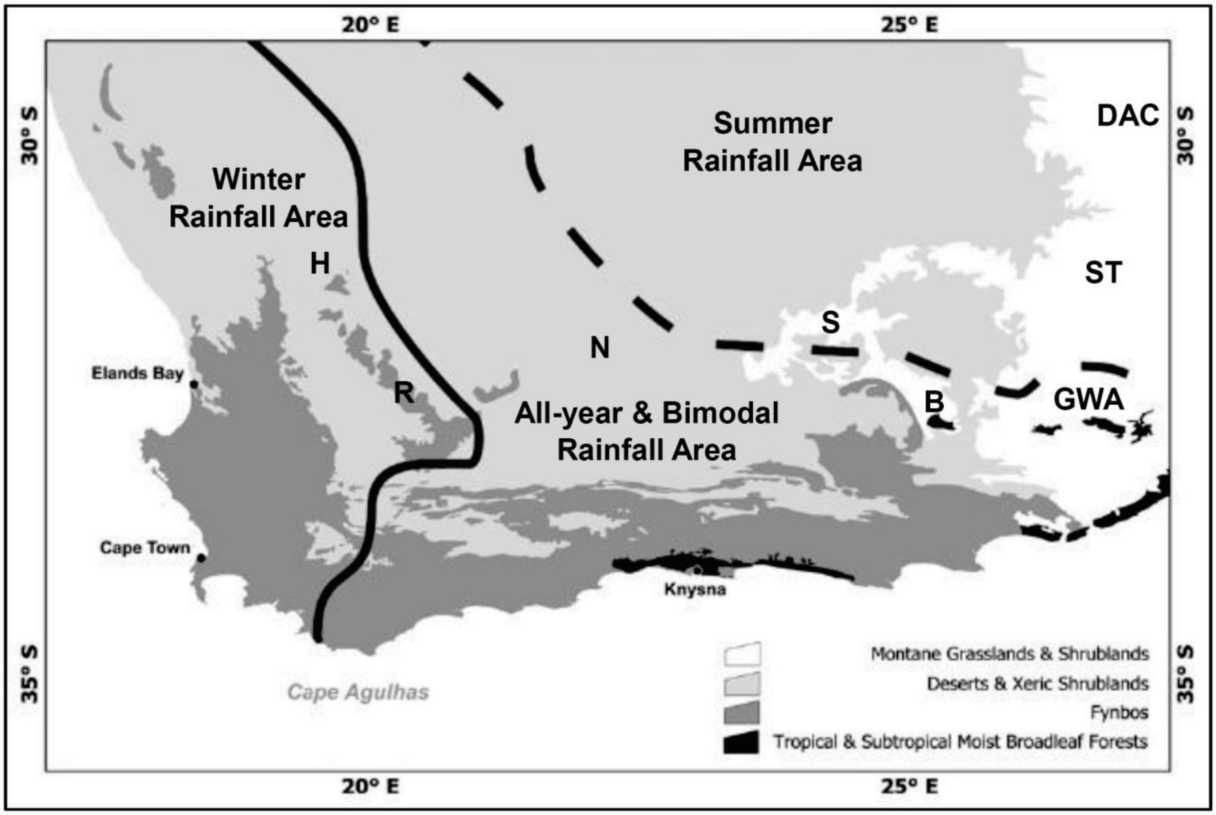


Figure 6.14: Rainfall seasonality over southern South Africa (from Chase and Meadows, 2007). Abbreviations (from west to east): H = Hantamberge, R = Roggeveldberge, N = Nuweveldberge, S = Sneeuberg, B = Boschberg, GWA = Great Winterberg–Amatolas, ST = Stormberg, DAC = Drakensberg Alpine Centre.

et al., 2007). The subsequent contraction of this moister Cape vegetation westward associated with warming up of the climate after the LGM would explain relictual/divergent Cape species now only found on the highest (i.e. climatically most stable) points of the Great Escarpment (such as on the Sneeuberg; Clark et al., 2009), as is the case in the CFR (Midgley et al., 2005; Verboom, et al., 2009). The two most important Sneeuberg (“flagship”) examples are *Hesperantha helmei*, which is possibly most closely related to three Roggeveld species (Goldblatt and Manning, 2007), and the woody *Cliffortia bolusii*, which (if rediscovered) might turn out to belong to section Arboreae, other representatives of which are from the KM and NW Centres and the Hantam–Roggeveld–Nuweveldberg Escarpment (Oliver and Fellingham, 1994; Whitehouse and Fellingham, 2007).

The opposite may have taken place during periods when an eastern cyclonic climate became dominant (the Holocene for example seems to have had a succession of wetter and drier spells; Scott, 1993; Tyson, 1999a; Scott and Lee-Thorpe, 2004). An increased rainfall would facilitate the spread of vegetation typical of the eastern Great Escarpment westwards, and the low hills between the

Nuweveldberge and the Sneeuberg (i.e. in the Nelspoort Interval) would become effectively stepping stones, as would also the lower-altitude Great Escarpment rim between the Nuweveldberge and the Sneeuberg. Under these conditions, species typical of the east (and requiring higher moisture in summer) may have been able to move westwards along the Great Escarpment. The grasslands on the eastern Nuweveldberge may be relicts from such a period (Branch, 1998), as might be the numerous Sneeuberg endemics and DAC near-endemics now also known from the Nuweveldberge (see Chapter 4). It is possible that montane grassland would then have existed as far west as the western Nuweveldberge (grassland expansion is cited having taken place in both in the LGM and in the wetter parts of the Holocene; Scott, 2002; Scott and Lee-Thorpe, 2004), and that progressive aridification over the past 4 000 years on the Nuweveldberge (Sugden, 1989) has probably caused the local extinction of numerous other remaining eastern species and fostered an increase of Karoo ubiquitists at higher altitudes (and possibly exacerbated since by poor land-use management; Acocks, 1988; Sugden, 1989). This may explain the almost complete absence of Orchidaceae in the Nuweveldberge (only three species have been recorded), and also the very low Orchidaceae diversity in the Sneeuberg, compared to the consistently wetter DAC.

It is thus proposed that there has been a continual tension on the Nuweveldberge between the westerlies and easterlies that has rendered it unsuitable for high local speciation and endemism or as a montane refugium. The climatic harshness of the Nuweveldberge is evident by its low number of endemics (only six species; see Chapter 4) compared to the more climatically stable Hantam–Roggeveld (92 endemics; see Chapter 5) and the higher-altitude sections of the eastern Great Escarpment (16% endemism in the DAC; Carbutt and Edwards, 2004; Clark et al., 2009). It is thus argued that the western and eastern components of the Great Escarpment are thus comparatively stable climatic refugia with resultant high species accumulation (Jetz et al., 2004), comparable perhaps on a limited scale to the same process in the CFR (Cowling and Lombard, 2002; Midgley et al., 2005; Procheş et al., 2006; Bergh et al., 2007; Goldblatt and Manning, 2007; Verboom et al., 2009), versus a probable high local species extinction on the Nuweveldberge since the LGM. Determining speciation versus extinction rates in the southern Great Escarpment (as elsewhere) will remain difficult however (Linder, 2006), and the Great Escarpment has probably not been as climatically stable as the CFR (Meadows and Baxter, 1999; Dynesius and Jansson, 2000).

6.5.2. Was the southern Great Escarpment in fact wetter during the LGM?

A problem with this hypothesis is whether the southern Great Escarpment was in fact wetter or drier during the LGM. A moister LGM scenario for the southern Great Escarpment (particularly the Nuweveldberge) is not evidenced from the four models presented by Chase and Meadows (2007) in

Fig. 6.15. Their models do however consistently indicate that the southern Great Escarpment was at least as wet as at present. However, it may be possible to argue for a moister southern Great Escarpment during the LGM. As indicated previously, it has generally been considered that the interior of southern Africa received much less rainfall during the LGM than at present (Iriondo, 1999; Partridge et al., 2004). Grab (2002) however suggests that the KZN-side of the Main Drakensberg Escarpment still received 70% of its current MAP during the LGM, amounting to over 1 000 mm per annum, while Mills et al. (2009) and Grab and Simpson (2000) actually motivate for a higher precipitation on the Main Drakensberg Escarpment in the LGM based on the displacement of the westerlies to 25^{o}S over the interior and 30^{o}S over the eastern regions of South Africa. Similarly, Partridge et al. (2004) comment that although rainfall over the subcontinent was lower in the LGM, parts of the western Cape and western Great Escarpment possibly received more rainfall than at present due to more frequent exposure to the westerlies. Based on this Midgley et al. (2005), indicate fynbos having feasibly extended as far as the southern Namibian mountains between 12 000–80 000 BP, and possibly eastwards too (Bergh et al., 2007). The consequent refugial status of the Kamiesberg fynbos outlier (Weimarck, 1941) has subsequently been supported by the phylogeographic work of Bergh et al. (2007). The orographic effects on local climate can also be considered to have been as prevalent under an LGM climatic regime as at present (Van Zinderen Bakker, 1962; Jetz et al., 2004; Partridge et al., 2004), with west-facing mountains being prime recipients of westerly moisture (Partridge et al., 2004). Thus a generally drier climate in the LGM might not necessarily mean that the mountains of the southern Great Escarpment (particularly the Nuweveldberge, Sneeuberg and Great Winterberg–Amatolas) were any less dry than today (Chase and Meadows, 2007), given their high relative altitude above the surrounding Karoo plains and prime positions as moisture-harvesters. This is not an absolute certainty however, and this assumption is contradicted by Thomas et al. (2002) for the Stormberg and by Norström et al. (2009) for Braamhoek wetland (near van Reenen's Pass on the KZN Escarpment), who indicate drier conditions during the late LGM.

Although parts of the south-western Cape have a lower MAP than many of the summer rainfall regions in southern Africa, the gentle nature of frontal precipitation typical in this westerly regime is often more effective and persistent (and therefore useful) than the heavy thundershowers typical of the easterly regime. The generally cooler temperatures under the LGM would have lowered evapo-transpiration rates rendering the overall effective available moisture to plants perhaps as good or better than a higher rainfall with higher temperatures in an easterly regime (Van Zinderen Bakker, 1962). Thus a lower rainfall scenario in the LGM might not have been less beneficial to vegetation.

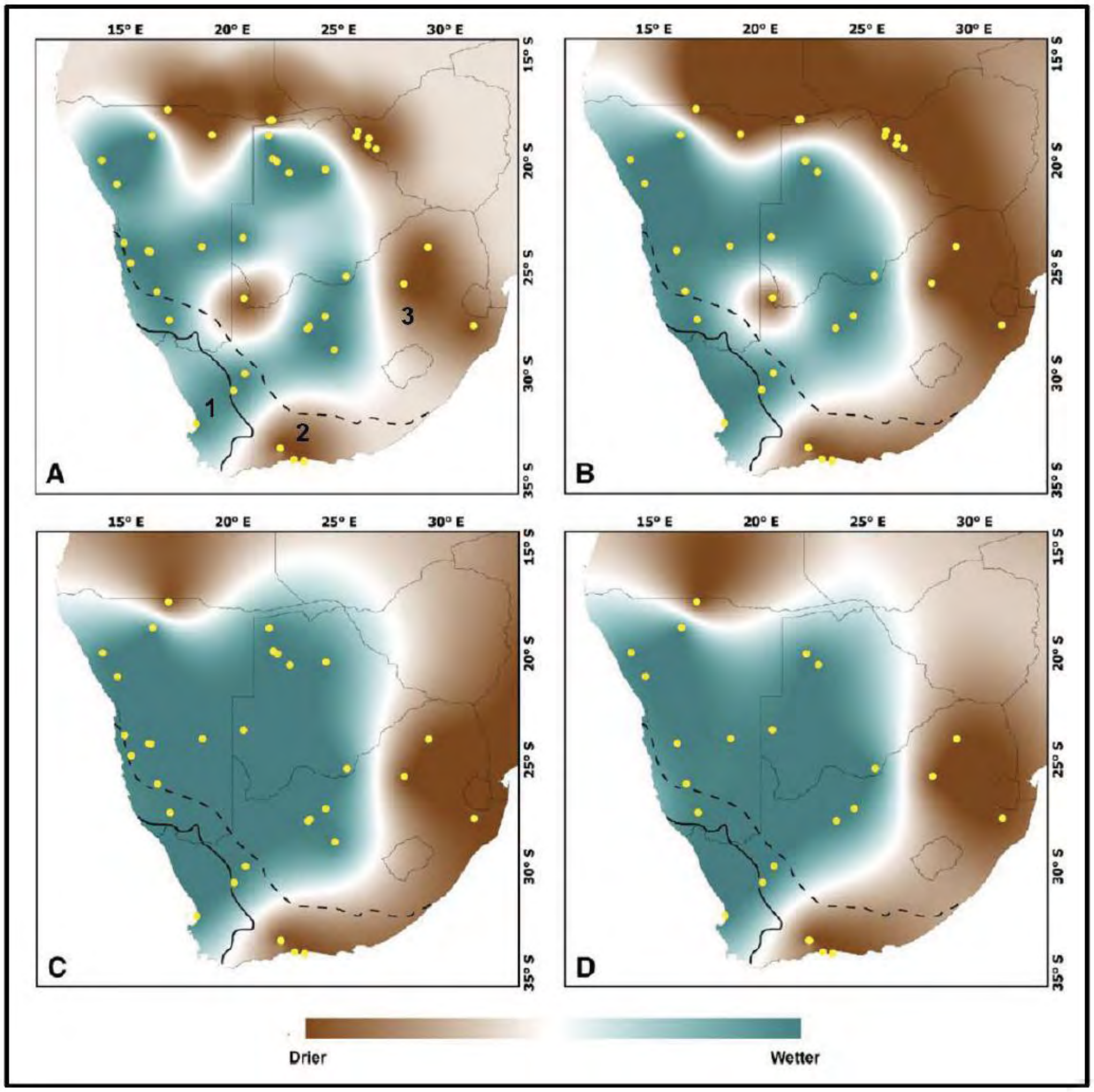


Figure 6.15: Various Last Glacial Maximum interpolations for southern Africa from available palaeo-environmental evidence (yellow dots). 1 = Current winter rainfall zone, 2 = Current all-year rainfall zone, 3 = Current summer rainfall zone. From Chase and Meadows (2007).

The possibility of increased moisture on the southern Great Escarpment during the LGM raises the question of possible glaciation on the higher areas of the southern Great Escarpment and the effect on vegetation. LGM glaciation in southern Africa is a highly controversial and debated topic (Butzer, 1973; Boelhouwers and Meiklejohn, 2002; Hall, 2004; Mills and Grab, 2005; Mills et al., 2009 – this debate has largely been fuelled by periglacial research in the Eastern Cape Drakensberg by Lewis, 1994a, b, 1999, 2005 etc.), with until recently no unequivocal evidence compared to, for instance, Tasmania (Hall, 2004; Colhoun, 2004) and the East African mountains (Hastenrath, 2009). While glaciation in Lesotho and the Main Drakensberg Escarpment has now been well substantiated (Mills et al., 2009), there has been little or no work in this regard along the southern Great Escarpment. The mostly likely montane candidates for glaciations in the LGM along the southern Great Escarpment are the Sneeuberg and Great Winterberg–Amatolas (Boelhouwers and Meiklejohn, 2002; Hall, 2004). The possibility of marginal glaciations in these mountains is argued as follows:

(1) Their relative high altitude (up to 2 504 m in the Sneeuberg and 2 368 m in the Great Winterberg; Clark et al., 2009), and ample steep, south-facing slopes conducive to ice accumulation (see Grab and Simpson, 2000, and Mills et al., 2009, for the highest altitude parts of the Main Drakensberg Escarpment).

(2) Ample areas of mountain face exposure to the prevailing westerlies (as for Tasmania; Colhoun, 2004). Although a lack of suitable precipitation and generally drier conditions has been considered to reduce the probability of glaciation in southern Africa (Boelhouwers and Meiklejohn, 2002; Hall, 2004) – somewhat supported by Tasmania having received much less glaciation in the LGM than in preceding glacial events (Colhoun, 2004) – increased precipitation on the Main Drakensberg Escarpment during the LGM (Grab, 2002; Mills et al., 2009) would have negated this. Also, a glacial event lasting several thousand years with regular snowfall (and assuming no thawing) is likely to have built up a stable layer of ice in protected sites, such as on high altitude, steep, south-facing slopes (Mills et al., 2009; Grab, 2002, notes snow lying in such sheltered sites for up to five months on the Main Drakensberg Escarpment). Mills et al. (2009) motivate for marginal glaciation in Lesotho that would have feasibly occurred under the generally recognised 6^{o}C temperature depression.

(3) These mountains are currently situated well-within the effects of westerly weather systems and have an average of 31 days per year of snow (Hall, 2004). Thus under a dominant westerly regime they would be even more likely to receive snow and more reliably through the year (Mills et al., 2009). (The Sneeuberg has occassional snowfalls in summer at present; Clark et al., 2009).

(4) The higher adiabatic lapse rates from increased intensity and frequency of cold fronts in the LGM, therefore lowering temperatures further on windward slopes (Grab and Simpson, 2000; Grab, 2002).

(5) Lower sea levels of ca. 130 m in the LGM would have augmented the effect of altitude (Hall, 2004), hence an altitude today of 2 504 m on the Compassberg would have effectively been equal to 2 634 m during the LGM.

(6) The southern Great Escarpment is situated parallel to latitude, thus further augmenting the effect of altitude on the ambient montane climatic environment (Steele et al., 1998; Clark

et al., 2009). At least minor glaciation in the form of marginal plateau glaciers, cirque glaciers and niche glaciers (Boelhouwers and Meiklejohn, 2002) is therefore not impossible (see Grab, 2002, and Hastenrath, 2009 as instances in the Main Drakensberg Escarpment).

Butzer (1973) presents periglacial evidence for the Stormberg. Although periglacial activity is purported for the Amatolas (Boelhouwers and Meiklejohn, 2002), and permafrost may have been present in the Great Winterberg–Amatolas and in the Sneeuberg (see Mills and Grub, 2005, for the the Main Drakensberg Escarpment), no work addresses glacial or periglacial activity in the Sneeuberg (Butzer, 1973). Butzer (1973) suggests that the Sneeuberg above 2 100 m and the Nuweveldberge above 1 700 m should be examined closely for nivation niches, oversteepened slopes and blockfields. It is likely that relict glacial features have been masked or removed by more recent geomorphological activities over much of the Nuweveldberge and Roggeveldberge (Butzer, 1973; Meadows, 2001). The Hantam–Roggeveldberge must have been even more bitterly cold in the LGM than it presently is in winter. A much flatter region than the Sneeuberg, and with an escarpment composed mostly of soft sediments such as shale, the presence of any palaeo-periglacial features may have long since been obliterated by current geomorphological processes, e.g. fluvial activity on the plateau and rapid landform processes such soil creep, rock shattering and mass wasting of the softer sediments (especially shale) on the Great Escarpment slopes. There do not appear to have been any studies on paleao-periglacial phenomena done in the Roggeveld. The Sneeuberg at least deserves careful attention in this regard and is a prime candidate for relict glacial and periglacial landforms, particularly debris ridges (see Mills and Grub, 2005).

6.5.3. The current role of the southern Great Escarpment as an interglacial refugium

The presumed recent aridification of the Nuweveldberge begs the question of any indication of relict elements along this piece of Great Escarpment from a cooler, moister time. Three habitats (cliff, high peaks and wetlands) can be considered as obvious candidates to serve as current refugial niches sheltering species more typical of past climatic periods. Each is considered in detail.

a) South-facing cliffs

South-facing cliffs provide an important micro-habitat for many plants, especially temperate and high-altitude specialists ("alpine" species), along the southern Great Escarpment (Clark et al., 2009). Throughout the southern Great Escarpment particular cliff communities with characteristic species occur, many of these species not occurring elsewhere. Examples are *Zaluzianskya ovata*, *Cromidon decumbens* and *Urtica lobulata*. South-facing cliffs are shaded for much of the day (the higher cliffs providing the shadiest micro-habitat) and thus provide protection from high evapo-transpiration and desiccation, especially in summer (Clark et al., 2009). This is particularly true of cliffs eroding by parallel retreat, as typically found in the more arid areas of the southern Great Escarpment. These cliffs provide deeper and more extensive shade than cliffs which are eroding by slope decline (Larson et al., 2000).

Cliffs harvest moisture from mist, which condenses on the cold rock and drips down to the base of the cliffs, often resulting in seepage zones. Cliffs also turn into waterfalls during rain showers. These in effect result in an increase in local precipitation at the base of cliffs (Cooper, 1997; Larson et al., 2000). Snow can linger at the base of, and in crevices of, cliffs much longer than elsewhere, and together with ice waterfalls maintain a cooler micro-climate. Snow also percolates into the soil much better than rain, providing groundwater recharge for seeps. Cliffs are fire-shy and do not support enough flammable material. They are also often inaccessible to livestock (although cliff-bases are often the favoured choice by small antelope for game-paths in the southern Great Escarpment). Cliff faces are environments characterised by low levels of competition for basic soil resources and space – hence serving as harbingers of competitively weak lineages. South-east-facing cliffs are exposed to the moisture-bearing south-east winds that ameliorate the summer heat (Clark et al., 2009). Cliffs and rock spurs that are thus aligned are easily evidenced as such by a much richer plant growth (Clark et al., 2009). In effect, the south-east-facing slopes of the Sneeuberg harbour Afromontane vegetation from as low as 1 300 m, in contrast to the usual 1 600 to 1 800 m minimum altitudes on slopes of other aspect (Clark et al., 2009).

Cliffs may thus represent climatically stable environments protected from rapid environmental change, and harbour vegetation that is relatively constant (Larson et al., 2000). Cliffs may function as refugia for species more suited to cooler, wetter conditions, as well as for those species which may have been more widespread on the southern Great Escarpment during the LGM (e.g. Larson et al., 2000). Along the southern Great Escarpment it is evident that the cliffs of the Nuweveldberge compensate for the coolness and available moisture that is more readily available to the east and west on the southern Great Escarpment. *Cliffortia arborea*, for example, is completely restricted to cliff-bases and southern slopes in the arid western and central Nuweveldberge, but on the Roggeveld and eastern Nuweveld also occurs on the plateaux, as rainfall here is higher and more consistent. (It is tempting to imagine much of the Hantam–Roggeveld–Nuweveld Escarpment being covered in vast thickets of *Cliffortia arborea* during the LGM – perhaps a southern Great Escarpment-version of *Widdringtonia cedarbergensis*, which has also declined in abundance on the Cederberg since the LGM; Meadows and Baxter, 1999). Cliffs also offer a corridor along the southern Great Escarpment for temperate species, as evidenced by numerous naturalised Palaearctic species typically occurring along these cliffs (e.g. *Urtica dioica*, *Myosotis arvensis*, *M. sylvaticus* and *Poa pratensis*). A parallel between climate favourability and cliff refugia can be seen from east to west along the southern Great Escarpment. In the Nuweveldberge, cliffs are the only habitat in which certain species that are more widespread in the Sneeuberg are to be found (such as *Senecio asperulus* and *Guthriea capensis*), while on the Sneeuberg, cliffs are the main habitat in which some widespread moister eastern species are found (such as *Ranunculus multifidus* and *Erica caespitosa*). Essentially then, south-facing southern Great Escarpment cliffs can be considered to be a climatic refugium with highest importance on the Nuweveldberge.

b) High peaks

High peaks play a similar role as cliffs in compensating for moisture and coolness, and present areas of relative climatic stability compared to the surrounding lower altitudes (Bergh et al., 2007; Clark et al., 2009). A clear example of this can be observed on the Sneeuberg, where many species common on the low altitude (1 600 m) but high-rainfall Boschberg (1 000 mm) – such as *Craterocapsa montana* and *Erica leucopelta* – are restricted to much higher altitudes on the Sneeuberg-proper. This is even more evident on the Nuweveldberge and Roggeveldberge, where grassy and fynbos elements (the latter absent from the Nuweveldberge) are found only on the highest plateaux. A good example of such an element is *Helichrysum trilineatum*. Some species ranging from the Sneeuberg to the DAC are only found on the highest points, good examples being *Erica* sp. aff. *reenensis* occurring on the Nardousberg and Great Winterberg above 2 300 m.

c) Wetlands

Wetland areas on the Great Escarpment can be broadly defined to include river systems, pans, pools, seeps, bogs, marshes, and dams. They are characterised by species that require at least non-perennial moisture. The species are usually of a similar composition across the southern Great Escarpment, being characterised by species with good long-distance dispersal abilities and which are thus ubiquitous in both natural and artificial wetland systems. Numerous examples include *Berula erecta* subsp. *thunbergii*, *Bulbostylis humilis*, *Cotula coronopifolia*, *Crassula natans*, *Cyperus marginatus*, *Isolepis cernua*, *Juncus exsertus* subsp. *exsertus*, *J. inflexus*, *Limosella* spp., *Mentha longifolia* subsp. *capensis*, *Phragmites australis*, *Pseudoschoenus inanis*, *Scirpoides dioecus* and *Typha capensis*. These wetland systems seem to only benefit such well-dispersed species, and their value as a refugium is doubtful. DAC afro-alpine bogs are considered to be about up to 13 500 years old, suggesting that the Main Drakensberg Escarpment was unvegetated in the LGM due to suppression of vegetation belts to lower altitudes (Grab, 2002). It is possible that this also occurred on the higher-lying areas of the Sneeuberg and Great Winterberg–Amatolas, meaning that the current plateau bogs and wetlands are more recent and secondary refugia, colonised since the LGM as species migrated up the mountains.

6.5.4. Synthesising climate, edaphic factors and intervals

While climate history plays a crucial role in determining levels of local endemism, edaphic factors have also been implicated as playing an important and often dominant role in local endemism (e.g. the serpentine soils of the Barberton Centre; Balkwill and Balkwill, 1999; Van Wyk and Smith, 2001). As elucidated in this thesis, both climate and edaphic factors are in evidence on the southern Great Escarpment and it is worth investigating which may be the dominant factor.

As indicated for the Sneeuberg and Nuweveldberge (Chapters 2 and 5), dolerite-derived soils host a richer vegetation cover than sedimentary-derived soils, and all of the DAC endemics now known from the Sneeuberg are only found on dolerite-derived black turf clays. It is worth identifying which substrates Sneeuberg and Nuweveldberge local endemics occur on in comparison to their typical climatic niche. To address this, 22 Sneeuberg and two Nuweveldberge endemics have been assessed in terms of their substrate preference, altitude, vegetation units and particular habitat niches (Table 6.5). Altitude, vegetation unit and habitat niche provide an indication of climatic niche. The remaining six Sneeuberg and four Nuweveldberge endemics lack suitable information to be assessed in this manner and have been excluded, and the same is true of the Great Winterberg–Amatola endemics. HRC endemics have not been assessed as it is well-known that edaphic-specific endemics occur on both dolerite- and sandstone-derived soils, particularly on the HRC border with the CFR in the Nieuwoudtville area (Mucina and Rutherford, 2006).

Almost half of the endemics assessed occur on both sandstone and dolerite (Fig. 6.16A), while slightly less than this are exclusively found on dolerite. Only a small percentage is found on sandstone alone. Thus the majority of the endemics are (by a small margin) “edaphic ubiquitists”, followed closely by “dolerite specialists”. This is in contrast to climatic controls (Fig. 6.16B) where a combination of those endemics confined to summit plateaux (and thus to a moister climate regime) and/or restricted to distinctly moister vegetation units and habitat niches (e.g. wetlands, upland grasslands, forest etc.) totals 84% of the endemics. This is twice the percentage of the “dolerite specialists” and suggests that climate is the dominant factor in determining the distribution of endemics. These results mirror those of McDonald and Cowling (1995) for the Langeberg, as well as for the CFR in general (Verboom et al., 2009). The following summary of observations made in Chapters 2, 3 and 4 lends supports to this:

Table 6.5: Summary of substrate, altitude, climatic and habitat preferences of 22 Sneeuberg and two Nuweveldberg endemics (the last two species in this Table).

Endemic Taxon	Substrate	Altitude (m)	Vegetation Unit	Habitat Niche
Acmadenia sp. nov. 1 aff. *sheilae* I.	Dolerite.	1 600 m	Karoo Escarpment Grassland.	Summit plateau.
Adromischus fallax	Dolerite.	1 400 m	Camdeboo Escarpment Thicket.	Uncertain.
Conium sp. no. 4	Dolerite and sandstone.	1 800+ m	Karoo Escarpment Grassland.	Cliff-bases and summit wetlands.
Delosperma sp. nov. 1 aff. *D. dyeri*	Dolerite.	2 400 m	Karoo Escarpment Grassland.	Summit peak.
Diascia ramosa	Sandstone.	1 200 m	Southern Evergreen Forest.	Forest
Dierama grandiflorum	Dolerite.	1 500+ m	Amathole Montane Grassland and Karoo Escarpment Grassland.	Summit plateau.
Erica passerinoides	Sandstone?	1 800+ m	Karoo Escarpment Grassland.	Summit plateau.
Euryops dentatus	Dolerite.	1 400+ m	Karoo Escarpment Grassland.	None.
Euryops exsudans	Dolerite and sandstone.	1 600+ m	Karoo Escarpment Grassland.	None.
Euryops proteoides	Dolerite and sandstone.	1 300+ m	Karoo Escarpment Grassland.	Stream-lines, cliff-bases and scarp seeps.
Faurea sp. nov. 1	Dolerite and sandstone.	1 300 m	Fynbos	SE-slope
Gazania caespitosa	Dolerite.	1 600+ m	Karoo Escarpment Grassland.	Summit plateau.
Haworthia marumiana var. *batesiana*	Dolerite and sandstone.	1 200–1 600 m	Camdeboo Escarpment Thicket.	Mid-altitude cliffs.
Hermannia sneeubergensis	Dolerite and sandstone.	1 300+ m	Karoo Escarpment Grassland.	Moist slopes and upland grassland.
Hermannia crassifolia	Dolerite.	1 200 m	Eastern Cape Escarpment Thicket/woodland	Moist woodland.
Hesperantha helmei	Dolerite and sandstone.	2 000+ m	Karoo Escarpment Grassland.	Summit plateau.
Indigofera sp. nov. 1	Dolerite.	1 800+ m	Karoo Escarpment Grassland.	Summit plateau.
Indigofera sp. nov. 2	Dolerite and sandstone.	1 800+ m	Karoo Escarpment Grassland.	Summit plateau.
Kniphofia acraea	Dolerite?	1 600 m	Karoo Escarpment Grassland.	Upland grassland.
Ornithogalum sp. nov. 1 aff. *flexuosum*	Dolerite and sandstone.	1 500+ m	Amathole Montane Grassland and Karoo Escarpment Grassland.	Mid- and summit plateaux.
Selago bolusii (includes S. cf. bolusii specimens)	Dolerite and sandstone.	1 600+ m	Karoo Escarpment Grassland.	Cliffs.
Selago retropilosa	Dolerite and sandstone.	1 800+ m	Karoo Escarpment Grassland.	Summit plateau.
Lotononis azureoides	Dolerite and sandstone.	1 700+ m	Karoo Escarpment Grassland.	Summit plateau.
Ruschia dejagerae	Dolerite.	1 600 m	Nama-Karoo.	None.

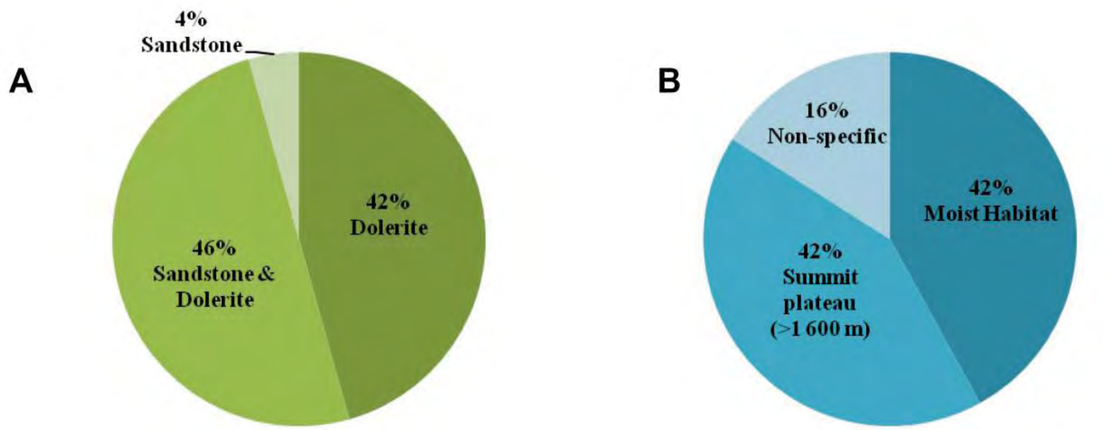


Figure 6.16: Ecological preferences of 22 Sneeuberg and two Nuweveldberge endemic species: (A) Edaphic substrate; (B) Habitat/moisture niche. Data from Chapters 2 and 5 as well as from field observations (2005–2009).

(1) South-eastern slopes in the Sneeuberg typically host vegetation from 1 300 m upwards that elsewhere in the Sneeuberg only occurs from 1 600 m or 1 800 m upwards. This is particularly evident on the Boschberg, where many species found at 1 300–1 500 m are only found elsewhere on the Sneeuberg above 1 800 m. The Boschberg has the highest MAP in the Sneeuberg.

(2) There is a "succession" of vegetation units along the southern Great Escarpment between the Great Winterberg–Amatolas and the Nuweveldberge based on increasing aridity westwards. Karoo Escarpment Grassland, for instance, occurs only on the inland margin of the Great Winterberg–Amatola plateau, but on the Sneeuberg becomes the dominant plateau vegetation unit, while on the Nuweveldberge grassland is almost completely replaced by Nama-Karoo at all altitudes except in the east and on the highest peaks in the centre and west.

It will be worthwhile in future to include shared southern Great Escarpment endemics in the above analyses, as well as Great Winterberg–Amatolas and Stormberg endemics once these have been researched further.

Further to this line of thought are the CFR outliers on the southern Great Escarpment, particularly those found in the Sneeuberg and Boschberg where they are mostly only found on rich dolerite-derived soils as opposed to nutrient-poor sandstones. As there are numerous substrates (including granite, shales, sandstones, silcretes and Dwyka tillites) in the core of the CFR – all of which support fynbos vegetation (van Wyk and Smith, 2001; Mucina and Rutherford, 2006) – it is not surprising then that fynbos outliers on the southern Great Escarpment occur (almost exclusively in some instances) on dolerite-derived soils (e.g. *Acmadenia* sp. nov., *Rhodocoma capensis* and *Helichrysum felinum*). Again however, as for the Sneeuberg and Nuweveldberge endemics, climatic controls are evident as fynbos is mostly found on the moister south-east-facing slopes, on the summit plateaux above 1 600 m (Sneeuberg), and particularly on the very well-watered Boschberg and Kamdebooberge. These tie in with principal refugia in the CFR being on south-eastern slopes (Verboom et al., 2009).

Related to climate and edaphic factors is the role of intervals on the southern Great Escarpment. It has already been indicated in this Chapter that intervals play a lesser role than climate in the distribution of endemic plant species on the southern Great Escarpment: with an increase in moisture there is a corresponding decrease in the altitude for mesic species. Also, there is a clear climatic gradient from east to west of diminishing rainfall and a shift in seasonality from summer to all-year to winter. Together with this shift of moisture availability and seasonality is a gradient of very high endemism in the east (DAC) diminishing to low endemism in the centre (Nuweveldberge) to high endemism in the west (HRC). It is here proposed that the mechanism involved is of climate-driven spread/dispersal across the southern Great Escarpment during favourable moisture regimes, followed by retreat of mesic species to regufia provided by altitude. The intervals are thus climate-driven barriers and are not geomorphological barriers in themselves i.e. under suitable climate they would be irrelevant obstacles to plant migration. The centres of endemism on the southern Great Escarpment are thus nodes of higher endemism resulting from where the climate has been the most stable (thus species are accumulated through speciation and from lower extinction rates) and where the altitude is sufficient to support previously more widespread endemics. The most species are conserved/accumulated where (1) the climate is the most stable (e.g. the HRC), (2) where the surface area at altitude is the most expansive (e.g. the DAC), (3) and (only) then where edaphic controls operate (e.g. the HRC).

6.6. Conclusion

The high local endemism along the southern Great Escarpment is a function of moisture reliability, geomorphological disjunction and edaphic substrate. It is concluded that moisture reliability is the main driver of endemism and species diversity on the southern Great Escarpment, accentuated by geomorphological disjunction, while edaphic controls are a further refinement in the distribution of endemics. The Hantam–Roggeveldberge and the DAC have the highest percentage of endemics (8.2% and 16% respectively) as a result of reliable moisture regimes since the LGM; this has resulted in a net gain of species (or less extinctions) here than elsewhere along the southern Great Escarpment. The Nuweveldberge has the lowest percentage endemism (0.5%) due to an unreliable moisture regime and consequent loss of many endemics and many near-endemics since the LGM. Endemism is also a factor of geomorphological disjunction, with each discrete orographic component of the southern Great Escarpment having its own suite of local endemics. Disjunction is somewhat ambivalent however, as there is a nested series of shared endemics along the Great Escarpment. In this regard the moisture gradient from east to west appears to play a more important role than simply the disjunctions presented by the Nelspoort and Great Fish River Intervals. In light of this, the delimitation of centres of endemism on the southern Great Escarpment is not easy. As the intervals between the different components of the southern Great Escarpment are all minor intervals (as defined in Chapter 1), and with the Macassarfontein and Queenstown Intervals not qualifying as even minor intervals, two climatically-driven centres can be argued for: the HRC in the west and an expanded DAC (to incorporate the Sneeuberg, Stormberg and Great Winterberg–Amatolas) in the east. Nevertheless, the pronounced local endemism on the Sneeuberg (and also on the Great Winterberg–Amatolas and Stormberg) – being stronger in percentage endemism than some other recognised centres – argue for separate delimitation. It will probably never be possible to completely resolve this biogeographically complicated montane scenario, but it should be acknowledged that these fragmented sections of Great Escarpment are rich in localised endemics and warrant further detailed botanical investigation and appropriate conservation measures.

The southern Great Escarpment is a palaeo-corridor between the Hantam–Roggeveld and the high altitude Sneeuberg and DAC. This is supported by ten sister-taxon disjunctions in the phylogenies analysed in this study. It is postulated that this southern Great Escarpment track was functional for taxa with a more mesic niche during the LGM when the entire southern Great Escarpment was wetter and cooler than at present, and has since been broken by the aridification of the Nuweveldberge. The current discontinuity is maintained by the less reliable moisture regime prevailing on the Nuweveldberge. This cycle of connection and interruption probably took place repeatedly during the Pleistocene (and perhaps are even further back), resulting in the suite of sister-taxon disjunctions between the eastern and western Great Escarpment, the ages of which are unknown.

The southern Great Escarpment is also an extant corridor, as exhibited by the high floristic similarity in the east from the Eastern Nuweveldberge through to the DAC. This high connectivity has largely been overlooked in the past as a consequence of inadequate field collecting (as evidenced from the numerous southern Great Escarpment and DAC endemics and near-endemics now found to be more widespread on the southern Great Escarpment than previously thought). On the other hand, floristic connectivity between the Hantam–Roggeveld and Nuweveldberge is cryptic, this despite them comprising one orographic entity and sharing 16 endemics. This is concluded again to be a result of the change in rainfall regime and sharp drop in moisture reliability east of the Komsberg onto the Nuweveldberge. The future availability of a comprehensive flora of the Hantam–Roggeveld will also facilitate a more robust comparison between them.

In addition to being a corridor, the southern Great Escarpment also consists of a series of refugia. These refugia occur where moisture availability has been the most reliable since the LGM and probably during any previous interglacial period in the past (at least since the Pliocene when winter rainfall commenced). This reliable moisture availability is represented by the winter rainfall regime in the west (Hantam–Roggeveld), and by the high summer rainfall in the east (Great Winterberg–Amatolas and DAC). In the centre (the Nuweveldberge and Sneeuberg) the higher peaks and plateaux, the south-east-facing slopes, and the south-facing cliff-lines represent areas of reliable moisture availability. While most of the Sneeuberg plateau above 1 800 m is a refugium, on the more arid Nuweveldberge the south-facing cliffs are the principal refugia. Wetlands are secondary refugia on the southern Great Escarpment, as wetland communities almost exclusively contain species that are easily dispersed and can be found in most natural and artificial wetland areas. Wetlands did thus not prove floristically important in this study (but have immense conservation value in water resource management, see below).

There is evidence of both palaeo-connectivity and current connectivity between the southern Great Escarpment and the CFR. Palaeo-connectivity via the SE connection is most strongly supported by the phylogenies, with eight sister-taxon disjunctions, while there are only two for the NW and Matjiesfontein connections. The SE connection is also supported by the UPGMA and PAE results. The NW and Matjiesfontein connections may be strengthened by the future availability of robust and comprehensive phylogenies of Cape geophyte genera such as *Hesperantha* and *Romulea*. Phylogenies of non-Cape centred taxa may also change this picture further. Current (or recent) use of all three of these CFR–Great Escarpment connections is evident from the numerous species (21 for the SE connection and 13 for the NW and Matjiesfontein connections from the phylogenies) that occur across the CFR–Great Escarpment connections. The SE connection is concluded to be the main link between the CFR and the Afromontane region on the eastern Great Escarpment in southern Africa.

Implications of this research

Accurate conservation assessments and Red Data listings for many of the previously poorly-known endemics can now be made, and appropriate conservation measures implemented. Many of these species were previously only known from their types or from scanty herbarium collections. Most of the new species encountered in this study require further material and description. Inclusion of these species in phylogenetic analyses will enhance the overall picture of floristic linkages and disjunctions on the southern Great Escarpment.

The study of the impact of climate change on the southern Great Escarpment endemics will allow for future planning and conservation measures to be considered and implemented. It is predicted that many of the local endemics will become confined to the highest peaks and the wettest (south-east-facing) slopes; those endemics already mostly confined to the highest altitudes will likely become extinct and may require *ex situ* conservation measures. Conservation of these highest peaks as refugia will be important. On the Hantam–Roggeveld there will likely be a decrease in the Cape elements and an increase in Karoo elements. The Nuweveldberge is not likely to change much as it is already dominated by an arid Karoo flora, however in the Eastern Nuweveldberge the grassland areas will likely be replaced by Karoo elements. The Sneeuberg will probably see a retreat of grassland to the highest plateaux, with a replacement by Karoo elements at mid-altitudes; similarly for the Great Winterberg–Amatolas, although – being the wettest component of the southern Great Escarpment – it might not be as severely affected. The DAC will likely see a retreat of many endemic species to the highest plateaux and an increase in Karoo elements in the rain-shadow areas and lower- to mid-slopes.

The study, protection and rehabilitation of montane wetlands on the southern Great Escarpment will become increasingly important with climate change, as these mountains are important sources of water for local communities, as well as further afield where major rivers such as the Great Fish and Sundays Rivers are important for irrigation and potable water supplies to distant municipalities. All currently intact wetlands should be protected, and a strategy to rehabilitate degraded wetlands should be instituted. As trampling by livestock is currently the biggest threat to these wetlands they should ideally be fenced off and excluded from grazing. Remnant intact wetlands across the southern Great Escarpment (such as Puttersvlei on the Nuweveldberge) can be identified and used as rehabilitation benchmarks.

The data acquired in this study will be of benefit to SANParks for their proposed Camdeboo National Park–Mountain Zebra National Park linkage across the eastern Sneeuberg. This conservation proposal, if realised, would allow for formal protection of a significant portion of the Sneeuberg Centre, including the second highest peak in the Sneeuberg and a suite of local endemics. For the Nuweveldberge, the excellent grassland and wetland conditions in the Karoo National Park – as evidenced during this study – serve as an example of good grazing management, fire regime and wetland protection that should serve as a baseline for rangeland management on the Eastern Nuweveldberge.

Future research

Although available floristic work on the Great Winterberg–Amatolas has been included in this study there is no comprehensive floristic treatment for this section of the southern Great Escarpment. Considering the steep climatic gradient across the Great Winterberg–Amatolas from south to north, coupled with a very high rainfall in the east (well over 1 000 mm), as well as being an isolated spur of the Great Escarpment, the total floristic diversity probably exceeds 2 000 taxa. It is also postulated that the Great Winterberg–Amatolas probably hosts around 2% endemism (up from 1.5%) and that its closest floristic links are with the DAC (as already strongly supported by the floristic analyses in this study). Similarly the Stormberg – for which very little is currently known floristically – a systematic research effort is warranted. It is postulated that the Stormberg has a flora comparable to the Great Winterberg–Amatolas and also exceeds 2 000 taxa. Local endemism is known to be high, and probably accounts for at least 2% of the flora. Key factors that will cause a high floristic tally in the Stormberg are: (1) It covers a total surface area between that of the Great Winterberg–Amatolas and Sneeuberg; (2) It is a very dissected mountain complex incorporating many smaller mountain ranges (e.g. the Bamboesberge and the Suurberg) and many high-altitude (2 000 m+) isolated peaks formed by dolerite ring structures and linear dykes occur; (3) a climatic gradient exists from both south to north and from east to west; (4) there is an altitudinal variation of 1.2 km (ca. 1 000 m on the plains to 2 207 m at the highest point); (5) and its geomorphological continuity with the Main Drakensberg Escarpment (as defined in Chapter 1 and of which it is the western limit). Detailed floristic research on the Great Winterberg–Amatolas and Stormberg will contribute substantially to the knowledge of the distribution of endemics, delimitation of centres of endemism, and floristic analyses of the southern Great Escarpment. Once this additional floristic data is available, comprehensive GIS-based models of species responses to proposed climate scenarios can be modelled, and potential corridors for migration recognised and incorporated into local, regional and national conservation plans.

Appendix 6.1: Floristic data.

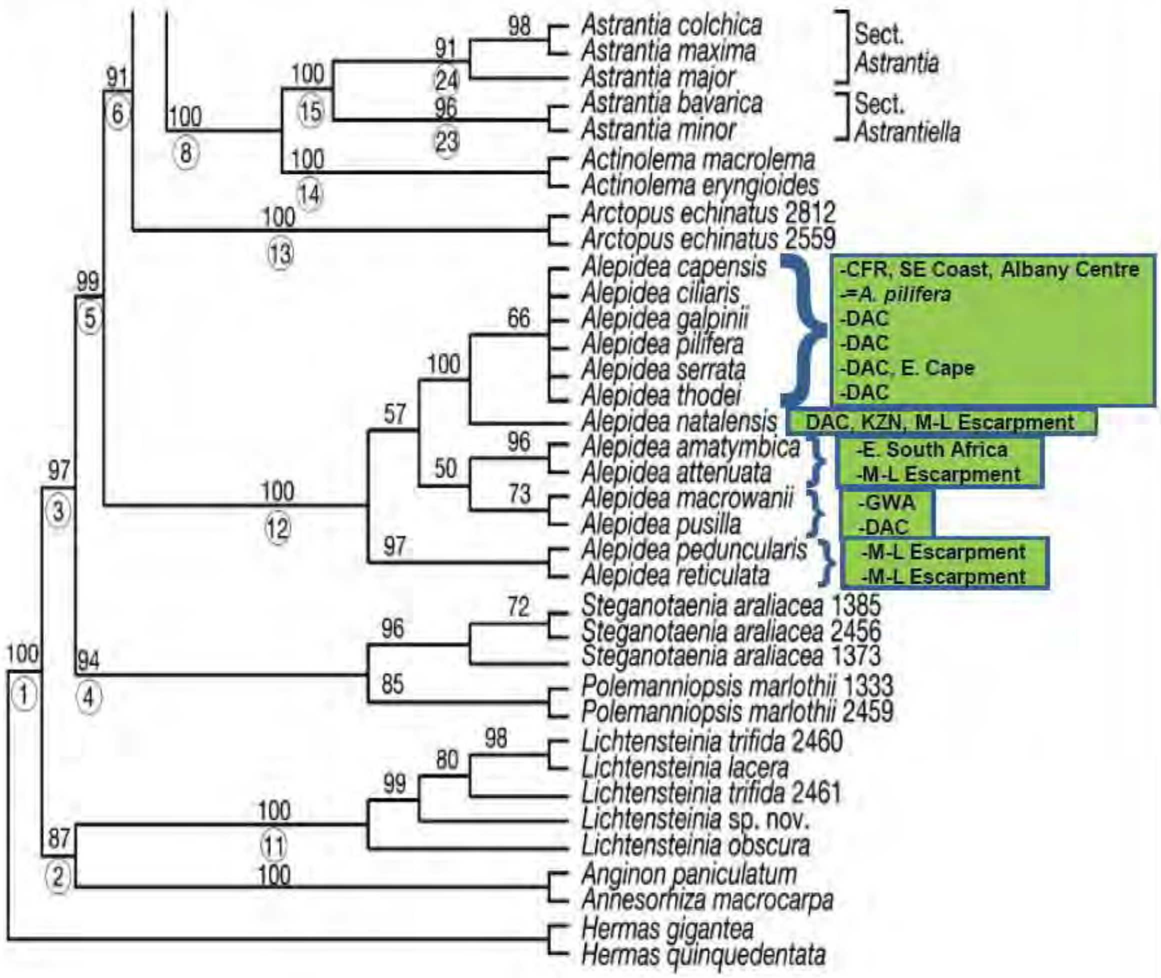
Appendix 6.2: Phylogenies. Order is as per Table 6.3.

Abbreviations:

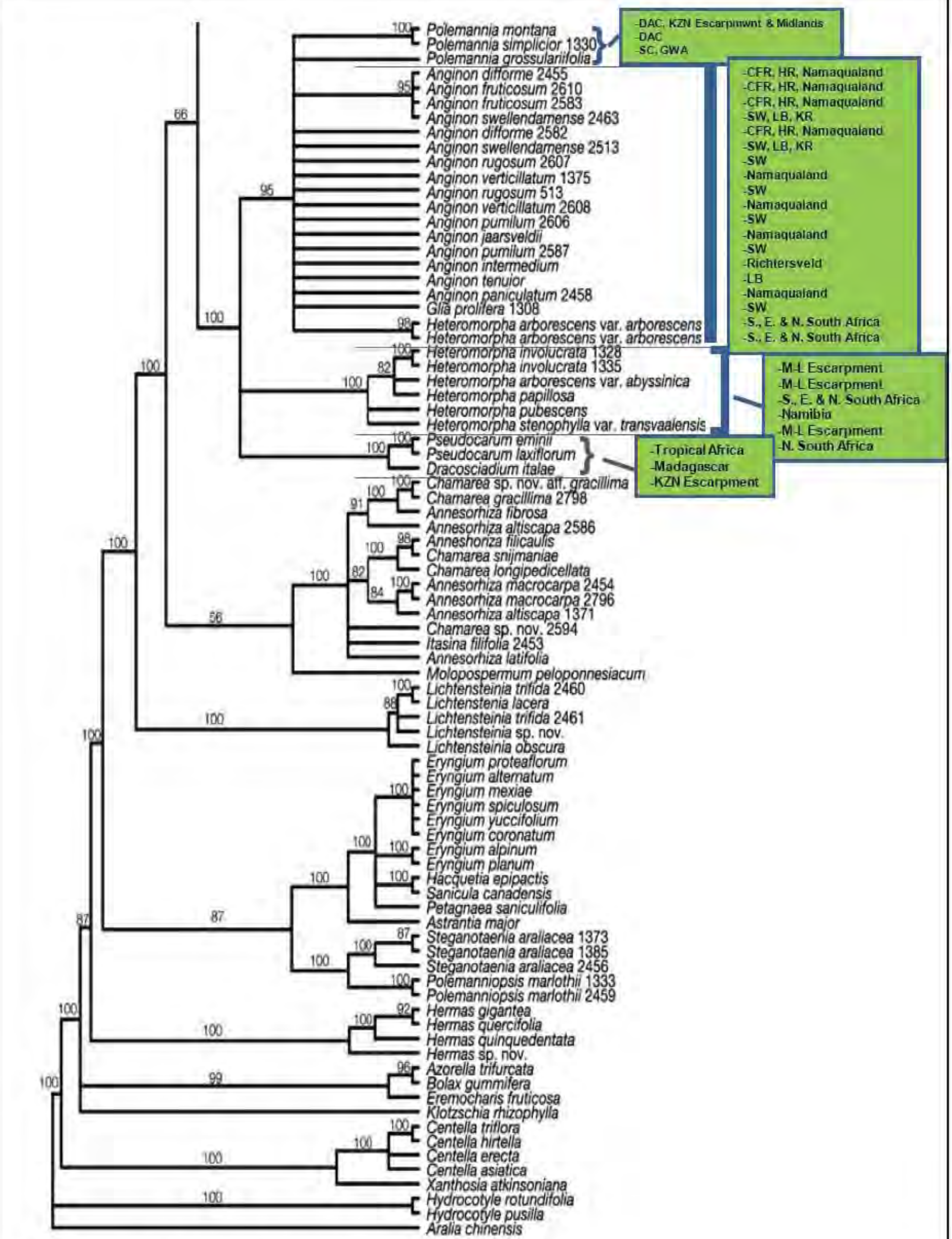
Cape Floristic Region (from west to east geographically):
SW = South-West Centre
NW = North-West Centre
LB = Langeberg Centre
KM = Karoo Mountain Centre
KR = Knysna Region
SE = South-East Centre
KB = Kamiesberg Centre (also part of the Great Escarpment)

Great Escarpment (from west to east geographically):
H–R = Hantam–Roggeveldberge
N = Nuweveldberge
SC = Sneeuberg Centre
GWA = Great Winterberg–Amatolas
ST = Stormberg
DAC = Drakensberg Alpine Centre
M–L = Mpumalanga–Limpopo Escarpment

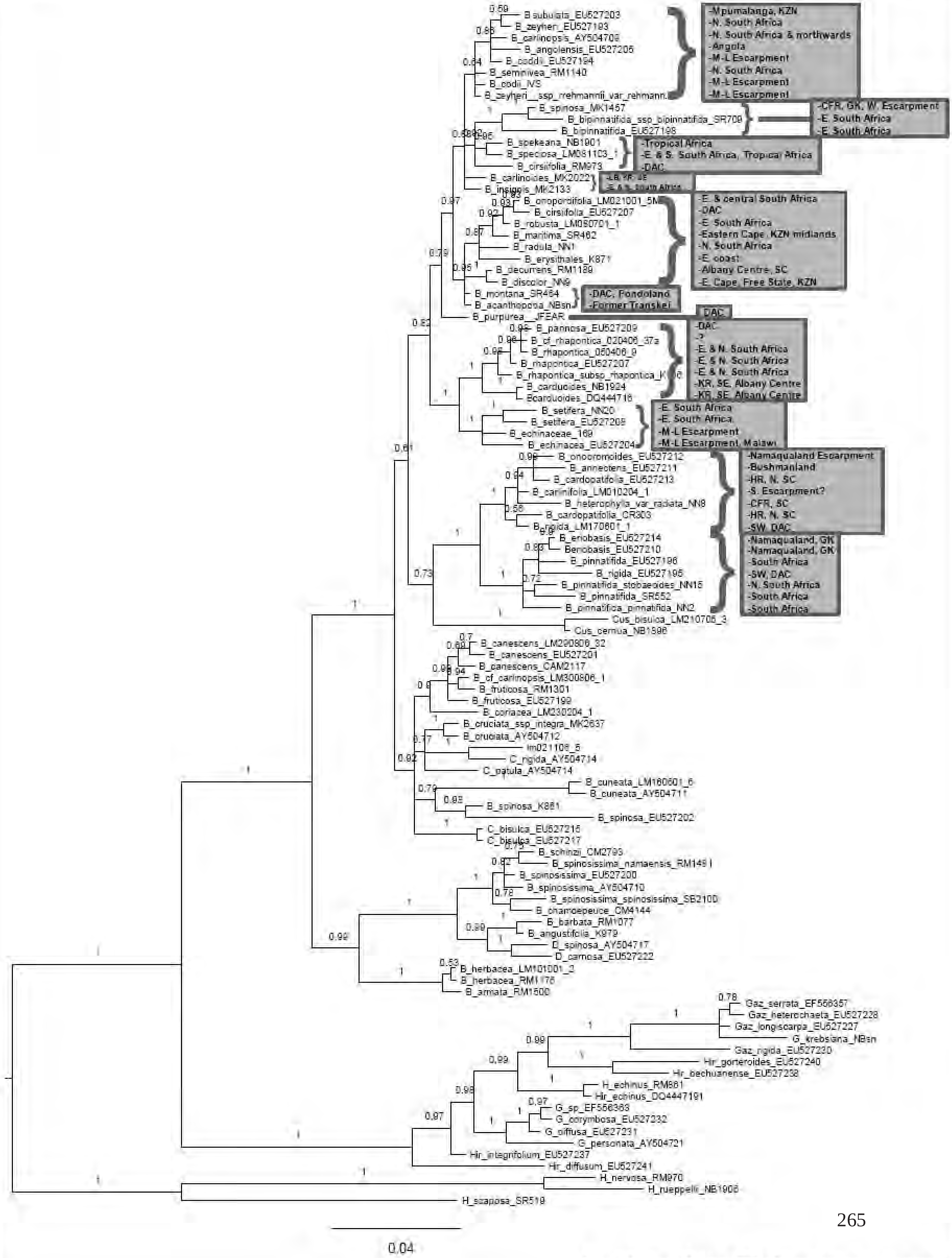
Other abbreviations:
CFR = Cape Floristic Region
E. = Eastern
Esc. = Escarpment (where abbreviated)
GK = Great Karoo
KZN = KwaZulu–Natal
Midl. = Midlands (where abbreviated)
Mnts = Mountains
Moz. = Mozambique (where abbreviated)
N. = Northern
Nam. = Namibia
Namaq. = Namaqualand (where abbreviated)
NW Province = North-West Province (South Africa)
Pond. = Pondolond (E. Cape) (where abbreviated)
W. = Western
S. = Southern
S.A. = South Africa (where abbreviated) (Note: South Africa is here used generically to include Lesotho and Swaziland and to avoid confusion with southern Africa).
Zim. = Zimbabwe (where abbreviated)



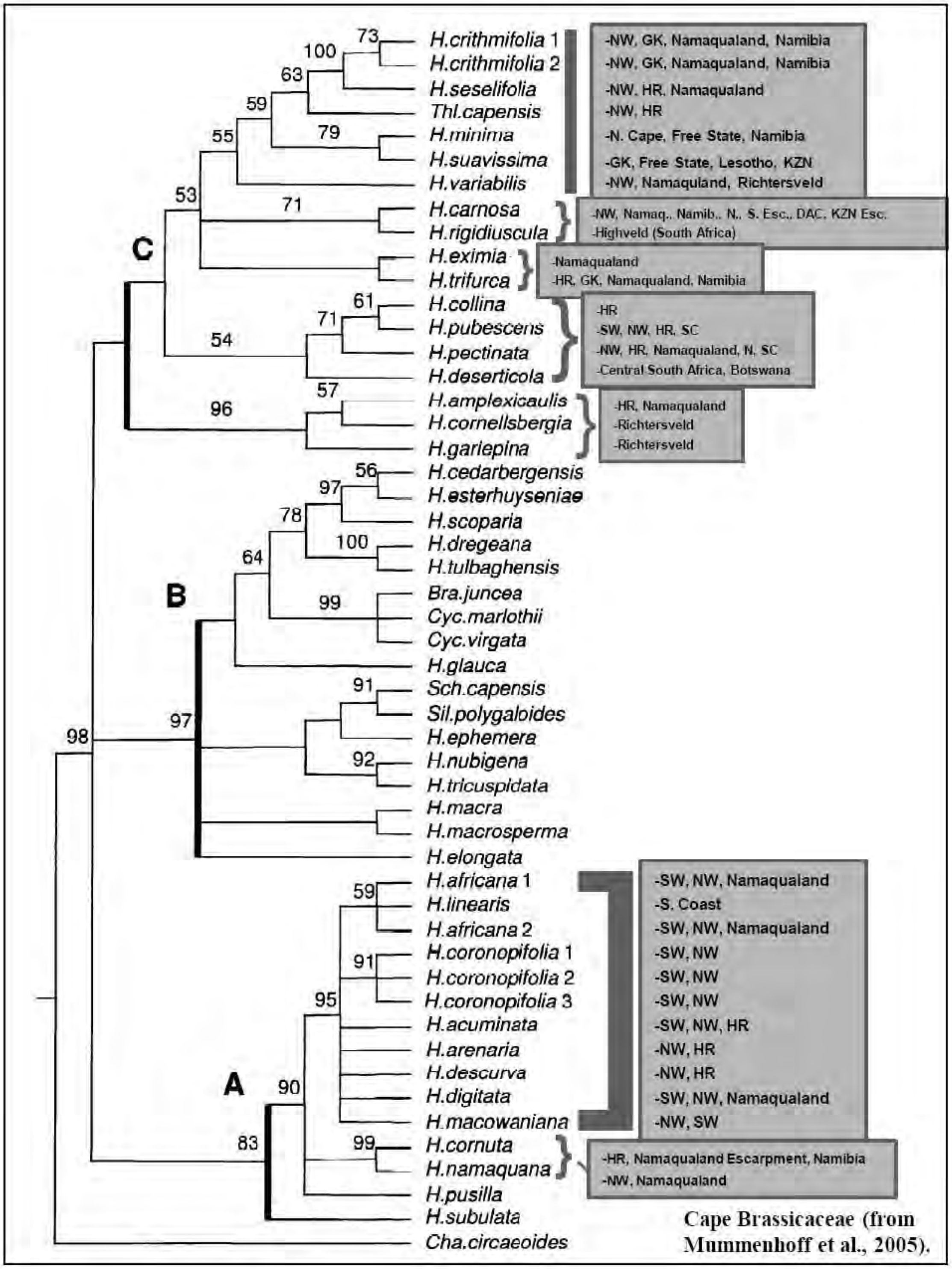
Alepidea **(from Calviño & Downie, 2007)**



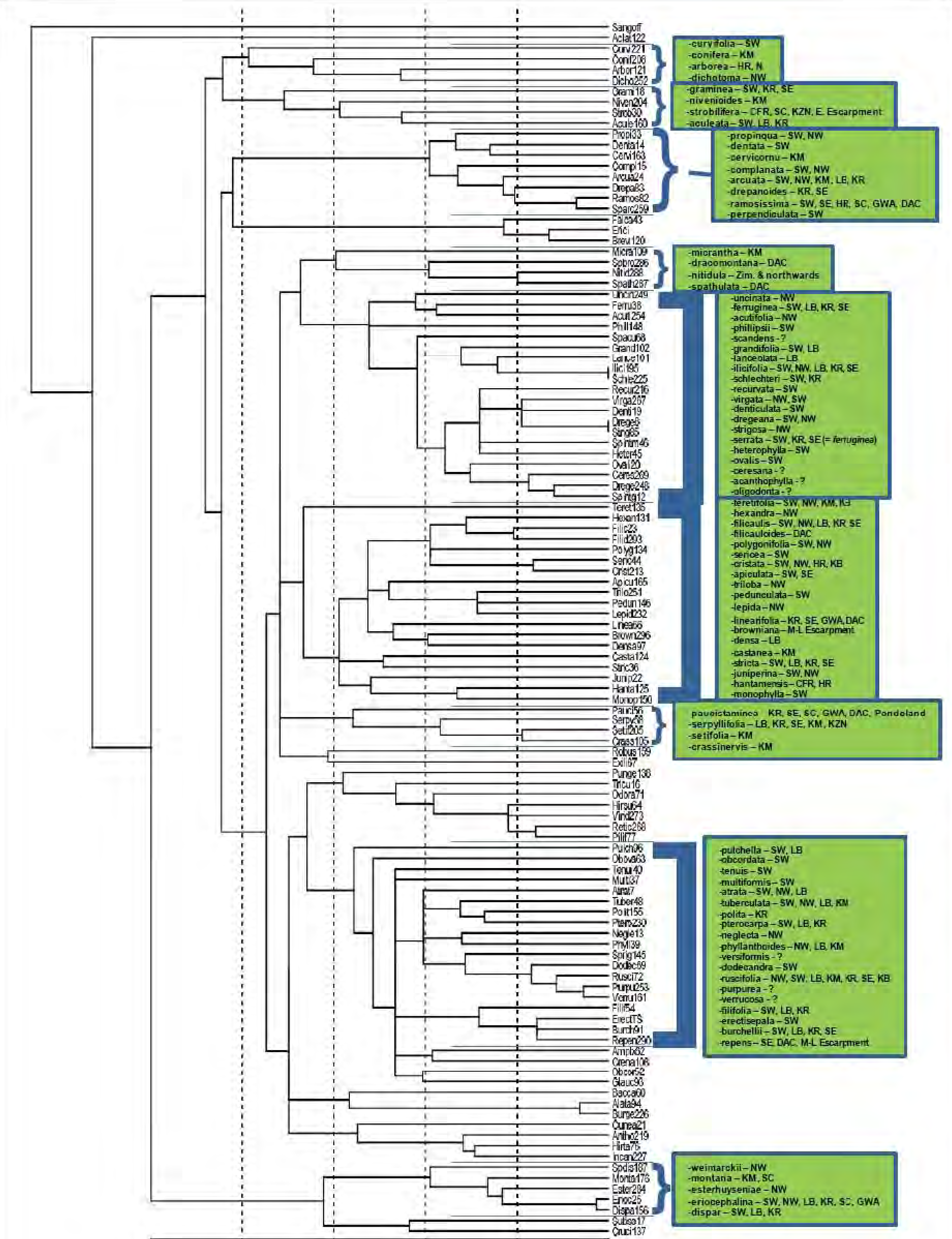
Various southern African Apiaceae (from Calviño et al., 2006).



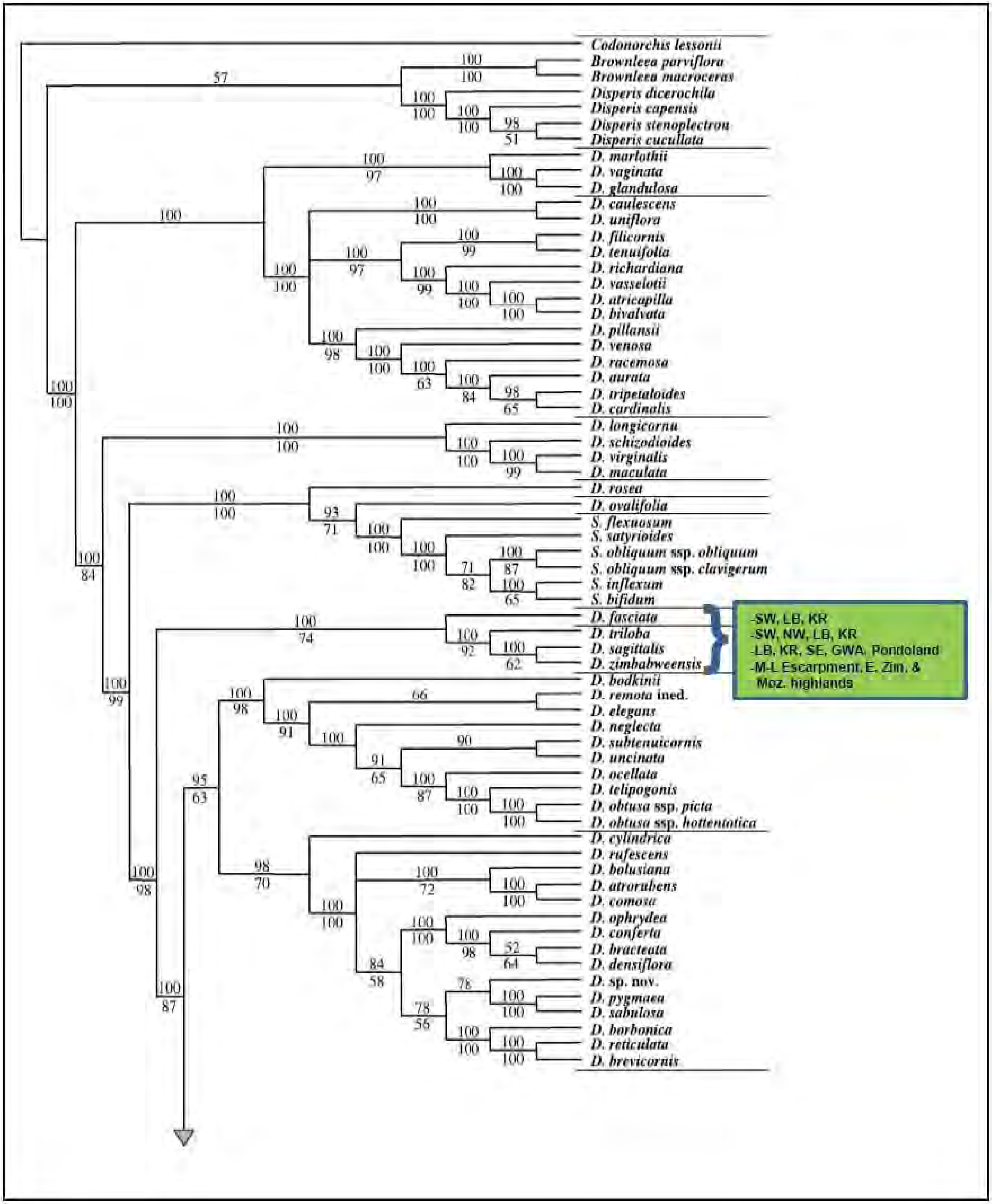
Berkheya (from Phaliso, pers. comm.).

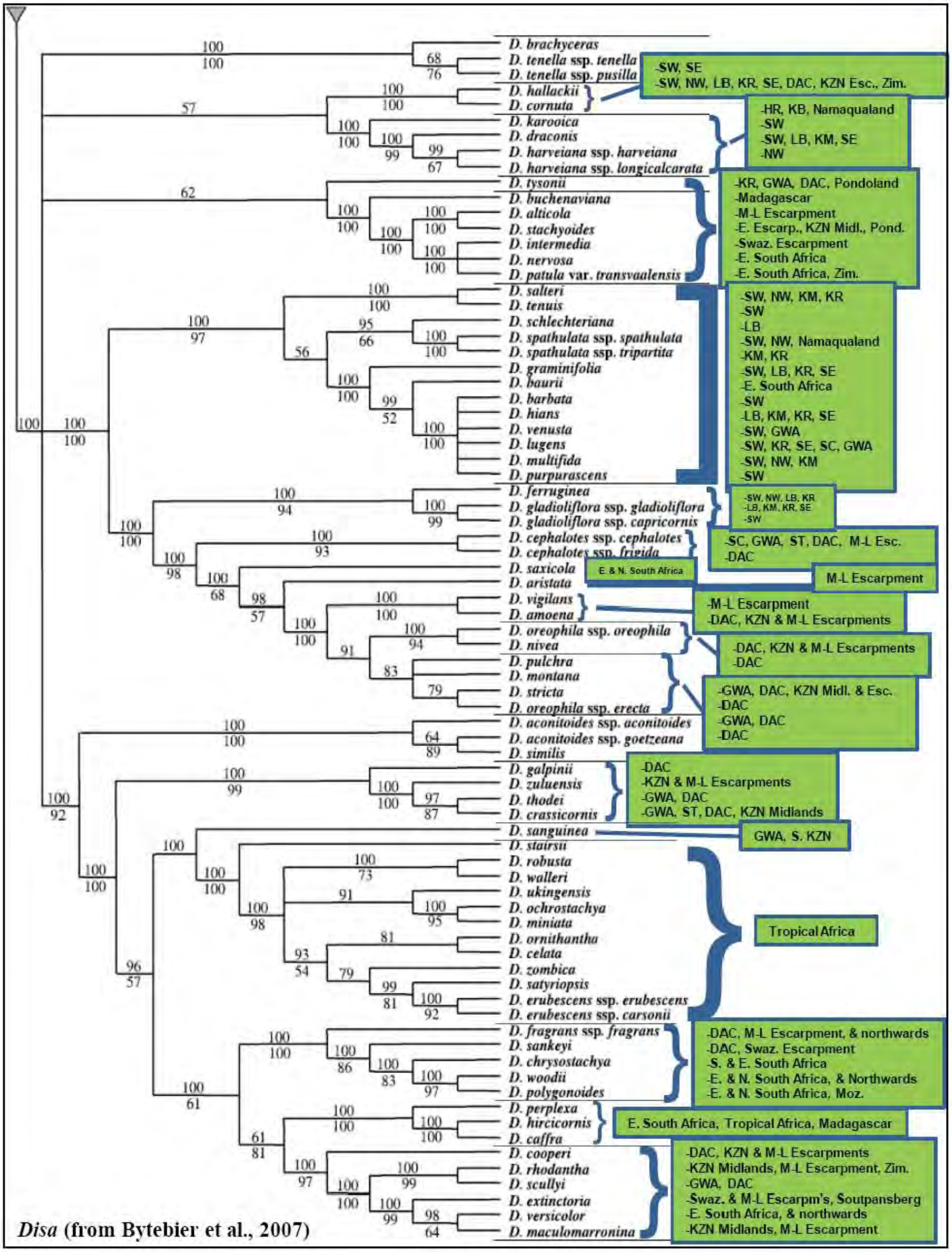


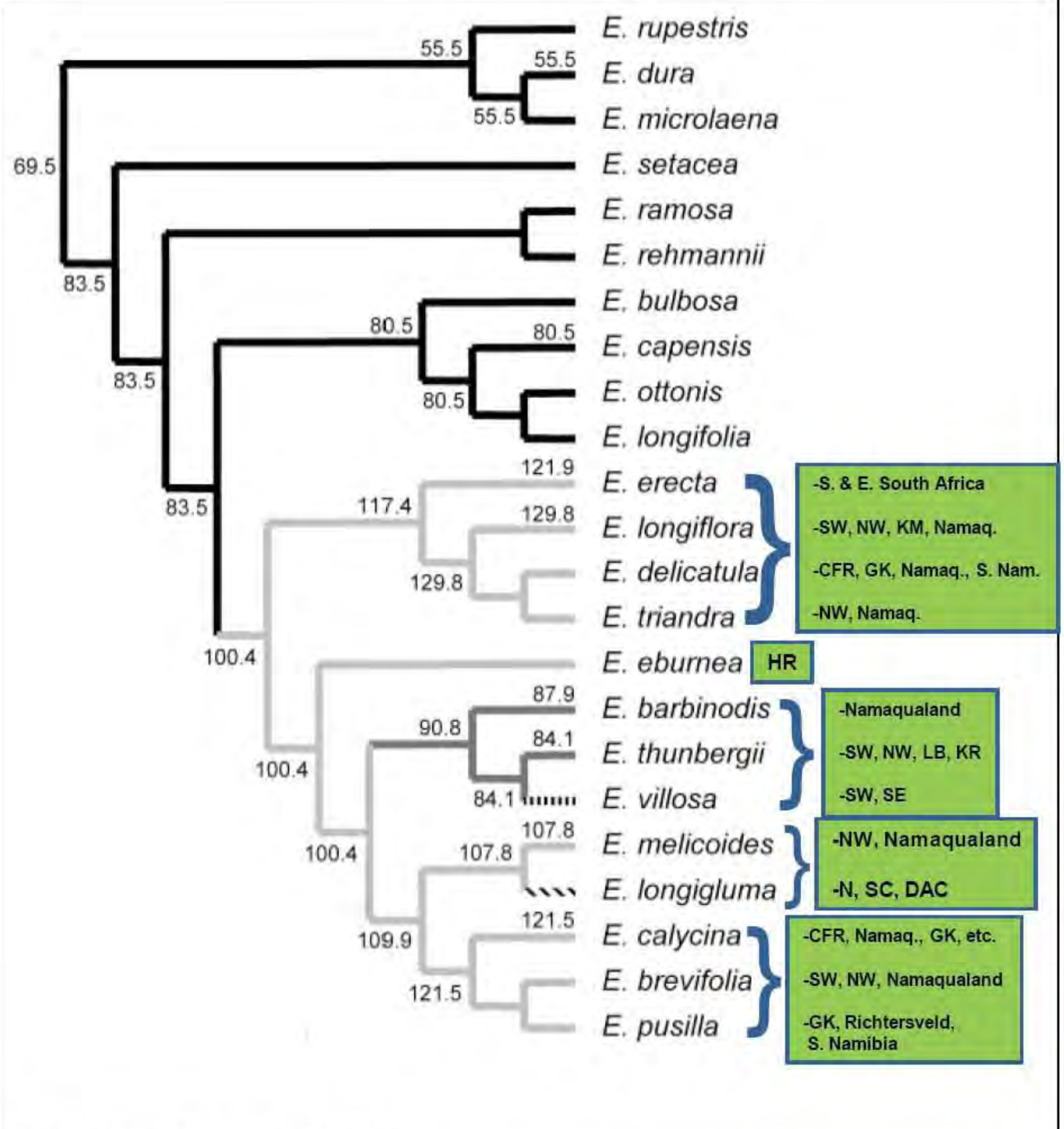
Cape Brassicaceae (from Mummenhoff et al., 2005).



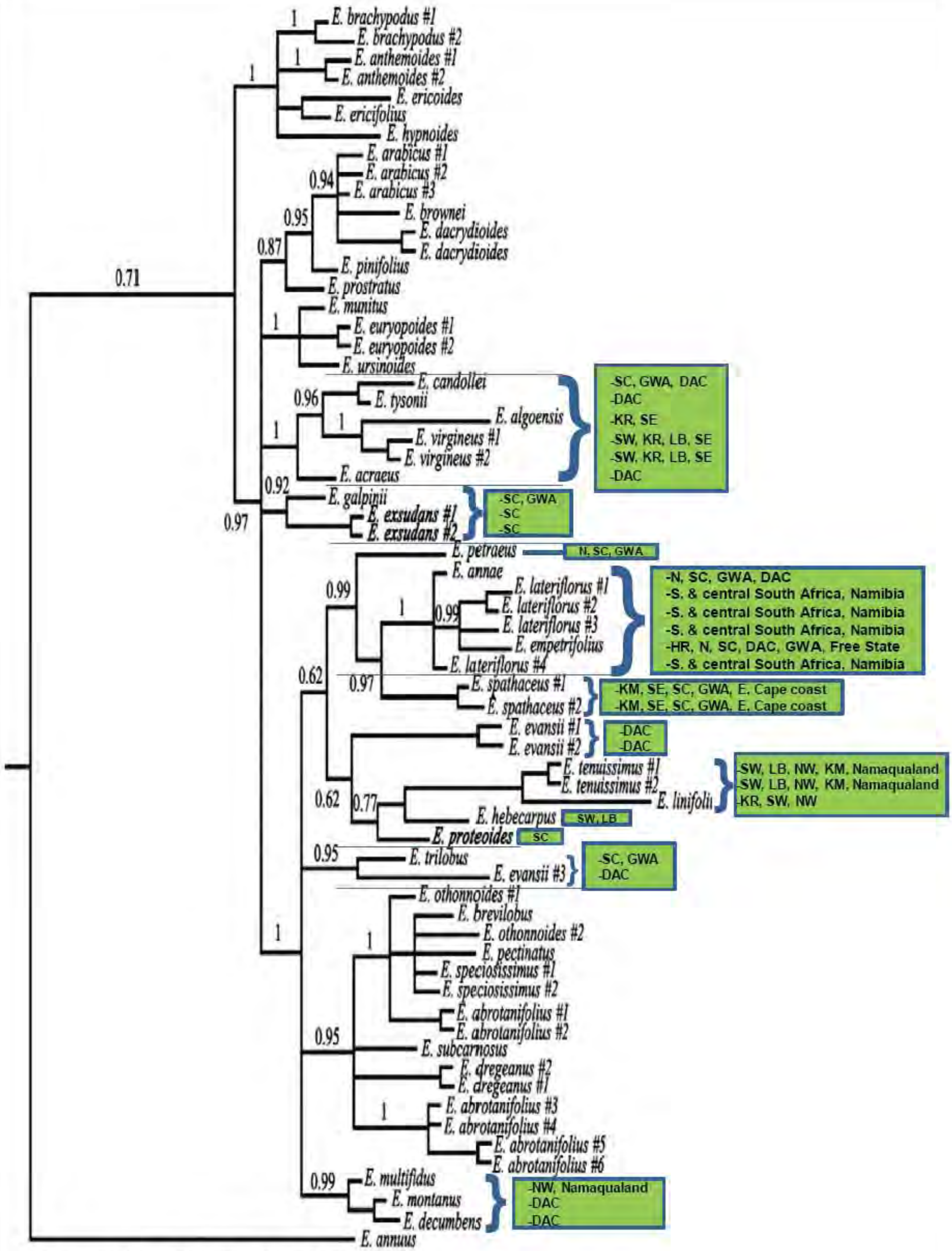
Cliffortia **(from Whitehouse, 2002).**


Codonorchis lessonii
Brownleea parviflora
Brownleea macroceras
Disperis dicerochila
Disperis capensis
Disperis stenoplectron
Disperis cucullata
D. marlothii
D. vaginata
D. glandulosa
D. caulescens
D. uniflora
D. filicornis
D. tenuifolia
D. richardiana
D. vasselotii
D. atricapilla
D. bivalvata
D. pillansii
D. venosa
D. racemosa
D. aurata
D. tripetaloides
D. cardinalis
D. longicornu
D. schizodioides
D. virginalis
D. maculata
D. rosea
D. ovalifolia
S. flexuosum
S. satyrioides
S. obliquum ssp. obliquum
S. obliquum ssp. clavigerum
S. inflexum
S. bifidum
D. fasciata
D. triloba
D. sagittalis
D. zimbabweensis
D. bodkinii
D. remota ined.
D. elegans
D. neglecta
D. subtenuicornis
D. uncinata
D. ocellata
D. telipogonis
D. obtusa ssp. picta
D. obtusa ssp. hottentotica
D. cylindrica
D. rufescens
D. bolusiana
D. atrorubens
D. comosa
D. ophrydea
D. conferta
D. bracteata
D. densiflora
D. sp. nov.
D. pygmaea
D. sabulosa
D. borbonica
D. reticulata
D. brevicornis
-SW, LB, KR
-SW, NW, LB, KR
-LB, KR, SE, GWA, Pondoland
-M-L Escarpment, E. Zin, &
Moz. highlands

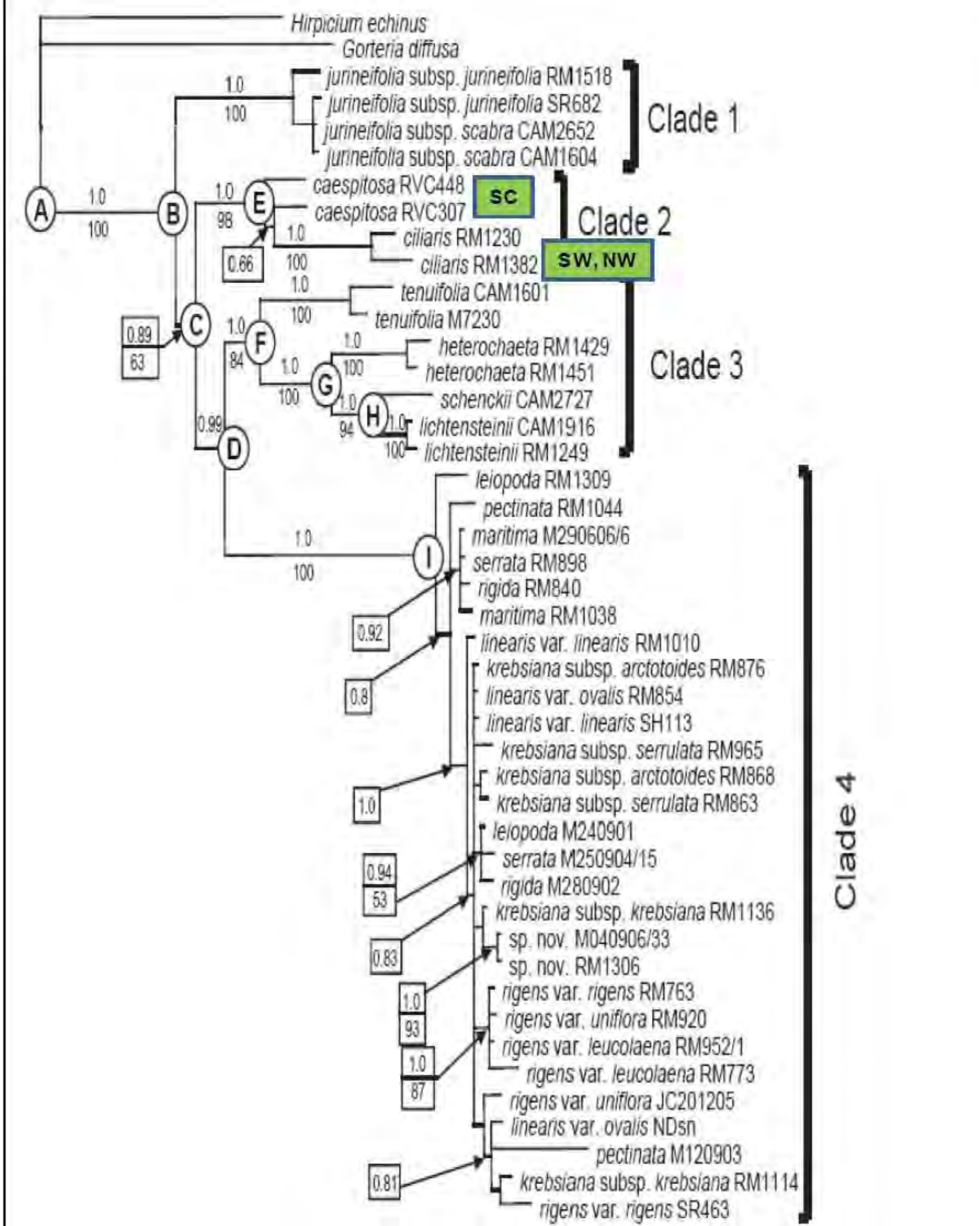

D. brachyceras
D. tenella ssp. tenella
D. tenella ssp. pusilla
-SW, SE
-SW, NW, LB, KR, SE, DAC, KZN Esc., Zim.
D. hallackii
D. cornuta
D. karooica
D. draconis
D. harveiana ssp. harveiana
D. harveiana ssp. longicalcarata
-HR, KB, Namaqualand
-SW
-SW, LB, KM, SE
-NW
D. tysonii
D. buchenaviana
D. alticola
D. stachyoides
D. intermedia
D. nervosa
D. patula var. transvaalensis
-KR, GWA, DAC, Pondoland
-Madagascar
-M-L Escarpment
-E. Escarp., KZN Midl., Pond.
-Swaz. Escarpment
-E. South Africa
-E. South Africa, Zim.
D. salteri
D. tenuis
D. schlechteriana
D. spathulata ssp. spathulata
D. spathulata ssp. tripartita
D. graminifolia
D. baurii
D. barbata
D. hians
D. venusta
D. lugens
D. multifida
D. purpurascens
-SW, NW, KM, KR
-SW
-LB
-SW, NW, Namaqualand
-KM, KR
-SW, LB, KR, SE
-E. South Africa
-SW
-LB, KM, KR, SE
-SW, GWA
-SW, KR, SE, SC, GWA
-SW, NW, KM
-SW
D. ferruginea
D. gladioliflora ssp. gladioliflora
D. gladioliflora ssp. capricornis
-SW, NW, LB, KR
-LB, KM, KR, SE
-SW
D. cephalotes ssp. cephalotes
D. cephalotes ssp. frigida
-SC, GWA, ST, DAC, M-L Esc.
-DAC
D. saxicola
E. & N. South Africa
D. aristata
M-L Escarpment
D. vigilans
D. amoena
-M-L Escarpment
-DAC, KZN & M-L Escarpments
D. oreophila ssp. oreophila
D. nivea
-DAC, KZN & M-L Escarpments
-DAC
D. pulchra
D. montana
D. stricta
D. oreophila ssp. erecta
-GWA, DAC, KZN Midl. & Esc.
-DAC
-GWA, DAC
-DAC
D. aconitoides ssp. aconitoides
D. aconitoides ssp. goetzeana
D. similis
D. galpinii
D. zuluensis
D. thodei
D. crassicornis
-DAC
-KZN & M-L Escarpments
-GWA, DAC
-GWA, ST, DAC, KZN Midlands
D. sanguinea
GWA, S. KZN
D. stairsii
D. robusta
D. walleri
D. ukingensis
D. ochrostachya
D. miniata
D. ornithantha
D. celata
D. zombica
D. satyriopsis
D. erubescens ssp. erubescens
D. erubescens ssp. carsonii
Tropical Africa
D. fragrans ssp. fragrans
D. sankeyi
D. chrysostachya
D. woodii
D. polygonoides
-DAC, M-L Escarpment, & northwards
-DAC, Swaz. Escarpment
-S. & E. South Africa
-E. & N. South Africa, & Northwards
-E. & N. South Africa, Moz.
D. perplexa
D. hircicornis
D. caffra
E. South Africa, Tropical Africa, Madagascar
D. cooperi
D. rhodantha
D. scullyi
D. extinctoria
D. versicolor
D. maculomarronina
-DAC, KZN & M-L Escarpments
-KZN Midlands, M-L Escarpment, Zim.
-GWA, DAC
-Swaz. & M-L Escarpm's, Soutpansberg
-E. South Africa, & northwards
-KZN Midlands, M-L Escarpment
Disa (from Bytebier et al., 2007)



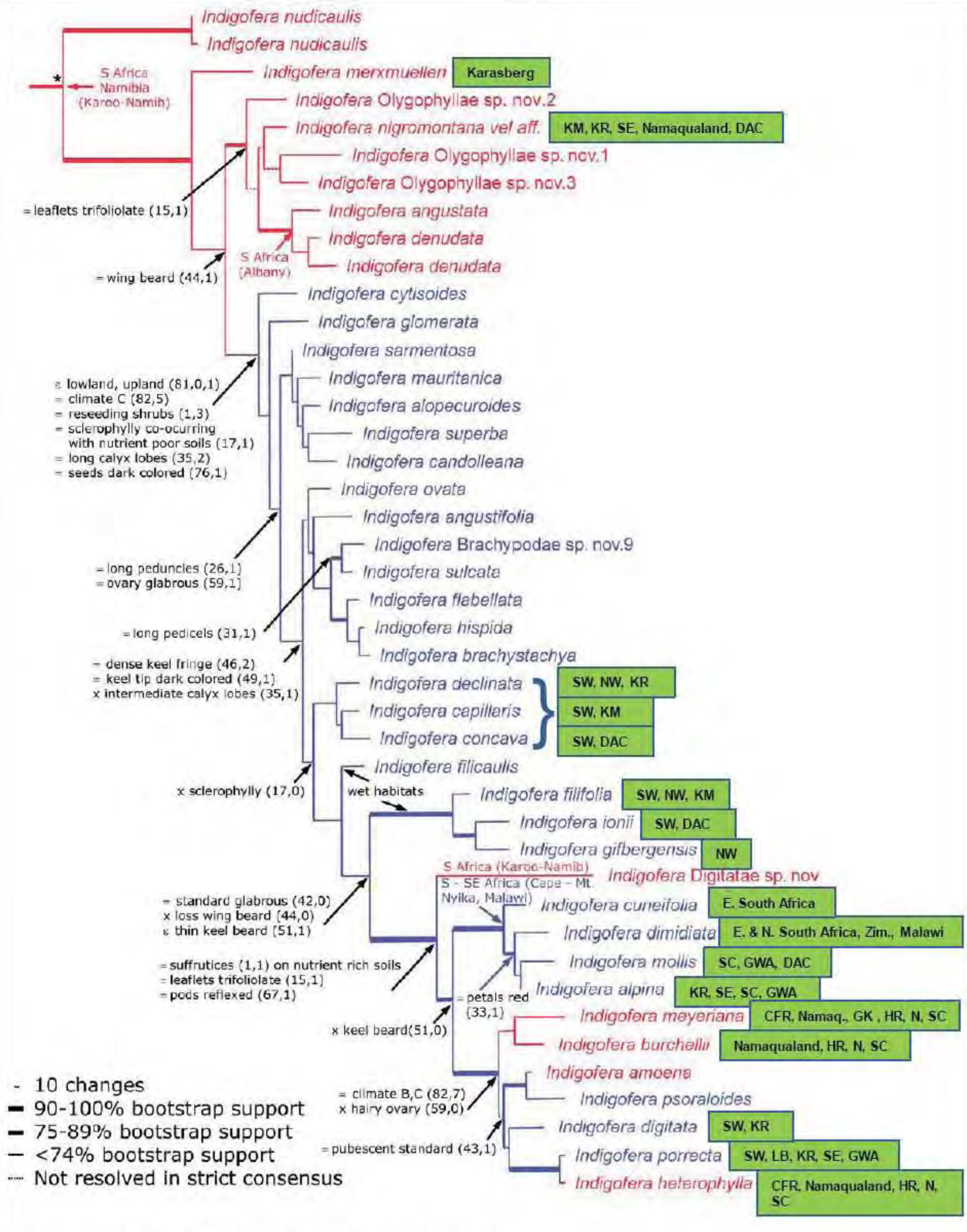
Ehrharta **(from Verboom et al., 2004)**



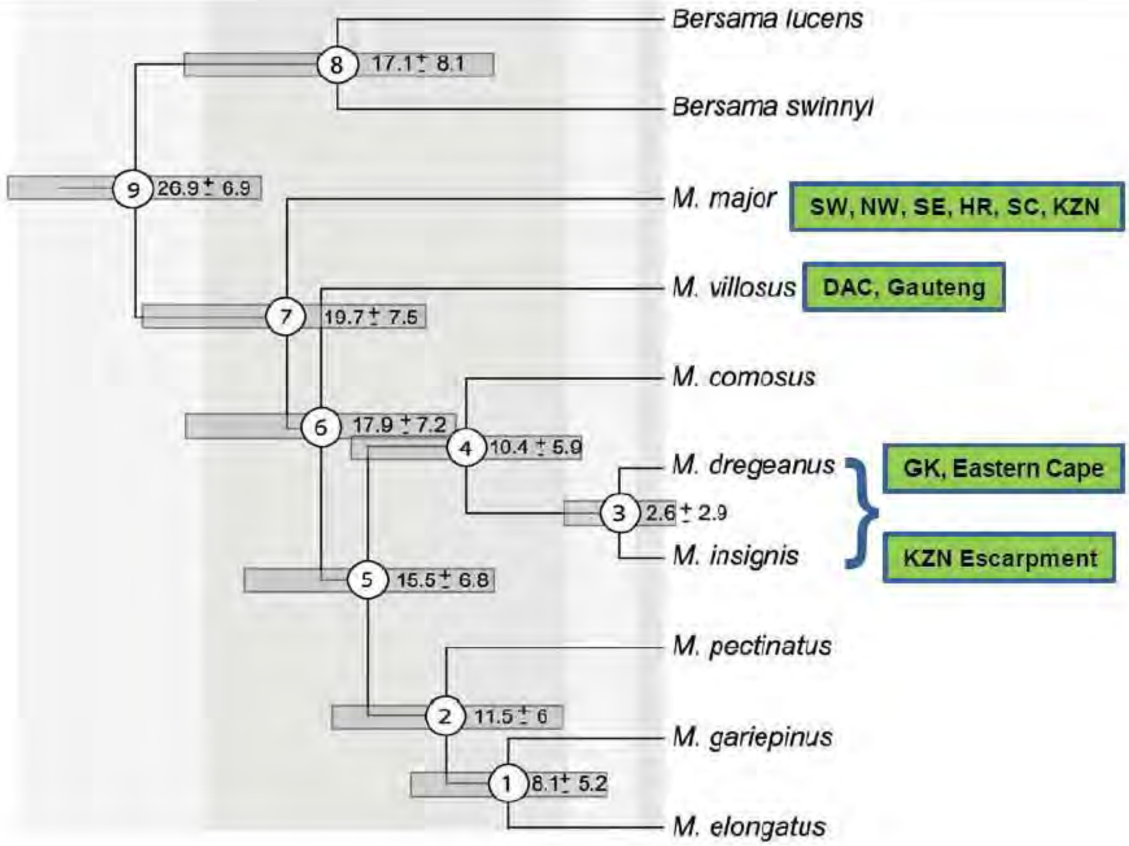
***Euryops* (from Nordenstam et al., 2009).**



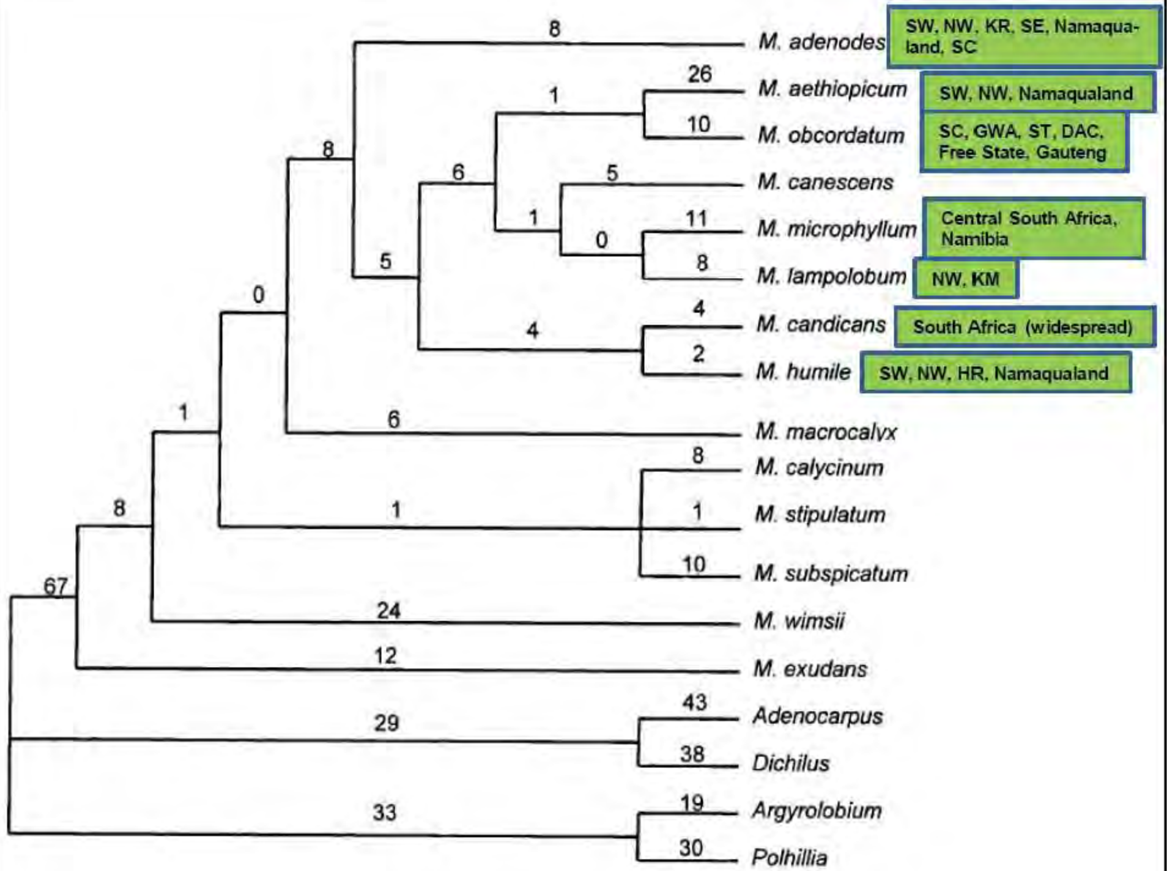
***Gazania* (from Howis et al., 2009).**



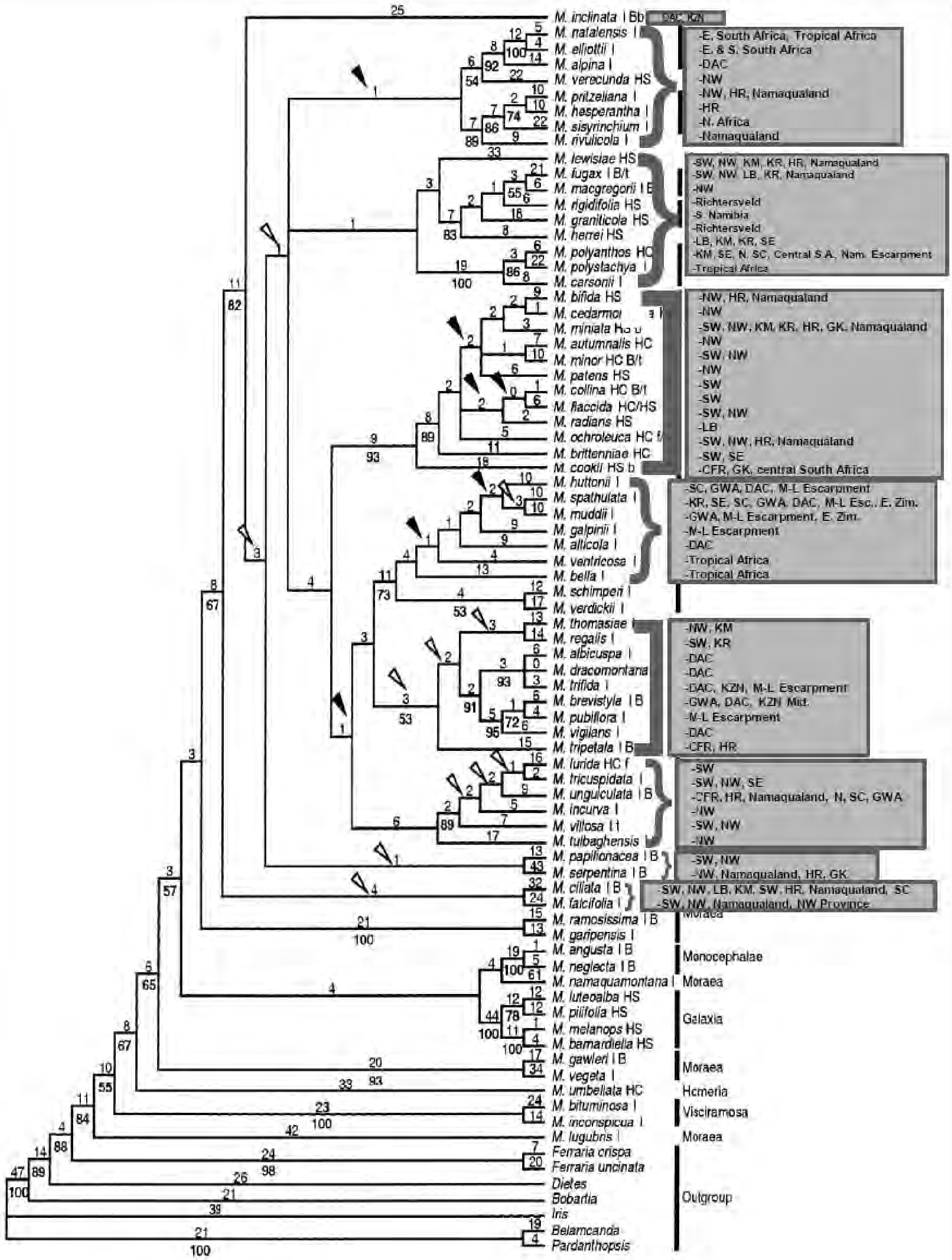
Indigofera , Cape Clade (from Schrire et al., 2009).



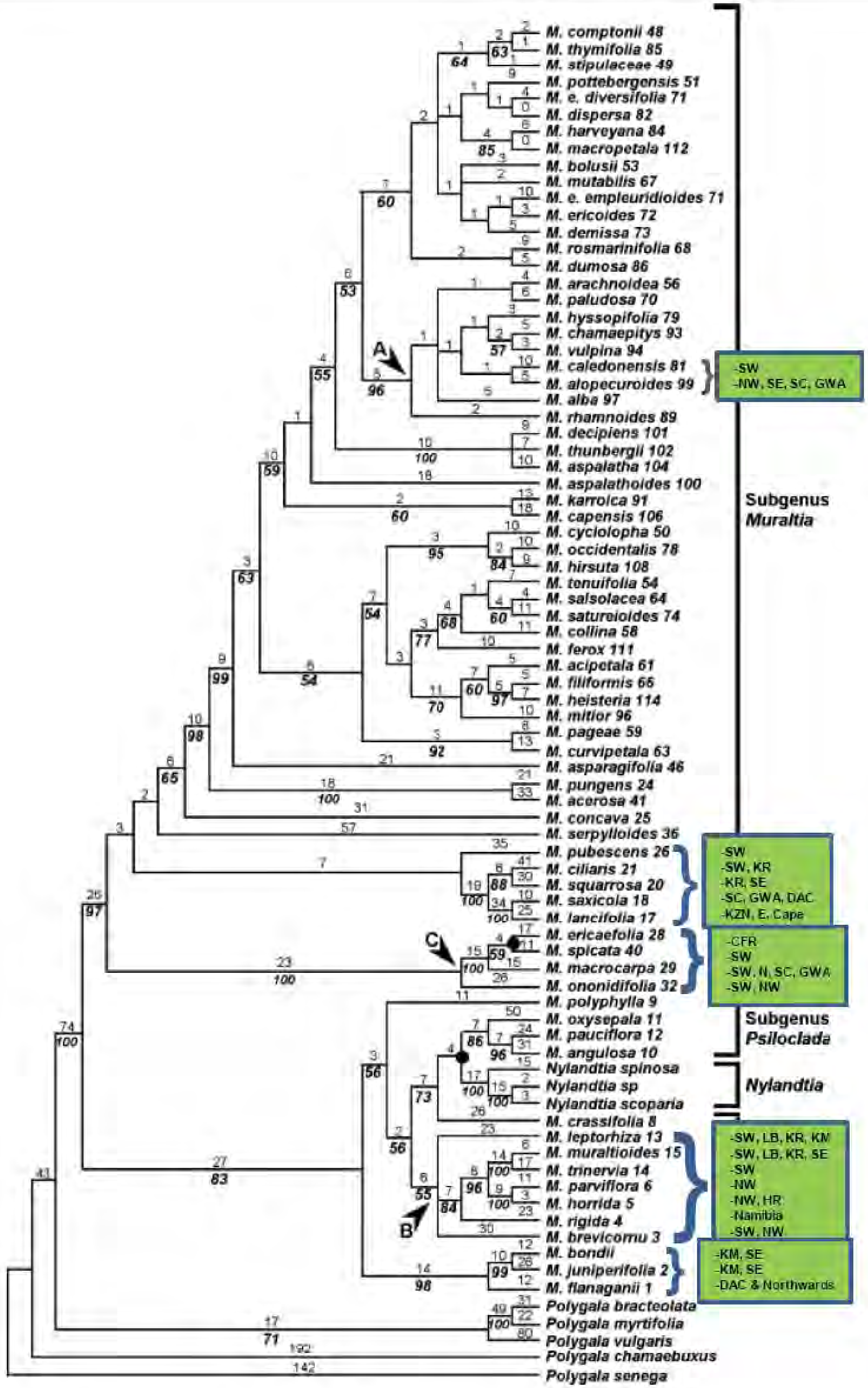
Melianthus (from Linder et al., 2006).



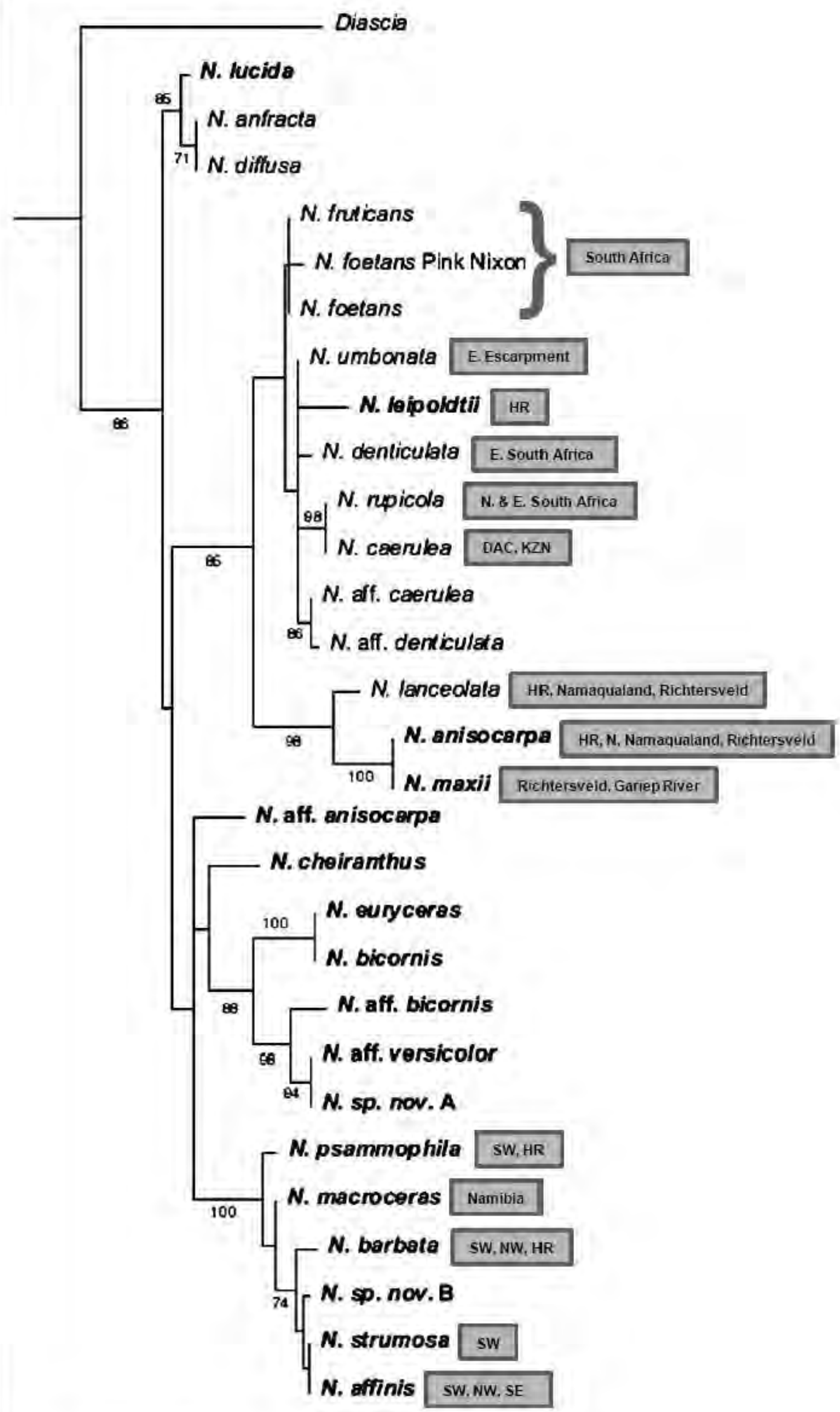
Melolobium **(from Moteetee & van Wyk, 2006).**



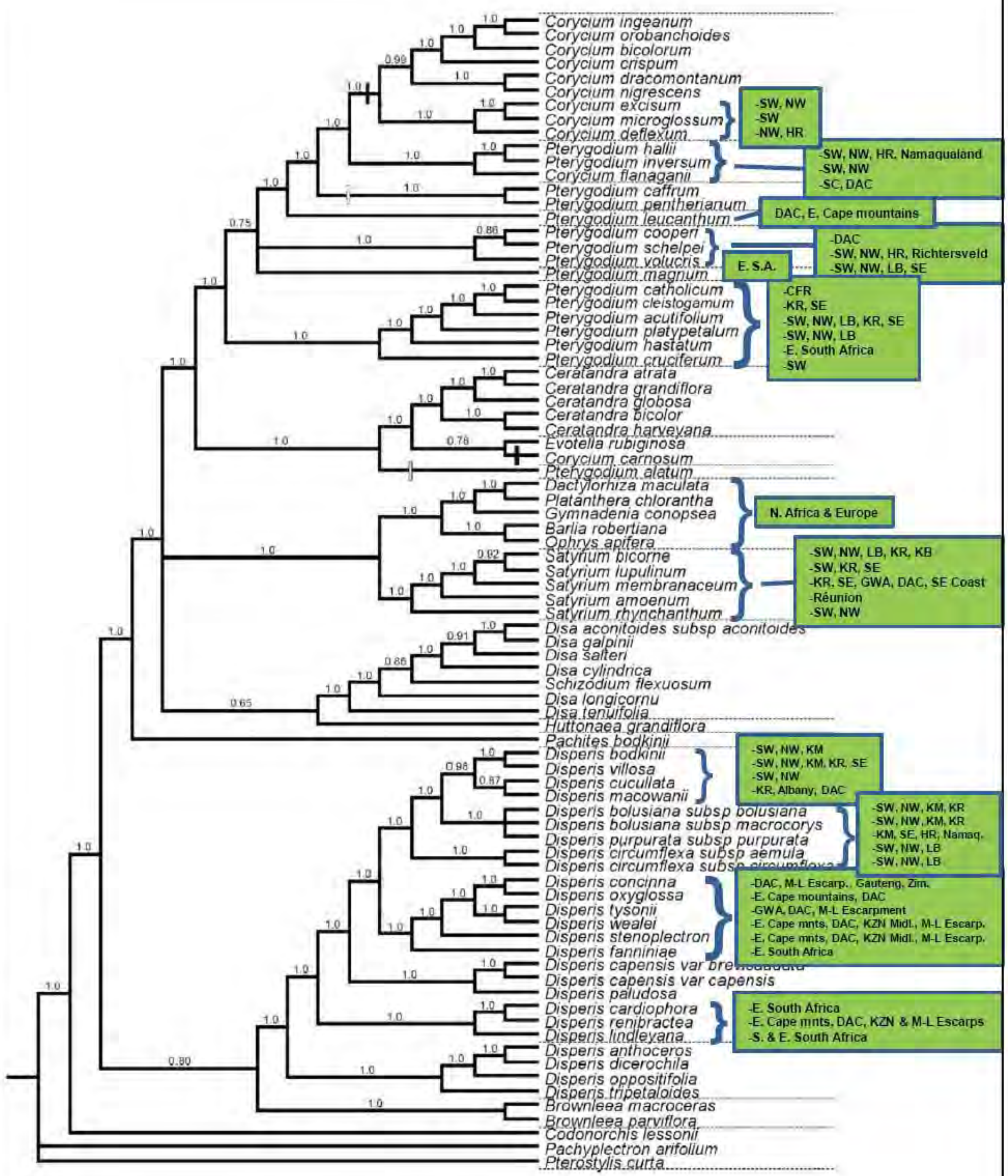
Moraea **(from Goldblatt et al., 2002).**



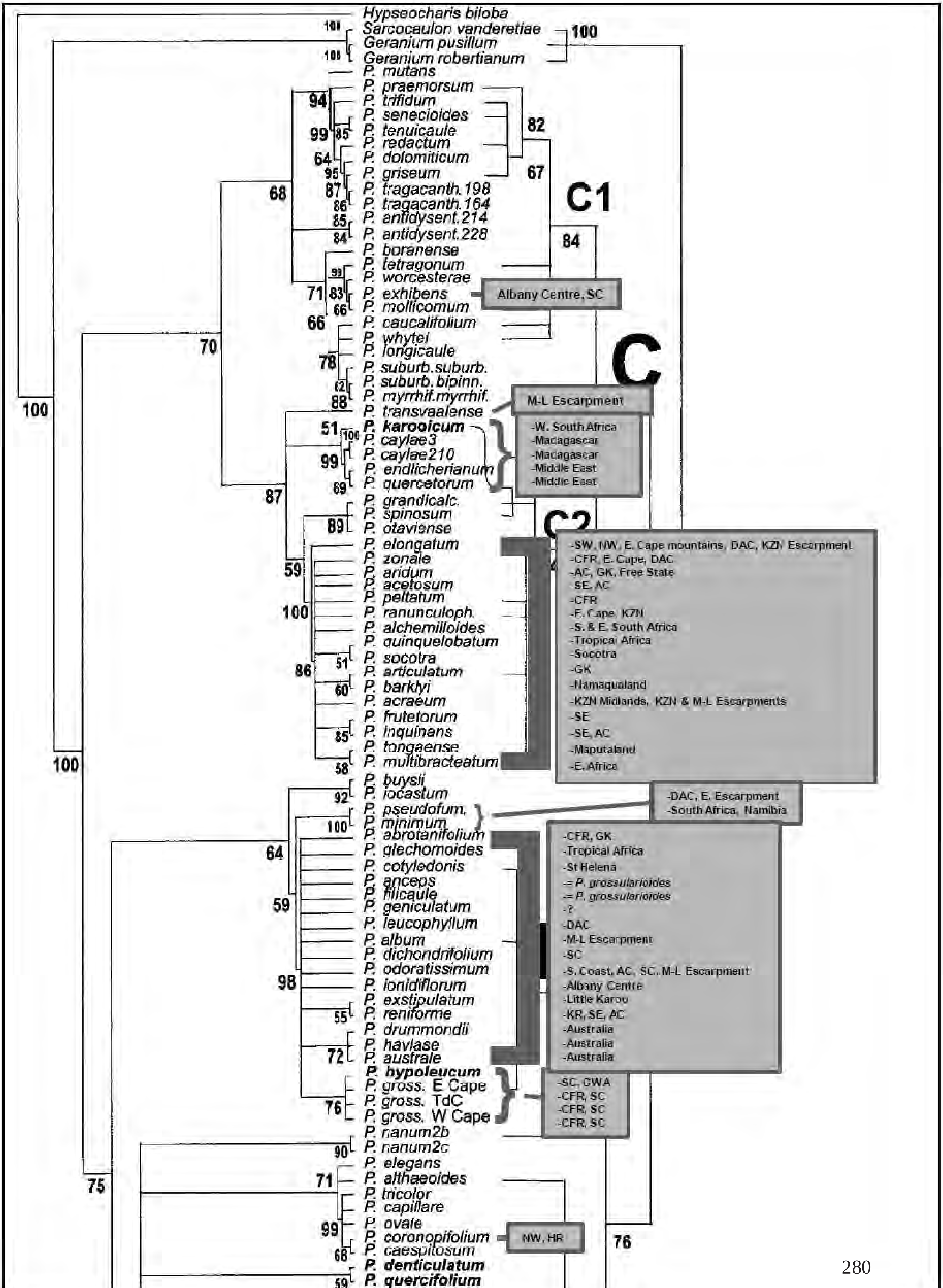
Muraltia (from Forest et al., 2007).

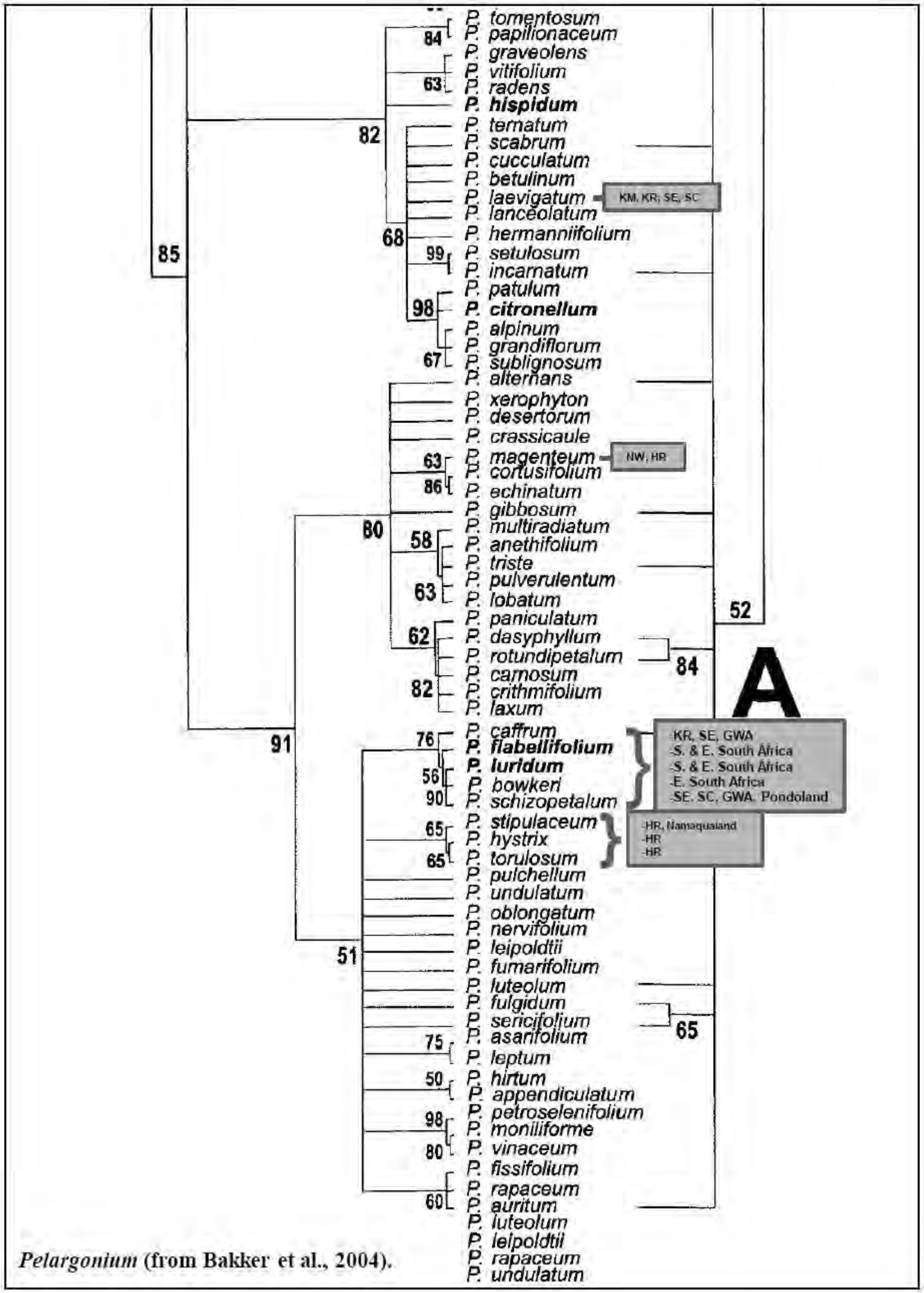


Nemesia **(from Datson et al., 2008).**

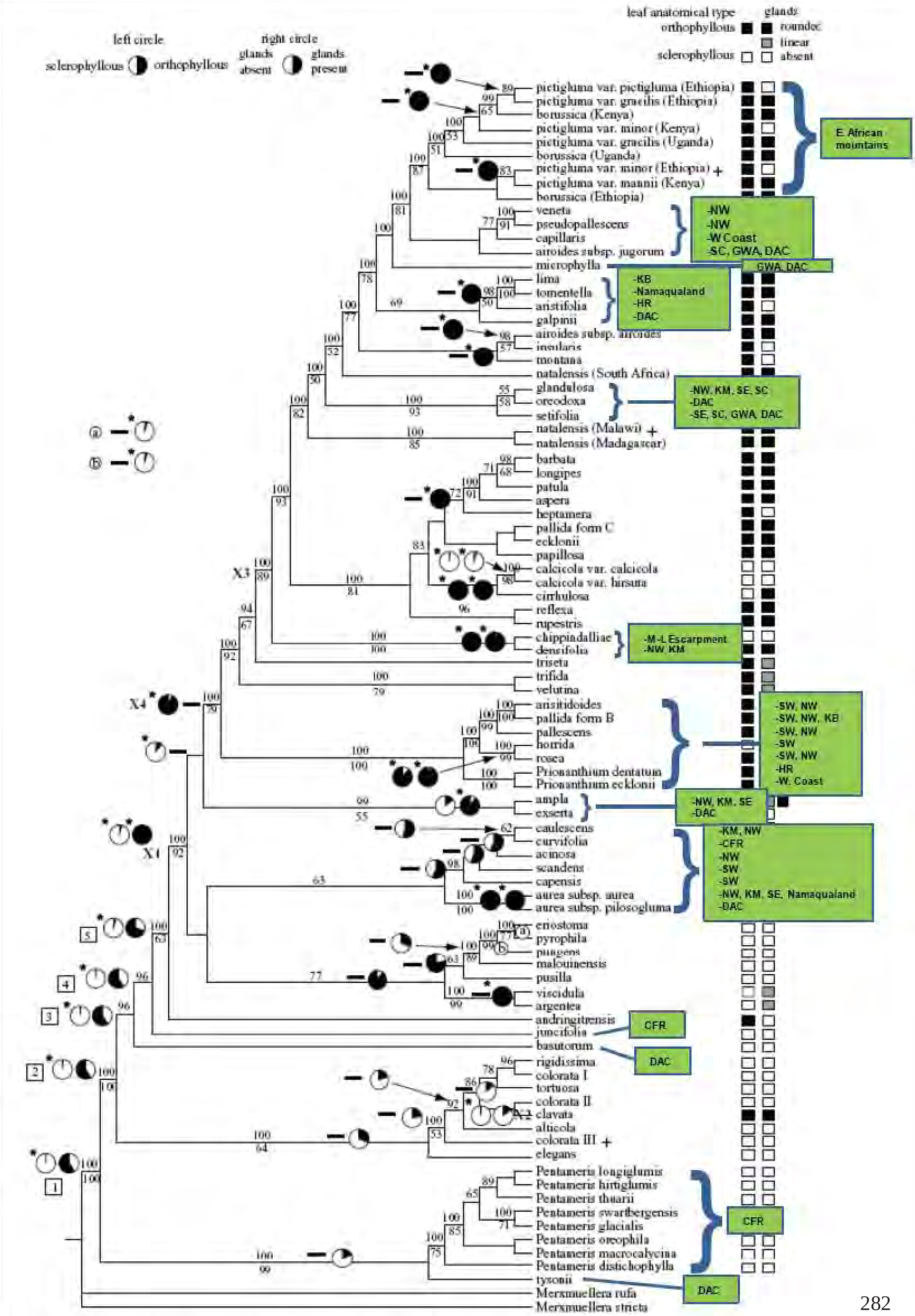


Subfamily Coryciinae, Orchidaceae (from Waterman et al., 2009)

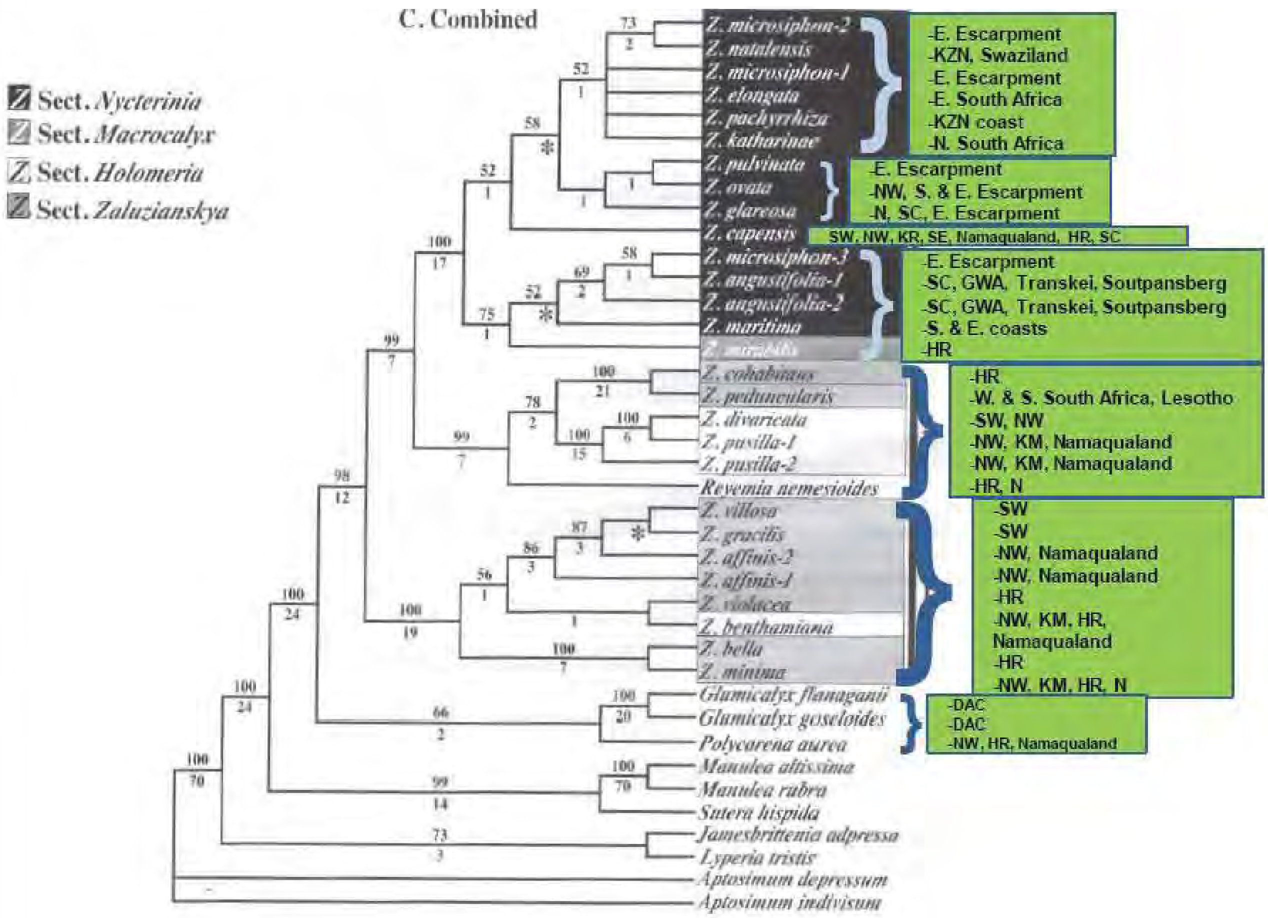

Hypseocharis biloba
Sarcocaulon vanderetiae
Geranium pusillum
Geranium robertianum
P. mutans
P. praemorsum
P. trifidum
P. senecioides
P. tenuicaule
P. redactum
P. dolomiticum
P. griseum
P. tragacanth.198
P. tragacanth.164
P. antidysent.214
P. antidysent.228
P. boranense
P. tetragonum
P. worcesterae
P. exhibens
P. mollicomum
P. caucalifolium
P. whytei
P. longicaule
P. suburb.suburb.
P. suburb.bipinn.
P. myrrhif.myrrhif.
P. transvaalense
P. karooicum
P. caylae3
P. caylae210
P. endlicherianum
P. quercetorum
P. grandicalc.
P. spinosum
P. otaviense
P. elongatum
P. zonale
P. aridum
P. acetosum
P. peltatum
P. ranunculoph.
P. alchemilloides
P. quinquelobatum
P. socotra
P. articulatum
P. barklyi
P. acraeum
P. frutetorum
P. inquinans
P. tongaense
P. multibracteatum
P. buysii
P. iocastum
P. pseudofum.
P. minimum
P. abrotanifolium
P. glechomoides
P. cotyledonis
P. anceps
P. filicaule
P. geniculatum
P. leucophyllum
P. album
P. dichondrifolium
P. odoratissimum
P. ionidiflorum
P. exstipulatum
P. reniforme
P. drummondii
P. havlase
P. australe
P. hypoleucum
P. gross. E Cape
P. gross. TdC
P. gross. W Cape
P. nanum2b
P. nanum2c
P. elegans
P. althaeoides
P. tricolor
P. capillare
P. ovale
P. coronopifolium
P. caespitosum
P. denticulatum
P. quercifolium
C1
C
C2
Albany Centre, SC
M-L Escarpment
-W. South Africa
-Madagascar
-Madagascar
-Middle East
-Middle East
-SW, NW, E. Cape mountains, DAC, KZN Escarpment
-CFR, E. Cape, DAC
-AC, GK, Free State
-SE, AC
-CFR
-E. Cape, KZN
-S. & E. South Africa
-Tropical Africa
-Socotra
-GK
-Namaqualand
-KZN Midlands, KZN & M-L Escarpments
-SE
-SE, AC
-Maputaland
-E. Africa
-DAC, E. Escarpment
-South Africa, Namibia
-CFR, GK
-Tropical Africa
-St Helena
-= P. grossularioides
-= P. grossularioides
-?
-DAC
-M-L Escarpment
-SC
-S. Coast, AC, SC, M-L Escarpment
-Albany Centre
-Little Karoo
-KR, SE, AC
-Australia
-Australia
-Australia
-SC, GWA
-CFR, SC
-CFR, SC
-CFR, SC
NW, HR



Pelargonium (from Bakker et al., 2004).



Pentaschistis (from Galley & Linder, 2007).



Zaluzianskya (from Archibald et al., 2005).

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Additional Appendices