CHAPTER 3

DIVERSITY AND ENDEMISM IN THE MOSS FLORA OF SOUTHERN AFRICA

Chapter Outline

A. Historical Perspective

1. Regional diversity studies

Diversity and endemism in the flora of southern Africa have recently been studied by Goldblatt (1978), Gibbs Russell (1985), Cowling *et al.* (1989), Cowling & Hilton-Taylor (1994, 1997), Cowling *et al.* (1997), and Golding (1999).

Goldblatt (1978) covered a wide range of topics in his *An analysis of the flora of southern Africa:...*, including the diversity, endemism, phytogeography and origin of the vascular plants of southern Africa.

Gibbs Russell (1985) compared the numbers of taxa in southern Africa to the numbers recorded in other parts of Africa as well as the world. She also compared the numbers of taxa in each family to previous counts by Dyer (1975, 1976) and Goldblatt (1978). The numbers of genera and species in each bryophyte family in southern Africa were listed for the first time.

Cowling *et al.* (1989) analysed different components of plant species diversity (alpha, beta, gamma) within and among the southern African biomes of Rutherford and Westfall (1986). They also compared species/area ratios among a number of

comparable sized countries and found that southern Africa has the richest flora in the world.

O'Brien (1993) mapped the number of woody plant species per 20000 km² grid square in southern Africa including Zimbabwe. She found that maximum species richness occurs along the eastern escarpment of KwaZulu-Natal and the Northern Province and lowest in Namibia and the Kalahari Basin. Woody plant species richness increases longitudinally from west to east.

Cowling & Hilton-Taylor (1994, 1997) analysed the size and composition of the vascular plant flora of southern Africa. Species diversity and endemism were compared among a number of families as well as countries. The transition from a tropical to a temperate flora and steep ecological gradients are thought to be among the reasons for the high species diversity and endemism in southern Africa. They also studied patterns and correlates of species diversity and endemism in the region.

Cowling *et al.* (1997) reviewed and developed models on the determinants of regional or biome level (vascular) plant richness in South Africa. They identified the fynbos biome in the south-west "...and some areas along the subtropical east coast and eastern escarpment ..." as especially rich in vascular plants. They found that "Plant species richness at the regional scale in South Africa is determined largely by environmental heterogeneity.", especially in the fynbos and karroid regions. Warm, moist and aseasonal environmental conditions were found to be responsible for high plant diversity in the "...tropical-derived savanna and grassland flora,...". Cowling *et al.* (1997) also compared patterns of regional richness among several mediterranean-climate regions in order to test aspects of convergence theory. They found that patterns of regional diversity in the species-rich fynbos biome are not unique.
Golding (1999) has recently plotted the number of recorded plant species against the land surface area for Southern African Botanical Network (SABONET) countries to illustrate under-collecting and recording in some countries.

As far as the bryophytes are concerned, **Kis** (1985) compiled a list of mosses reported from south-east tropical Africa and compared the number of species in the genera on this list with the numbers of species in the same genera present in southern Africa (FSA area), West Africa, and Madagascar/Mascarenes.

O'Shea (1997a) has recently studied diversity and endemism in the mosses of sub-Saharan Africa. He compared species richness (taxa per 10000 km^2) and endemism (using Bykov's Index) among the countries. O'Shea (1997a) inadvertently omitted the family Wardiaceae, and the genera *Microcrossidium*, *Physcomitrellopsis*, and *Wardia*, all endemic to southern Africa, from his list of endemic families and genera. He concluded that "Clearly the paucity of collections and the urgent need for taxonomic review mean that the data does not give an accurate reflection of the actual diversity or endemism of the flora."

2. Centres of plant diversity and endemism

The most important contemporary studies in which southern African centres of plant diversity and endemism have been identified are briefly discussed here.

Weimarck (1941) described a number of 'endem centres' in the Cape flora, based on the distribution of endemic species of the Cape element (see *Historical Perspective*, Chapter 5).

Croizat (1965) identified 4 main 'biogeographic centres' in southern Africa (see *Historical Perspective*, Chapter 5) and defined his centres as "...centres of massing and form-making,...".

In addition to his phytogeographic groups (see *Historical Perspective*, Chapter 5) **Nordenstam** (1969) identified a number of 'phytogeographical centres' in southern Africa based on the distribution of *Euryops* as well as other genera. He defined

phytogeographical centres as "...geographical areas...outstanding as centres of species concentration and of endemism.", therefore centres of diversity and endemism.

Nordenstam's (1969) phytogeographical centres of diversity and endemism in southern Africa

1. The Caledon Centre
2. The Albany Centre
3. The Little Karroo Centre
4. The Vanrhynsdorp Centre
5. The Gariep Centre
6. The Western Upper Karroo Centre
7. The Sneeubergen Centre
8. The Drakensbergen Centre
9. The Barberton Centre

Oliver *et al.* (1983) studied patterns of species richness in a range of taxa representing the Cape flora. They identified the Sir Lowry's Pass area in the Hottentots Holland Mountains (grid square 3418 BB) as the main centre of diversity. They pointed out that the patterns of species richness are "To some extent ... artifacts produced by uneven collecting."

Cowling (1983) recognised two 'endem' centres in the south-eastern Cape: 1) a South Eastern Centre for Cape taxa after Weimarck (1941) and 2) the Kaffrarian Transition Zone for other species, incorporating the non-Cape regions of the south-eastern Cape.

Centres of high genus diversity, called 'chorological centres', within the geographic distribution of the family Mesembryanthemaceae "...the largest and most important taxon of the leaf succulent zone.", have been mapped by **Jürgens** (1986, 1990). The concentrations (centres of diversity) of Mesembryanthemaceae genera along the western and southern Cape coast provide further evidence for the inclusion of these

'Cape' areas into the Karoo-Namib Region (see *Discussions* under the *Cape Domain* and *Karoo-Namib Region* in Chapter 4).

Within the proposed 'Afrotemperate Region', **Linder** (1990) recognised three main centres of endemism: 1) the Cape Floristic Centre, 2) the Afromontane Centre, and 3) a separate centre in "...the Drakensberg and surrounding mountains...".

Van Wyk (1990, 1994, 1996) identified three areas of high floristic endemism, or centres of endemism, in the vascular plant flora of the Tongaland-Pondoland Regional Mosaic of White (1983). These three centres of endemism are: 1) the Maputaland Centre in the north, 2) the Pondoland Centre in the middle, and 3) the Albany Centre in the south.

Rebelo & Siegfried (1990), followed by Rebelo (1994), presented a classification of centres of endemism in the Cape Floristic Region, "...based on clustering and ordination of the Proteaceae data set,..." (Rebelo & Siegfried 1990). These 'centres' were assigned to the formal phytogeographic categories of Province (5), District (20) and Zone (6), usually applied to different levels of floristic regions. However, there is no evidence of, or literature reference to, a numerical analysis in the two publications. It appears that these 'centres' are based on floristic elements identified in the Cape flora by Weimarck (1941), and vegetation types and subdevisions of vegetation types by Acocks (1975), Kruger (1977), and Moll & Bossi (1984).

Van Wyk (1991) identified centres of diversity and endemism for *Lotononis* (Fabaceae), a genus with a more or less temperate distribution throughout Africa. In southern Africa the following areas stand out as 'centres of richness or diversity': 1) the south-western Cape, 2) the north-western Cape, 3) the eastern Cape, and 4) the Drakensberg. The following centres of endemism are recognised:

Endemic centres in the geographic distribution of Lotononis *(Van Wyk 1991)*

Cape Region
Namaqualand
Eastern Cape
Natal-Drakensberg area
Southern Namibia and Griqualand-West
Transvaal
Central Zimbabwe
North-western Namibia and southern Angola
Nyika plateau
Morocco and southern Spain
Turkey and south-eastern Bulgaria

High vascular plant species endemism along the 'north-eastern Transvaal escarpment' promted **Matthews** *et al.* (1993) to describe rock outcrops of the Transvaal Sequence (Black Reef Quartzite Formation, Wolkberg Group, Timeball Hill Formation and Chuniespoort Group) as the Wolkberg Centre. This geological centre of high vascular plant species endemism is subdivided into 1) the Blyde Subcentre south of the Olifants River, and 2) the Serala Subcentre north of this river.

A number of areas with high species diversity and endemism has recently been identified worldwide as major sites for conservation (**Davis** *et al.* 1994). The phytochoria recognised by White (1983) were used as a basis for selecting sites in Africa, which are a mixture of geographic areas, phytogeographic regions, biomes, vegetation types and nature reserves. Seven 'centres', or phytogeographic regions of high species diversity and endemism, are listed for southern Africa. Of these the Kaokoveld (Hilton-Taylor 1994a), Western Cape Domain (Hilton-Taylor 1994), Cape Floristic Region (Rebelo 1994a), Maputaland-Pondoland Region (Van Wyk 1994), and Drakensberg Alpine Region (Killick 1994) were selected for 'Data Sheet treatment'.

Areas in southern Africa identified as Centres of Plant Diversity *by Davis* et al. *(1994).*

Kaokoveld (Namibia)
Western Cape Domain (Succulent Karoo)
Albany Centre
Cape Floristic Region
Maputaland-Pondoland Region
Drakensberg Afromontane Regional System
Drakensberg Alpine Region

In an overview of the African centres of diversity selected for inclusion in Davis *et al.* (1994), **Beentje** *et al.* (1994) listed a number of 'centres' recognised within the Drakensberg Afromontane Regional System. The location of these 'centres' is shown on a map by Van Wyk (1994: 229).

Centres within the Drakensberg Afromontane Regional System (Beentje et al. *1994)*

Soutpansberg Centre
Wolkberg Centre
Barberton Centre
Afromontane region of the Natal/Transkei Midlands
southern Drakensberg mountains of Natal and north-eastern Cape
Amatola Mountains
Outeniqua Mountains

The percentages of the total number of plant species in Namibia that occur in each of the magisterial districts of that country were plotted by **Maggs** *et al.* (1994). The southern Namib, Grootfontein, Kavango, Kaokoveld and Windhoek regions were identified as centres of diversity. The numbers of species per ½° grid square for a

selection of Namibian endemics or near-endemics were plotted in order to determine centres of endemism. The Kaokoveld, Windhoek, Naukluft, and southern Namibia were identified as areas of high endemism. They pointed out that inadequate taxonomy and collecting bias contributed to the high numbers of species in some areas.

Cowling & Hilton-Taylor (1994, 1997) and **Hilton-Taylor** (1996) treated the seven centres of plant diversity in Davis *et al.* (1994), as well as the Wolkberg Centre (of endemism) of Matthews *et al.*(1993), as southern African centres of plant species endemism or 'hot-spots':

Hot-spots of plant diversity and endemism within southern Africa (Cowling & Hilton-Taylor 1994, 1997)

Wolkberg
Maputaland
Pondoland
Eastern Mountain
Albany
Cape
Succulent Karoo
Kaokoveld

Cowling & Hilton-Taylor (1994) found that these centres or 'hot-spots' "...are distributed in an almost continuous arc below and including large portions of the Great Escarpment." The habitat, phylogenetic, taxonomic, and biological aspects, as well as the age, conservation status and threats of these centres were discussed in detail. Species level endemism in the largest flowering plant families was compared among floras representative of the Eastern Mountain, Cape, and Succulent Karoo centres of endemism or 'hot-spots' (Cowling & Hilton-Taylor 1994, 1997).

Rebelo (1994) plotted the number of (vascular) plant species and the number of narrow endemics per ¼° grid square in southern Africa. The resulting centres of diversity and centres of (narrow) endemism are clearly distinguishable. However, as Rebelo's objective was to determine the conservation requirements of the region he stopped short of describing these centres.

Van Wyk & Van Wyk (1997) mapped three 'principal regions of plant diversity and endemism' and 17 'principal local centres of endemism' in southern Africa, including Zimbabwe (Fig. 4). They based their centres on those of Davis *et al.* (1994) as well as on unpublished data.

Centres of plant diversity and endemism mapped by Van Wyk & Van Wyk (1997)

Principal regions of plant diversity and endemism

1. Succulent Karoo Region
2. Cape Floristic Region
3. Maputaland-Pondoland Region

Principal local centres of plant endemism

1. Kaokoveld Centre
2. Gariep Centre
3. Kamiesberg Centre
4. Knersvlakte (Vanrhynsdorp) Centre
5. Western Mountain Karoo Centre
6. Little Karoo Centre
7. Albany Centre
8. Pondoland Centre
9. Maputaland Centre
10 Drakensberg Alpine Centre
11. Barberton Centre
12. Wolkberg Centre

13. Sekhukhuneland Centre
14. Soutpansberg Centre
15. Griqualand West Centre
16. Great Dyke Centre
17. Chimanimani-Nyanga Centre

Cowling *et al.* (1998) has recently shown that the Succulent Karoo Biome is "...a major extratropical centre of plant biodiversity.". This region has previously been subdivided into a number of phytochoria with high levels of endemism called centres of endemism (Hilton-Taylor 1994). These subdevisions have also been referred to as geographical areas (Hilton-Taylor 1996) and bioregions (Cowling *et al.* 1999).

Patterns of endemism in plants, amphibians, reptiles, mammals and birds of Namibia were recently studied by **Simmons** *et al.* (1998). They found congruence among endemism hot-spots remarkably high for most taxa. A zone of high endemism runs along, and to the west of the Namib escarpment. There is also an important region of (succulent) plant endemism in the winter-rainfall Succulent Karoo biome in the south-western corner of Namibia. The overlap between areas of species richness and endemism was found to be relatively high for Namibian plants. The following areas were identified as endemism hot spots in Namibia:

1. Kaoko escarpment, plains and inselbergs of the north-west, particularly at Brandberg.
2. Brukkaros volcanic crater in the south.
3. Winter-rainfall Succulent Karoo Biome in the south-west.

From the examples discussed here it is clear that the centres of diversity and endemism identified in the vascular plant flora of southern Africa are a curious mixture of floristic regions, biomes, geological formations, and geographic areas with high concentrations of species and endemics. Examples in each category are:

Floristic regions:- The Drakensberg Alpine or Eastern Mountain Centre or hot-spot (Cowling & Hilton-Taylor 1994, 1997; Killick 1994; Van Wyk & Van Wyk 1997) and the Cape Floristic Region or hot-spot (Rebelo 1994a; Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997). The Succulent Karoo Region of plant diversity and endmism, which is a biome (see next heading) also coincides with the Western Cape Domain (Hilton-Taylor 1994), which is a phytochorion.

Biomes:- The Succulent Karoo Region or hot-spot (Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997; Cowling *et al.* 1998). The Cape Floristic Region of plant diversity and endemism (hot-spot) coincides with the Fynbos biome of Rutherford & Westfall (1986).

Geological formations:- The Pondoland Centre or hot-spot (Van Wyk 1990; Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997) and the Wolkberg Centre or hot-spot (Matthews *et al.* 1993; Cowling & Hilton-Taylor 1994, 1997). The Cape Floristic Region of plant diversity and endemism is also regarded as a geological centre (Van Wyk 1990, Matthews *et al.* 1993).

Geographic areas:- The 'centres' of Weimarck (1941), Croizat (1965) and Nordenstam (1969) and the Namibian centres of species diversity and endemism identified by Maggs *et al.* (1994) and Simmons *et al.* (1998). The moss centres of species diversity and endemism described in this chapter fall under this category.

B. Diversity

The moss flora of southern Africa consists of 503 species/infraspecific taxa in 204 genera and 54 families (see the checklist in Appendix I). This represents about 5% of the worlds mosses (Schofield 1985) and 17% of mosses in Africa (O'Shea 1997a). These

percentages are likely to increase as the total numbers of moss taxa are reduced through taxonomic revisions, especially in tropical regions of Africa (Frahm 1997, O'Shea 1997).

1. Families

The number of genera and species as well as the largest genus in each family are listed in Table 3. The 10 largest moss families according to the the number of genera, and the number of species are listed in Table 5 and Table 6 respectively. In both instances the acrocarpous families Pottiaceae, Dicranaceae and Bryaceae occupy the first three positions. The Pottiaceae is by far the largest of the three with 69 species/infraspecific taxa in 30 genera. The second largest family is the Dicranaceae with 49 species/infraspecific taxa in 15 genera followed by the Bryaceae with 40 species in 9 genera. The top three families have all been revised for the FSA (Magill 1981, Magill 1987) and the numbers of genera and species are not expected to change drastically.

The families Ditrichaceae, Orthotrichaceae, Bartramiaceae, Funariaceae, and Hypnaceae are listed as both genus and species rich among the top ten. Hookeriaceae, Amblystegiaceae and Leskeaceae are listed among the top ten families as far as the number of genera is concerned but they don't feature on the top ten species list. On the other hand, the families Fissidentaceae with 29 species, and Brachytheciaceae with 17 species are not among the top ten families on the genus list but feature as number five and eight respectively on the species list.

The number of families per ½° grid square is shown in Fig. 5. The highest concentrations of families, or centres of family diversity, are situated in:

a) The south western Cape, in particular the Table Mountain grid (3318 C) where 37 families (69% of all the moss families in southern Africa) have been recorded.
b) Montane forest of the Amathole Mountains, in particular grid 3227 C (Keiskammahoek-King William's Town) with 34 families, and the adjacent grid 3226 D (Hogsback) with 30 genera.

c) The Drakensberg and Midlands of KwaZulu-Natal, in particular grids 2828 D (37 families), 2929 A (36), 2929 C (35), 2930 C (35), and 2930 A (34).

d) The Mpumalanga escarpment, from the Wolkberg east of Pietersburg all along the Drakensberg Mountains to Barberton and north-western Swaziland. The grid squares in this centre with the most families recorded are grid 2430 D (Blyderivierspoort-Graskop) with 38 families, the highest number of families in the study area, and grid 2530 B (Sabie area) with 35 families.

Relatively high numbers of moss families (but less than 33) are also found in the following areas:

e) The southern Cape forests, from George in the east, all along the Outenikwa Mountains, to the Tsitsikamma in the west (grids 3322 C & D, 3323 C & D, and 3423 A).

f) The Zululand forests, from Qudeni in the west to Richards Bay in the east, in particular grids 2831 C & D.

g) The Magaliesberg Mountains between Pretoria and Rustenburg, with 25 families recorded from grid 2527 D.

2. Genera

The 10 largest moss genera in southern Africa are listed in Table 7. *Fissidens* is the largest genus of mosses in southern Africa with 29 species. It is also one of the largest moss genera in the world with c. 800 species. The second place is shared by the genera *Bryum* and *Campylopus* with 19 species each. These figures will increase once the new records already published (see introduction to the checklist in Appendix I) have been incorporated. *Archidium* is the 4th largest genus with 11 species. *Funaria* and *Fabronia* with 10 species each are also species-rich genera.

Among the top 10 genera only *Fabronia* (5th largest) and *Brachythecium* (7th largest) have not been revised recently and the number of species recognised is likely to decrease.

There is general concordance between areas of high moss family diversity and high moss genus diversity in southern Africa (compare Figs. 5 and 6). Centres of genus diversity are located in the south-western Cape, southern Cape, Amathole Mountains, KwaZulu-Natal Drakensberg and Midlands, Zululand, and the Mpumalanga escarpment, from the Wolkberg in the north to Sabie in the south (Fig. 6). Relatively great numbers of genera have also been been recorded from the Wild Coast in Pondoland (Eastern Cape), the Magaliesberg Mountains (North West), and the Soutpansberg in the Northern Province. The ½° grid squares with the greatest number of genera recorded (more than 80) are:

a) Grid 2430 D on the Mpumalanga escarpment (Blyderivierspoort or Mariepskop) with 100 genera.
b) Four grids in the KwaZulu-Natal Drakensberg and Midlands: 2929 C (100), 2930 C (98), 2828 D (96) and 2929 A (93).
c) The Cape Town (Table Mountain) grid with 94 genera.

3. Species/infraspecific taxa

The list of most frequently collected species in southern Africa (according to the number of specimens in PRE, see Table 8) is topped by *Trichostomum brachydontium* of the Pottiaceae followed by *Bryum argenteum* (Bryaceae) and *Fissidens glaucescens* (Fissidentaceae). It must be remembered though that the Thuidiales, Hypnobryales and Polytrichales are under-represented in PRE as a result of unidentified material awaiting revision for the 4th fascicle of the moss FSA.

The most widely distributed moss species on the subcontinent (Table 9), based on the number of grid squares in which they occur are: *Trichostomum brachydontium* (Pottiaceae), *Bryum argenteum* (Bryaceae) and *Pseudocrossidium crinitum* (Pottiaceae). *Trichostomum brachydontium* and *Bryum argenteum* are also nos. one and two on the list of most frequently collected mosses (Table 8). Not only are these two mosses widespread in southern Africa but *Trichostomum brachydontium* occur throughout warm temperate to tropical areas of the world and *Bryum argenteum* is

cosmopolitan in distribution. Not all widespread species are frequently collected and vice versa. For example, the widespread species *Bryum pycnophyllum*, *Grimmia pulvinata*, *Funaria hygrometrica* and *Fissidens rufescens* are not among the 10 most frequently collected mosses in southern Africa.

4. Centres of moss diversity

The number of moss species recorded in each ½° grid square in southern Africa is shown in Fig. 7. To identify centres of diversity, the grids were divided into classes according to the number of moss species/infraspecific taxa collected in each. The distribution at the six class interval is shown in Fig. 8 while the distribution of the top three classes (50-99, 100-149 & 150+) of a four class interval are mapped in Fig. 9. The five areas with the highest concentrations of moss species (100 + species recorded), which also overlap with centres of family and genus diversity, are here formally described as primary or main Centres of Diversity (Fig. 9). Two of these Centres are subdivided into Subcentres. Other areas of relatively high species richness, but with less than 100 species recorded, are described as secondary Centres of Diversity. The difference between the two categories is arbitrary.

Main centres of moss diversity in southern Africa

1. South-western Cape Centre of Diversity
2. Outeniqua Centre of Diversity
3. Amathole Centre of Diversity
4. KwaZulu-Natal Centre of Diversity
   - 4.1 Drakensberg Subcentre of Diversity
   - 4.2 Midlands Subcentre of Diversity
5. Mpumalanga Centre of Diversity
   - 5.1 Wolkberg Subcentre of Diversity
   - 5.2 Blyde Subcentre of Diversity

Secondary centres of moss diversity in southern Africa

6. Cederberg Centre of Diversity
7. Witteberge Centre of Diversity
8. Pondoland Centre of Diversity
9. Magaliesberg Centre of Diversity
10. Soutpansberg Centre of Diversity

a) Main centres of moss diversity

Concentrations of more than 100 species of mosses.

1. South-western Cape Centre of Diversity

This centre of moss diversity is situated in the south-western corner of southern Africa, at the junction between the two axes of the Cape Fold Mountains (Fig. 9). The grid square with the highest number of species (186) is the Cape Town or Table Mountain grid (3318 C), also the most species-rich grid in southern Africa (Fig. 7). Other grids with high numbers of mosses recorded are 3318 D and 3319 C, covering the Cape Fold Mountains between Stellenbosch in the west and Worcester in the east. This centre also covers the Cape Peninsula (grid 3418 A), the Hottentots Holland Mountains and Cape Hangklip (grid 3418 B), east to the Riviersonderend Mountains (3419 B), and north to the mountains around Ceres and Tulbagh (grid 3319 A).

This centre, also known as the Caledon Centre, has long been recognised as the most species-rich area in the Cape and in southern Africa (Levyns 1954, Dahlgren 1963, Croizat 1965, Nordenstam 1969). Rebelo & Siegfried (1990) identified the Cape Hangklip region, and Oliver *et al.* (1983) the Hottentots-Holland Mountains as the most species-rich areas in the south-western Cape.

2. **Outeniqua Centre of Diversity**

This centre of moss species diversity covers the Knysna and Tsitsikamma forests, roughly between George in the west and Stormsriviermond in the east, and between the Outeniqua Mountains and the Indian Ocean (Fig. 9). However, high numbers of species are found right up to Port Elizabeth area. The grid with the highest number of species recorded is the George-Oudtshoorn grid (3322 C) with 110 species (Fig. 7). Between 50 and 100 species have been recorded in each of the grid squares to the east (3322 D, 3323 C & D, and 3423 A).

This area has been described as the Zitzikamma subcentre of the South-eastern centre of endemism by Weimarck (1941). He remarked on the high number of vascular plant species in this area. The Outeniqua Mountains as well as the Amathole Mountains, which constitutes the next centre, are known as Afromontane 'outliers' (Beentje *et al.* 1994, Van Wyk 1994). Contemporary schemes include this centre in the Cape Floristic Region (also Centre or hot-spot, see Fig. 4) of plant diversity and endemism (Cowling & Hilton-Taylor 1994, 1997; Rebelo 1994; Van Wyk & Van Wyk 1997).

3. **Amathole Centre of Diversity**

This comparatively small centre is situated in the high-rainfall Hogsback-Keiskammahoek area of the Eastern Cape where substantial stands of Afromontane forest exist (Fig. 9). The area is dominated by the Amathole mountain range in the northern part of the centre. Geologically this centre is associated with mudstones and sandstones (with dolorite intrusions) of the Beaufort Group.

A total of 103 species has been recorded from grid 3227 C (Keiskammahoek-King William's Town), most of these from the Pirie Forest, a historical collecting site. Hogsback (3226 D) has also been a popular collecting site and 54 species have been collected from this grid (Fig. 7).

The Amatola Range has been recognised as a subcentre of the Eastern Highlands Centre (see the *Eastern Highlands Element*, Chapter 5) within the palaeogenic element by Stuckenberg (1962).

The Amathole Centre of Diversity borders on, but is certainly not part of, the Albany Centre or hot-spot (Croizat 1965; Nordenstam 1969; Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997). The Albany Centre is situated between the cities of Port Elizabeth and East London, in "Low-lying river valleys and basins in south-eastern Cape Province,...", with a substantial cover of thicket vegetation (Fig. 4). It is characterized by the many succulent plant genera which are centred in the area (Beentje *et al.* 1994). The approximate location of the Amathole Centre is shown on the map of the Maputaland-Pondoland Region by Van Wyk (1994: 229).

4. KwaZulu-Natal Centre of Diversity

This area of high moss species richness covers the motane forests of the KwaZulu-Natal Drakensberg and Midlands (Fig. 9). Grid squares with more than 150 species are found along the Drakensberg escarpment, from the Mount aux Sources grid in the north (2828 D) to the Sani-Sehlabathebe area in the south (2929 C), and at Pitermaritzburg (2930 C) in the Midlands. These two areas are provisionally separated as subcentres. Geologically this centre is associated with rocks of the Karoo Sequence, topped with basalt of the Drakensberg Formation.

This centre of moss diversity falls mainly into the Maputaland-Pondoland Region as defined by Van Wyk (1994), and the Drakensberg Afromontane Regional System as described by Beentje et al. (1994), both treated as regional centres of plant diversity in Davis *et al.* (1994) (Fig. 4). Van Wyk (1991) has identified this region as a centre of diversity and endemism in the distribution of *Lotononis*.

4.1 Drakensberg Subcentre of Diversity

This centre is located in the Drakensberg and Maloti mountains of KwaZulu-Natal and northern Lesotho (Fig. 9). It extends from Fouriesburg in the west (2828 C) and Van Reenen in the north (2829 C), to Sehlabathebe (2929 C) in the south. More than 100 species have been recorded from each of grids 2828 D, 2829 C, and 2929 A & C. The interval between the two KwaZulu-Natal subcentres may be as a result of collecting bias and their separation is arbitrary and provisional.

The Drakensberg Alpine Region (Killick 1994; Chapter 4), is generally recognised (under different names) as one of the southern African centres of vascular plant diversity and endemism (Weimarck 1941; Croizat 1965; Nordenstam 1969; Davis *et al.* 1994; Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997; Fig. 4). However, the Afromontane forests below c.1800 m, which greatly contribute to the high number of mosses in the Drakensberg Subcentre of Diversity, are generally excluded from the Drakensberg Alpine Region. Weimarck's (1941) Drakensberg Centre included the Drakensberg mountain range north of Lesotho, right up to the Northern Province, with the Soutpansberg as outlier.

4.2 Midlands Subcentre of Diversity

This centre is separated from the Drakensberg Subcentre on the basis of high species numbers in grids 2930 A (Karkloof area) and 2930 C (Pietermaritzburg). The Pietermaritzburg grid (2930 C) contains 169 species (Fig. 7), the highest number in this subcentre, while 121 species have been recorded from the Karkloof grid (2930 A). The centre probably extends right up the the Kranskop area east of Greytown.

Although the Zululand grids 2830 D (Kranskop), 2831 C (Nkandla-Eshowe), and 2831 D (Empangeni) are treated as part of the Midlands subcentre, relatively high family and genus diversity in these grids (Figs. 5

& 6) indicate that they might represent a separate centre or subcentre of diversity. Collections from the Afromontane forests of Qudeni, Nkandla, Ngoje, Dlinza, Umgoye and Mtunzini are largely responsible for the high numbers of mosses in the Zululand grids. The Zululand forests are separated from the Midlands centre by the Tugela River valley.

The 'Afromontane region of the Natal/Transkei Midlands' has been listed as a 'centre' within the Drakensberg Afromontane Regional System (centre of diversity) by Beentje *et al.* (1994).

5. Mpumalanga Centre of Diversity

This centre extends along the Drakensberg escarpment of the Northern Province and Mpumalanga, roughly from the Wolkberg Mountain east of Pietersburg, to the mountains of north-western Swaziland (Fig. 9). Afromontane forests such as Woodbush, De Hoek, Serala, New Agatha, Mariepskop, Uitsoek and Kaapsehoop (Von Breitenbach 1990) are largely responsible for the high degree of diversity in mosses. The centre is associated with rocks of the Transvaal Sequence (Matthews *et al.* 1993).

Grid squares with more than 100 species recorded are: 2330 C (Tzaneen-Duiwelskloof area), 2430 D (Graskop-Blyderivierspoort), and 2530 B (Nelspruit-Sabie). The Graskop-Blyderivierspoort grid (2430 D) with 181 species is only second to the Cape Town grid (3318 C) in the number of specie/infraspecific taxa recorded in southern Africa (Fig. 7).

This centre coincides with the Barberton Centre of Croizat (1965) and Nordenstam (1969), and the Wolkberg Centre (of endemism) of Matthews *et al.* (1993), Cowling & Hilton-Taylor (1994, 1997), and Van Wyk & Van Wyk (1997) (Fig. 4). The concentration of Eastern Highlands taxa (see the *Eastern Highlands Element*, Chapter 5) along the Mpumalanga escarpment has been described as the Eastern Transvaal Subcentre by Stuckenberg (1962).

5.1 Wolkberg Subcentre of Diversity

The northernmost of the two subcentres is named after the Wolkberg Mountain situated between Pietersburg and Tzaneen in the Northern Province, the heart of this centre (Fig. 9). It comprises the Drakensberg escarpment area roughly to the north of the Olifants River gorge. The highest number of species (100) is found in grid 2330 C (Tzaneen) while grids 2329 D (Haenertsburg-Houtboschdorp area) and 2430 A (Wolkberg Wilderness area) contain 92 and 68 species respectively (Fig. 7).

The Wolkberg Subcentre of Diversity is synonymous with the Serala Subcentre of Matthews *et al.* (1993).

5.2 Blyde Subcentre of diversity

The main area of this subcentre is situated along the Drakensberg escarpment between Blyderivierspoort (grid 2430 D with 181 species) and Nelspruit (grid 2530 B with 119 species) in Mpumalanga. However, grid squares to the east (2430 C & 2530 A) and to the south (2530 D, 2531 C & 2631 A) of the main area are also species-rich with between 50 and 100 species recorded. This subcentre extends as far south as the mountains at Barberton and the Malolotja-Mbabane area in north-western Swaziland.

This subcentre is named after the Blyde Subcentre of Matthews *et al.* (1993). The Barberton/north-western Swaziland area has been identified and mapped as a separate centre, the Barberton Centre (of endemism) by Beentje *et al.* (1994), Van Wyk (1994), and Van Wyk & Van Wyk (1997) (Fig. 4).

b) Secondary centres of moss diversity

Species-rich areas where between 50 and 100 species of mosses are concentrated.

6. Cederberg Centre of Diversity

This area is probably an outlier of the South-western Cape Centre of Diversity but presently grid 3218 B, with 61 species recorded, stands out as a centre of moss diversity (Fig. 7 & 9). This grid square covers the town of Clanwilliam and the Pakhuispas leading into the northernmost part of the Cederberg Mountains. It is linked to the South-western Cape Centre of Diversity by grids 2319 A & C (between 20 and 50 species recorded), situated in the Cederberg and Kouebokkeveldberge. It also extends northward along the Bokkeveldberge between Vanrhynsdorp (3118 D) and Nieuwoudtville (3119 A). The Cederberg Centre of Diversity is largely restricted to quartzitic sandstones of the Table Mountain Group.

The centre of moss species diversity overlaps with, and is named after, the Cederberg Centre of Weimarck (1941). The Vanrhynsdorp Centre of vascular plant diversity and endemism (Nordenstam 1969; Hilton-Taylor 1994, 1996; Van Wyk & Van Wyk 1997; Cowling *et al.* 1999) is situated on the Knersvlakte to the north-east of the Cederberg Centre (Fig. 4).

7. Witteberge Centre of Diversity

Grid 3027 C in the Witteberge mountains at Lady Grey in the Eastern Cape is by far the most species-rich grid in the area with 50 species recorded. The grid squares between this centre and the KwaZulu-Natal Centre of Diversity are completely under-collected and may link the two in future. Indeed, the 'southern Drakensberg mountains of Natal and north-eastern Cape' have been listed as one of the 'centres' within the Drakensberg Afromontane Regional System by Beentje *et al.* (1994). It is therefore possible that this grid stands out as a result of uneven collecting (see the *Discussion* further on).

8. Pondoland Centre of Diversity

The Pondoland Centre of Diversity extends roughly from Port Shepstone on the KwaZulu-Natal South Coast in the north, to Port St. Johns on the Transkei Wild

Coast in the south (Fig. 9). The grids with the highest number of species recorded are 3030 C (Port Shepstone) and 3129 B (Lusikisiki).

The Table Mountain Sandstone areas along the southern KwaZulu-Natal/Pondoland coast are known to be rich in vascular plant endemics (Van Wyk 1990) and the area has been described as the Pondoland Centre (of plant endemism) or hot-spot (Van Wyk 1994, 1996; Cowling & Hilton-Taylor 1994; Cowling *et al.* 1997b; Van Wyk & Van Wyk 1997). The Podoland Centre falls into the Maputaland-Pondoland Region of vascular plant diversity (Van Wyk 1994, Fig. 4).

9. Magaliesberg Centre of Diversity

This centre of moss diversity is situated in the Magaliesberg mountains between Pretoria in Gauteng and Rustenburg in the North-West province (Fig. 9). Afromontane forest elements are found in sheltered kloofs or ravines on the northern side of this mountain range. Like the Mpumalanga Centre of Diversity, the Magaliesberg Centre of Diversity is situated on rocks of the Transvaal Sequence (Carruthers 1990).

Grid squares 2528 C (Pretoria), 2527 D (Brits) and 2527 C (Rustenburg) contain between 50 and 100 species of moss. Although species diversity is not exceptionally high, corresponding high family and genus diversity (Figs. 5 & 6) suggest that this area might indeed represent a major centre of bryophyte diversity.

10.Soutpansberg Centre of Diversity

Relatively high numbers of species have been recorded from the Entabeni grid (2230 C) and the Blouberg outlier (2329 A) in the Soutpansberg mountains of the Northern Province (Fig. 9). However, high numbers of mosses are likely to be found all along the Soutpansberg mountain range. Afromontane forests, e.g. the Entabeni Forest, contribute greatly to the recognition of this area as a centre of

moss species diversity. This centre is situated on sandstones and conglomerates of the Soutpansberg Group.

Beentje *et al.* (1994) list the Soutpansberg Centre as one of the centres (of endemism) recognised within the Drakensberg Afromontane Regional System. It is also listed as a principal local centre of plant endemism by Van Wyk & Van Wyk (1997) (Fig. 4).

Concentrations of less than 50 species per ½° grid square may also represent centres of diversity but as a result of inadequate distribution data these areas are not formally described. Examples are:

a) Relatively high moss species diversity (between 20 and 50 species recorded) in grid squares 2927 D (Springbok), 3017 B (Kamieskroon), and 3018 A (Kamiesberge) may warrant the recognition of a Kamiesberg centre of diversity. This area is known as a local centre of vascular plant diversity and endemism within the Succulent Karoo Region (Weimarck 1941; Hilton-Taylor 1994, 1996; Van Wyk & Van Wyk 1997; Fig. 4).

b) Grid squares in the Richtersveld of the Northern Cape province and southern Namibia (2716 D, 2816 B & D, 2827 A & C) are relatively species-rich (Fig. 8). This area is well known as the Gariep Centre of vascular plant diversity and endemism (Croizat 1965; Nordenstam 1969; Hilton-Taylor 1994,1996; Van Wyk & Van Wyk 1997; Cowling *et al.* 1999; Fig. 4).

c) Higher species numbers in grid squares 2822 B & C (Fig. 8) suggest that the Langeberge and Kurumanheuwels of the Northern Cape represent another centre of moss diversity in southern Africa. This area is known as the Griqualand West Centre of plant endemism (Van Wyk & Van Wyk 1997, Fig. 4).

d) In Botswana the highest number of moss species occurs in the Okavango delta (Fig. 8) and this area probably represents another centre of moss diversity.

e) The Drakensberg escarpment in the Wakkerstroom-Vryheid area stands out as another species-rich area which may warrant recognition as a centre of moss diversity. Grid squares 2730 A, B & D and 2731 C contain between 20 and 50 species each (Fig. 8).

f) The Waterberge mountains in the Northern Province may very well prove to be another centre of moss diversity. It consists of sandstone and conglomerate of the Waterberg Group. Grids 2427 B (Kransberg) and 2428 C (Nylstroom) stand out with between 20 and 50 species recorded in each (Fig. 8).

5. Distribution in the geographic regions of the moss FSA

A number of geographical regions was established by Magill (1981) to describe the distribution of mosses within the *Flora of Southern Africa* area. The regions have since been revised by Van Rooy (1997a). The distribution of moss species in the regions of Magill (1981) is as follows:

Species richness in the geographic regions of the moss FSA

Botswana – 22 (4% of mosses in the FSA area)
Central Cape – 106 (21%)
Eastern Cape – 180 (36%)
Northern Cape – 34 (7%)
Southern Cape – 197 (39%)
Northwestern Cape – 82 (16%)
Southwestern Cape – 260 (52%)
Lesotho – 145 (29%)
KwaZulu-Natal – 318 (63%)
Free State – 136 (27%)

Swaziland – 102 (20%)
Namibia – 58 (12%)
Transkei – 144 (29%)
Central Transvaal – 146 (29%)
Eastern Transvaal – 249 (50%)
Northern Transvaal – 197 (39%)
Southern Transvaal – 59 (12%)
Western Transvaal – 5 (1%)
Zululand – 152 (30%)

KwaZulu-Natal, the Southwestern Cape, and the Eastern Transvaal are the most species-rich geographic regions in southern Arica. Together they contain 88% of mosses in the study area and 24% of mosses occur in all three the regions. The two largest regions, Namibia and Botswana, situated in the (semi)arid, under-collected northwestern part of the study area only contain 58 (12% of the total) and 22 (4%) species respectively. Only five species have been recorded from the western Transvaal, a totally under-collected area.

6. Aquatic mosses

The preliminary list of aquatic/semi-aquatic mosses presented here has been compiled from information recorded in the MOSS database. An earlier version of this list, including common names, habitat, growth form, status, and origin (see Table 10), was published as part of a list of southern African aquatic plants by Glen *et al.* (1999).

Problems surrounding the definition of various terms associated with aquatic or water plants are discussed by Glen *et al.* (1999). Aquatic/semi-aquatic mosses included in this list are defined as plants "...dependent on living either in or on the water for part of their life cycle and (are) adapted to this aquatic habitat." (Glen *et al.* 1999). The physiological and structural adaptations of aquatic bryophytes have been discussed by Glime & Vitt (1984) and Vitt & Glime (1984).

Sphagnaceae with seven, Amblystegiaceae with six, and Fissidentaceae with four species/infraspecific taxa are the families with the most aquatics while *Sphagnum* (7) and *Fissidens* (4) are the largest genera on the list.

Preliminary list of the aquatic/semi-aquatic mosses of southern Africa

Sphagnaceae

- Sphagnum capense
- Sphagnum fimbriatum
- Sphagnum perichaetiale
- Sphagnum pycnocladulum
- Sphagnum strictum *subsp.* pappeanum
- Sphagnum truncatum
- Sphagnum violascens

Fissidentaceae

- Fissidens fasciculatus
- Fissidens palmifolius
- Fissidens glaucescens
- Fissidens porrectus

Pottiaceae

- Barbula ehrenbergii
- Timmiella pelindaba

Bryaceae

- Bryum apiculatum
- Bryum cellulare

Fontinalaceae

- Fontinalis antipyretica *var.* gracilis
- Fontinalis squamosa

Wardiaceae

Wardia hygrometrica

Leskeaceae

Pseudoleskea chilensis

Amblystegiaceae

Campyliadelphus polygamus

Cratoneuron filicinum

Drepanocladus aduncus

Leptodictyum riparium

Platyhypnidium aquaticum

Vittia pachyloma

Plagiotheciaceae

Plagiothecium rhynchostegioides

Hypnaceae

Isopterygium strangulatum

7. Recent range expansions

In southern Africa the following mosses have been reported as 'introduced', mainly from Europe:

a) ***Sphagnum fimbriatum***. Magill (1981), supported by Eddy (1985), is of the opinion that this species was introduced from Europe during trout introduction in the streams at Belfast on the Mpumalanga Highveld. However, its occurrence in temperate South America and on subantarctic islands suggests a bipolar distribution pattern.

b) ***Tortula muralis***. Magill (1981) noted that this species frequently occurs on man-made structures which indicates its introduction by man. It has a subcosmopolitan distribution.

c) ***Leptobryum pyriforme***. Common in greenhouses and nurseries in southern Africa, it has been described as a weed of disturbed habitats in many parts of the world, probably as a result of introductions (Duell 1992).

d) ***Fontinalis antipyretica*** **var.** ***gracilis*** and ***F. squamosa***. These two aquatic species are thought to have been introduced into the streams of the south-western Cape with fish from Europe (Magill & Van Rooy 1998). As far as I know they have not been reported from any other southern Hemisphere country.

Recent changes in the distribution ranges of (European) bryophytes have been reviewed by Söderström (1992). Bryophytes reported as immigrants to Europe from the southern Hemisphere, including southern Africa, are:

a) ***Campylopus introflexus***. Introduced from the southern Hemisphere, probably through trade with the British Isles (its range includes southern Africa) it is today present over a large part of Europe (Söderström 1992).

b) ***Campylopus pyriformis***. Also introduced to Europe from the southern Hemisphere, probably before the end of the eighteenth century (Söderström 1992).

c) ***Trichostomopsis trivialis***. Although Söderström (1992) lists this species as an immigrant into Spain from southern Africa, it is more likely that it belongs to a group of mosses which displays a mediterranean-type distribution pattern (the Mediterranean Element). *Trichostomopsis trivialis* has also been reported from Jordan in the Middle East. Frey & Kürschner (1993) cites this moss as another example of their Xerothermic Pangaean Genoelement.

d) ***Oedipodiella australis***. Listed as introduced into Spain from South Africa (also known from Macaronesia and southern France) by Söderström (1992), this is another species which could be regarded as part of a Mediterranean Element.

e) ***Racomitrium lamprocarpum***. Regarded as a relatively recent immigrant to Portugal from the southern Hemisphere, probably through transatlantic spore dispersal (Ochyra *et al.* 1988, Söderström 1992).

f) ***Orthodontium lineare***. Introduced into Europe from the southern Hemisphere where it displays a pan-temperate distribution (Ochyra 1982, Söderström 1992). This species, plus the two *Campylopus* species, have been successful in spreading over large parts of Europe, probably facilitated by their ability to produce spores (Söderström 1992).

8. Substrate preferences

The distribution of southern African moss species/infraspecific taxa in the three basic types of substrate (**saxicolous**, **terricolous** and **corticolous**) is illustrated in Fig. 10. The greatest number of species/infraspecific taxa (331 or 66% of the total number of mosses in the FSA area) occurs on soil (terricolous). The second largest group is the saxicolous mosses with 281 species (56% of the total), while corticolous taxa number 177 species (35% of the total). Different substrate combinations are shown in Fig. 10. Only 54 mosses (11% of the total) were recorded from all three basic types of substrate. Mosses that grow on rock as well as soil number 119 (24% of the total), those that were recorded from rock as well as bark number 115 (21% of the total), and only 66 mosses (13% of the total) occur on soil as well as bark.

Other types of substrate recorded in the MOSS database are:

Forest litter (includes mosses on decaying wood, leaf and wood litter):- 52 species (10% of all species).

Humicolous (species growing on humus and humus-rich soil):- 35 species (7% of the total).

Other substrates (e.g. concrete, charcoal, walls, roofs):- 33 species (7% of the total).

9. Altitudinal distribution

Altitudinal information on herbarium specimens in PRE, and therefore in the PRECIS and MOSS databases, is too scanty to accurately determine the upper and lower altitudinal limits of the species, or altitudinal zones in the moss flora of southern Africa, as was done in other parts of the world by, for example, Van Reenen & Gradstein (1983,

1984), Frahm & Gradstein (1991), Gradstein *et al.* (1989), Enroth (1990), and Pocs (1994). The bryophyte altitudinal zones identified in different parts of the tropics generally coincide with vascular plant altitudinal zones or vegetation belts (Gradstein *et al.* 1989, Enroth 1990, Frahm & Gradstein 1991, Pocs 1994).

The altitudinal distribution of southern African mosses (number of species per 500 m interval), based on specimen label data in PRECIS, is graphically presented in Fig. 11. There is a rapid increase in species richness over the first 500 m to 255 species (51% of all species in southern Africa). In the next altitudinal interval (501–1000 m) the number of species jumps to a maximum of 312 (62% of the total) after which it gradually and slowly decreases to 297 (59%) between 1001 and 1500 m, and 280 (56%) between 1501 and 2000 m. Between 2000 and 2500 m species richness drops to 190 (38%), after which it again drops to 101 species (20%) between 2501 and 3000 m. At altitudes above 3000 m the number of species recorded decreases slightly to 88 or 17% of all mosses in the study area.

Compared to the altitudinal distribution of mosses in other tropical regions, e.g. in Colombia where species numbers were also plotted per 500 m interval (Churchill 1991a, Churchill & Linares 1995), and mosses on the slopes of Kilimanjaro in Africa (Pocs 1994), species numbers in southern Africa peak at lower altitudes, which is consistent with findings that altitudinal (and vegetation) belts decrease in altitude with an increase in latitude (Gradstein & Pocs 1989, Jacobsen & Jacobsen 1989, Linder 1990, Frahm & Gradstein 1991). Pocs's (1994) observation that bryophyte altitudinal zones on Kilimanjaro in Africa lie slightly lower than zones in other tropical regions of the world may be explained by the Massenerhebung effect which causes altitudinal zones of forests on lower mountains to be lower than corresponding zones on high mountains (Grubb & Whitmore 1966 in Frahm & Gradstein 1991).

The altitudinal distribution of mosses along a geographic transect, running from Durban on the KwaZulu-Natal coast (0 m) to the Sani Pass – Sehlabathebe area on top of the Drakensberg Mountains in Lesotho (3394 m), and between latitudes 29° 30′ and 30° 00′,

is shown in Fig. 12. This transect consists of grid squares 2929 C & D, 2930 C & D, and 2931 C. Species numbers are relatively low over the first 500 m above sea level (only 14 species recorded), most likely due to undercollecting in the low-lying areas around the city of Durban. Over the next 500 m (501–1000 m) the number of moss species rises dramatically to 99. The highest number of species along the transect occurs in the altitudinal interval of 1001 – 1500 m above sea level where 119 species are known to occur. This maximum or 'peak' in species richness lies in the Montane Belt (1280–1829 m) of Killick (1963), which contains the *Podocarpus* forests of the Drakensberg. Above 1500 m species richness decreases to 100 species at 2000 m and 71 species between 2001 and 2500 m.

Between 2501 and 3000 m above sea level species numbers rise again to form a second 'peak' or maximum of 80 species (Fig. 12). Similar 'double peaks' in bryophyte abundance and species richness have been observed on other tropical mountains (Pocs 1994), but at much higher altitudes. These 'peaks' in the altitudinal distribution of tropical bryophytes have been attributed to the presence of 'condensation zones' (Van Reenen & Gradstein 1983, Pocs 1994). In southern Africa the second peak in species richness lies above the forests and is largely due to the (sub)alpine moss element of Lesotho (Magill 1987). Above 3000 m there is a sudden drop in species numbers to 30, partly due to the inaccessibility of the terrain.

10. Distribution in biomes

The distribution of southern African moss species/infraspecific taxa in the seven vascular plant biomes of Rutherford & Westfall (1986), see Fig. 2, is as follows:

Moss species diversity in the biomes of Rutherford & Westfall (1986)

Desert Biome – 2 (0.4% of the total)
Grassland Biome – 375 (75%)
Succulent Karoo Biome – 77 (15%)
Forest Biome – 93 (19%)

Nama-Karoo Biome – 133 (26%)
Savanna Biome – 283 (56%)
Fynbos Biome – 271 (54%)

The Grassland, Savanna, and Fynbos Biomes along and below the eastern and southern escarpment contain the highest number of mosses while the Succulent and Desert Biomes in the arid west contain the lowest number. In spite of it's small size (restricted to the Knysna area of the Western Cape Province) the Forest Biome contains 19% of all mosses in the study area. However, a total of 133 species (26% of all mosses) occurs in forests and forest patches outside the Forest Biome (sensu strictu). If these two figures are added then a total of 226 species (45% of the total number) occurs in the forests of southern Arica.

Of course many species occur in more than one biome, for example:

- 239 species (48% of the total) are found in the Grassland as well as the Savanna Biome,
- 207 species (41% of the total) occur in grasslands as well as forests,
- 188 species (37% of the total) are found in the Grassland as well as the Fynbos Biome,
- 178 species (35% of the total) accur in the Savanna Biome as well as in forests,
- 160 species (32% o fthe total) are found in the Savanna as well as the Fynbos Biome.

A total of 112 species (22% of the total number of mosses) occurs in the Savanna, Grassland, and Fynbos Biomes as well as forest areas throughout southern Africa.

11. Comparison with other regions in Africa

A number of diversity and similarity indices are available to compare the floras of different areas (Miller 1982, Slack 1984, Birks 1987). However, many of these statistical methods are not suitable for presence/absence, museum-type data sets and have been rather unsuccessful in comparing areas of diverse size, topography, climate etc.

O'Shea (1997) has recently compared moss diversity and endemism among the countries of Africa (including islands) by employing a geographic index (taxa per 10000 km²) and Bykov's Index of Endemicity. In both cases islands (e.g. Annobon, Ascension, Rodrigues, Seychelles, St. Helena) and small countries (e.g. Equatorial Guinea, Eritrea, Lesotho, Rwanda, Uganda) received the highest values. O'Shea (1997) observed that the low level of diversity recorded for some countries does not represent the true picture, and that Bykov's index does not seem to be useful in comparing endemism among areas of such diverse sizes. He concluded that "Clearly the paucity of collections and the urgent need for taxonomic review mean that the data does not give an accurate reflection of the actual diversity or endemism of the flora." (O'Shea 1997).

The exercise of comparing diversity and endemism among African countries will therefore not be repeated here. Instead, the numbers (percentages) of southern African mosses that occur in each of the African regions of Hollis & Brummit (1992) have been obtained from the MOSS database (Table 4) to determine affinities with other African floras.

It is not surprising to find that southern Africa has the greatest number of taxa (50% and more) in common with adjacent areas (South Tropical Africa) and areas with substantial Afromontane vegetation (East Tropical Africa). Relatively great numbers of taxa are also shared with islands of the Western Indian Ocean (33%), and West-Central Tropical Africa (33%).

Discussion

The following hypotheses are commonly invoked to explain patterns of plant diversity at a regional scale (Cowling *et al.* 1997b):

1. **Area.** Species number usually increases with area and the rate of increase decreases with progressively larger area.
2. **Environmental heterogeneity.** There is strong theoretical and empirical support for the hypothesis that environmental heterogeneity promotes species richness (Cowling

et al. 1997b). Measured in variables such as topographic diversity, and length of rainfall and temperature gradients.

3. **Climatic favourableness**. Measures of favourableness (e.g. mean anual rainfall, mean annual temperature) are usually positively correlated with species richness.
4. **Energy**. The number of species increases with environmentally available energy. Measured in a wide range of variables, e.g. solar radiation, precipitation (in arid zones), evapotranspiration, and primary production.
5. **Seasonality and irregularity** may promote diversity in species-rich regions.
6. **Dispersal**. Transition areas between different biotas are likely to be species rich.
7. **Speciation history**. Species richness increases in areas where ecological factors promote diversification.
8. **Effect of local processes**. The size of the regional species pool will influence local richness, especially in spore plants with the potential to disperse readily over longer distances.
9. **Convergence of regional richness**. Regions that are physiographically similar should support similar numbers of species. If not then different geographical circumstances and speciation histories may be the reason.

Goldblatt (1978) attributed the extraordinary diversity of plants in southern Africa to: 1) environmental diversity, 2) rainfall seasonality, 3) recurrent climatic fluctuations since the mid-Pliocene, and 4) the survival of relicts in favourable habitats along the coasts. Cowling & Hilton-Taylor (1994) and Cowling *et al.* (1997b) found that "Plant species richness at the regional scale in South Africa is determined largely by environmental heterogeneity.", especially in the fynbos and karroid regions. Warm, moist and aseasonal environmental conditions were found to be responsible for high plant diversity in the "...tropical-derived savanna and grassland flora,..." Cowling *et al.* (1997b). A water or moisture gradient, and in particular rainfall, has long been accepted as one of the most important climatic variables determining the diversity and distribution of (vascular) plants in southern Africa (see the *Discussion* and references at the end of Chapter 4).

What are the determinants of moss species diversity in southern Africa? The answer includes both a collecting bias and an ecological component:

- Historically Cape Town, situated at the foot of Table Mountain (grid 3318 C), the most species-rich area in southern Africa, has been the first port of call and plant collecting site for travellers from Europe (Sim, 1926, Gunn & Codd 1981).

- Similarly the high species diversity at and around Pietermaritzburg in the KwaZulu-Natal Midands (grid 2930 C) may be explained by the collecting efforts of T.R. Sim, the 'father' of southern African bryology, who resided there from 1903 to shortly before his death in 1937 (Bayer 1971, Gunn & Codd 1981).

- In the late 1800's and early 1900's the Rydal Mount and Royal Natal National Park localities, both situated in the species-rich grid of Witsieshoek (2828 D), were the only means of access for most visitors to the Drakensberg of KwaZulu-Natal and the famed Mont aux Sources (Pearse 1973).

- The Mariepskop centre of high species diversity (grid 2430 D) is largely the result of intense collecting by P. Vorster for his M.Sc. thesis (Vorster 1970, 1990).

- The Lady Grey area (grid 3027 C) probably stands out as a centre of diversity as a result of a collecting trip by J. van Rooy in February 1986.

- Higher species numbers along the southern KwaZulu-Natal – Pondoland coast are largely the result of collecting by Abbott (3030 C, 3130 A), and Van Rooy and Smook (3129 B).

- Collecting activities are frequently concentrated around large towns and cities, e.g. the grid squares at Bloemfontein (2926 A) and Kimberley (2824 D), the two largest cities in the central part of the study area, are also the most species-rich grids in that area.

Russell & Van Rooy (1988) observed that existing bryophyte records from Namibia show the influence of population centres and roads on collecting frequency. For example, the grid square where Windhoek, the largest town and capital of Namibia is situated (grid 2217 C), is also the most species-rich in that country. According to Rebelo (1994) the extraordinary high number of plant species (>2000) in the PRECIS database for each of the Cape Town and Pretoria grids is because both grids contain major herbaria and botanical gardens.

- One can also recognise roads on the moss species diversity maps of southern Africa. For example, the relatively high species numbers in grids 3224 A & B, 3124 B & D, 3125 A, 3025 B, C & D, 2926 A & C (Fig. 8) represent roadside collections along the N9 and N1 roads between Graaff-Reinet and Bloemfontein. In the same area the N6 road between Bloemfontein and Aliwal North is also visible on the diversity map. More examples of the effect of roadside collecting can be found in Rebelo (1994: 238) where the road between Gauteng and Durban via the Free State (N3), the N1 through the Karoo, and the N14 between Gauteng and Springbok via Upington are clearly visible on the species per grid map.

More examples of collecting bias are highlighted under the *Widespread Subelement*, Chapter 5.

Ecologically the southern African centres of moss diversity share the following characteristics:

- The centres are situated in the orogenic zone of southern Africa (see the map of orogenic zones compiled by M. Sherald at the Mountain Forum web site: www2.mtnforum.org/mtnforum/resources/...). This zone is characterised by steep environmental gradients, e.g. topography, moisture and temperature gradients (Schulze 1997a), which provide for hetergeneous moss habitats. Orogenic factors have been put forward by Churchill *et al.* (1995) as the most important determinants of

moss diversity in the Neotropics. In southern Africa the following favourite moss habitats are in abundance in the orogenic zone:

* stream banks in forests,
* decaying logs in or near forest openings,
* shady boulders and cliffs at waterfalls,
* rock ledges and overhangs on southern aspects,
* seepage areas, especially over rock of eastern and southern slopes.

- The centres occur in areas that contain montane forests, classified as Afromontane Forest (Low & Rebelo 1996), known worldwide as centres of high species diversity (Gradstein & Pocs 1989, Webster 1995). In southern Africa Vorster (1990) studied the distribution of bryophytes within different phanerogam communities on Mariepskop, siuated on the Drakensberg escarpment of Mpumalanga, and found that the montane forest community is the most species-rich. It is generally accepted that climatic factors, especially the higher rainfall and air humidity, and lower temperatures, as well as the habitat heterogeneity, are responsible for the higher bryophyte (plant) diversity in montane forests (Slack in Bates 1982, Gradstein & Pocs 1989, Churchill *et al.* 1995, Gradstein 1995, Webster 1995).

- The centres of high moss species diversity are situated in the highest rainfall areas of southern Africa (Schulze 1997a). The three major centres, and most of the secondary centres (the Magaliesberg centre excluded), receive in excess of 1000 mm of rain annually. O'Brien (1993) found that woody plant species richness in southern Africa is positively correlated with a range of moisture variables, in particular 'annual precipitation' and 'maximum monthly precipitation'. As far as environmental variables are concerned mean annual precipitation (Shultze 1997a) appears to be the best predictor of moss species richness in southern Africa.

- All of the centres (except the Magaliesberg centre) are situated along and below the eastern and southern escarpment (Fig. 9), a transition zone between the tropical and

temperate floras of the subcontinent (the tropical-temperate convergence zone). It is therefore an area where measures of diversity are likely to capture elements of both floras. For example along the KwaZulu-Natal Drakensberg escarpment where grid squares include temperate mosses along the edge of the Lesotho plateau as well as tropical mosses in the Afromontane forests down below (Fig. 9).

With increased collecting most of the centres of diversity will probably link up to form a more or less continuous band of high species diversity all along and below the Great Escarpment of southern Africa.

C. Endemism

1. Families

The monotypic family Wardiaceae is the only moss family endemic to southern Africa. This family is restricted to the Fynbos Biome of the south- western Cape (Fig. 13). At 2%, endemism at the family level is very low compared to the 23% of vascular plant families (Table 13). Excluding Wardiaceae, the families with the highest percentages of generic endemism in southern Africa are: Ptychomitriaceae (50%), Funariaceae (33%), Bartramiaceae (14%), and Pottiaceae (3%). In fact these families are the only ones with endemic genera in the FSA area (Table 11).

Apart from the Wardiaceae, the Catagoniaceae, with a single representative in the FSA area, is the only family with 100% endemism at the species level (Table 11). Other families with high percentages of endemic species in southern Africa are the Archidiaceae (55%), Ephemeraceae (50%), Plagiotheciaceae (50%), Ptychomitriaceae (50%), Rhizogoniaceae (50%), Brachytheciaceae (47%), Orthotrichaceae (47%), Funariaceae (44%), and Fabroniaceae (43%). The families Ptychomitriaceae and Funariaceae have high percentages of genera as well as species endemic in the FSA area (Table 11).

2. Genera

Only six, or 3% of the 204 moss genera in southern Africa are endemic to the region. This figure is low compared to the 29% generic endemism of vascular plants (Cowling & Hilton-Taylor 1997, Table 13). All of these genera except *Ptychomtriopsis* are monotypic. The geographic distributions of the genera are shown in Fig. 13. Although the endemic genera are not concentrated in any specific area, three of them (*Cygnicollum*, *Microcrossidium* and *Wardia*) occur in the winter-rainfall region of the south-western Cape (Fig. 13).

Moss genera endemic to southern Africa

Cygnicollum
Microcrossidium
Physcomitrellopsis
Ptychomitriopsis
Quathlamba
Wardia

The basic information recorded for each of the six endemic genera in the MOSS database are given here. Authors of the names can be found in Appendix I. Under the *Biome* heading, "Forest" stands for the Forest Biome as defined by Rutherford & Westfall (1986), and "For" means forests and forest patches outside the borders of this biome (see Midgley *et al.* 1997). The abbreviations used under 'Distribution in FSA-regions' are those of Magill (1981): B–Botswana, CC–central Cape, CE–eastern Cape, CN–northern Cape, CS–southern Cape, CNW–northwestern Cape, CSW–southwestern Cape, L–Lesotho, N–KwaZulu-Natal, O–Free State, S–Swaziland, SWA–Namibia, T–Transkei, TC–central Transvaal, TE–eastern Transvaal, TN–northern Transvaal, TS–southern Transvaal, TW–western Transvaal, Z–Zululand.

Endemic Genera

Family: Funariaceae

Genus: **Cygnicollum**

Species: C. immersum

Grids: 3119A

Distribution in FSA regions: CNW Endemic

Substrate: Terricolous

Biome: Fynbos

Family: Pottiaceae

Genus: **Microcrossidium**

Species: M. apiculatum

Grids: 3118D

Distribution in FSA regions: CNW Endemic

Substrate: Terricolous

Biome: Succulent

Notes: (= Crossidium apiculatum) -Cano *et al.* (1993), Zander (1993).

Family: Funariaceae

Genus: **Physcomitrellopsis**

Species: P. africana

Grids: 3228B

Distribution in FSA regions: N -Locality not precise T Endemic?

Substrate: Terricolous

Biome: Savanna For

Notes: Reported as cf. from Eastern Africa -Bizot & Pocs (1974); uncertain in Tanzania -Kis (1985), O'Shea (1995).

Family: Ptychomitriaceae

Genus: **Ptychomitriopsis**

Species: P. africana, P. aloinoides

Grids: 2016B 2016D 2017A 2116D 2117C 2217C 2230C 2317A 2318D 2718B 2718C 2827D 2830A

2918b

Distribution in FSA regions: SWA CNW CN -Locality not precise O N TN Endemic

Substrate: Saxicolous Terricolous

Biome: Succulent Savanna Grassland

Family: Bartramiaceae

Genus: **Quathlamba**

Species: Q. debilicostata

Grids: 2929C

Distribution in FSA regions: L N Endemic

Substrate: Terricolous

Biome: Grassland Nama

Family: Wardiaceae

Genus: **Wardia**

Species: W. hygrometrica

Grids: 3318B 3318C 3318D 3319A 3319C 3320C 3418A 3418B 3419A 3419B

Distribution in FSA regions: CSW Endemic

Substrate: Saxicolous Semi-aquatic

Biome: Fynbos Forest

Most of the moss genera that display 100% specific/infraspecific endemism in southern Africa are either monotypic or have single representatives in the study area (Table 12). These genera are: *Anoectangium, Cardotiella, Catagonium, Chamaebryum, Crossidium, Cygnicollum, Dimerodontium, Goniomitrium, Helicodontium, Leskeella, Leucoperichaetium, Meiothecium, Microcrossidium, Physcomitrellopsis, Plaubelia, Pottia, Quathlamba, Stoneobryum, Streptocalypta, Tetrapterum, Ulota,* and *Wardia*. Other genera with all of their species endemic to the

study area are: *Microbryum* (3), *Oligotrichum* (4), *Oxyrrhynchium* (2), and *Ptychomitriopsis* (2).

Other genera with high percentages (50% or more) of species endemic to the region are: *Acaulon* (50%), *Anomobryum* (50%), *Archidium* (55%), *Brachythecium* (50%), *Breutelia* (60%), *Dicranoloma* (50%), *Distichophyllum* (50%), *Ephemerum* (50%), *Gymnostomum* (67%), *Isopterygium* (83%), *Macrocoma* (67%), *Mielichhoferia* (50%), *Orthotrichum* (50%), *Physcomitrium* (50%), *Plagiothecium* (50%), *Pyrrhobryum* (50%), and *Weissia* (60%).

Genera with the highest individual number of endemics in southern Africa are *Archidium* (Archidiaceae) with six, *Isopterygium* (Hypnaceae) with five, and *Brachythecium* (Brachytheciaceae), *Fabronia* (Fabroniaceae), *Fissidens* (Fissidentaceae) and *Oligotrichum* (Polytrichaceae) with four endemics each (Table 12). This may change once the taxonomy of the taxa becomes better known, especially in genera like *Isopterygium, Brachythecium, Fabronia* and *Oligotrichum*.

3. Species/infraspecific taxa

There are 114 species/infraspecific taxa (23% of the total moss flora) endemic to the FSA region. The species are here listed alphabetically by genus and species. Some of the basic information recorded for each species/infraspecific taxon in the Moss database, e.g. the geographic distribution, substrate, and biome, are also given. The abbreviations used for the FSA regions are those of Magill (1981) and a list can be found under *2. Genera*. The altitude has rarely been recorded for these taxa and is omitted in the list that follows. Only those notes on the distribution and taxonomic relationships that may effect the endemic status of a taxon have been retained for this list.

Southern African endemics

Family: Pottiaceae
Genus: Acaulon
Species: recurvatum
Grids: 2917D 3017B 3119A 3318B 3421A
Distribution in FSA regions: CNW CSW CS Endemic
Substrate: Terricolous
Biome: Fynbos Succulent

Family: Andreaeaceae
Genus: Andreaea
Species: bistratosa
Grids: 3219C
Distribution in FSA regions: CSW Endemic
Substrate: Saxicolous
Biome: Fynbos

Family: Pottiaceae
Genus: Anoectangium
Species: wilmsianum
Grids: 2329D 2530A 2530D 2730B 2828D 2829A 2829C 2927B 2928A 2929A 2929B 2929C 2929D 3027C 3027D 3028A
Distribution in FSA regions: CE L O N TE TN Endemic
Substrate: Saxicolous Terricolous
Biome: Nama Grassland For

Family: Bryaceae
Genus: Anomobryum
Species: drakensbergense
Grids: 2828D 2829C 2927B 2928B 2929A 2929C 3028A
Distribution in FSA regions: L N O Endemic
Substrate: Terricolous
Biome: Grassland Nama-karoo

Family: Archidiaceae
Genus: Archidium
Species: andersonianum
Grids: 3318D
Distribution in FSA regions: CSW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Archidiaceae
Genus: Archidium
Species: capense
Grids: 2828D 2926A 2929C 3318C 3318D 3319C

Distribution in FSA regions:
CSW O L Endemic
Substrate: Terricolous
Biome: Nama-karoo Fynbos Grassland
Note: Reported from Zaire by Demaret (1946), fide Born *et al.* (1993) and O'Shea (1995).

Family: Archidiaceae
Genus: Archidium
Species: dinteri
Grids: 2217C 2818B
Distribution in FSA regions:
SWA Endemic
Substrate: Terricolous
Biome: Savanna Nama-karoo

Family: Archidiaceae
Genus: Archidium
Species: julicaule
Grids: 2929C 3318C
Distribution in FSA regions:
CSW L Endemic
Substrate: Terricolous
Biome: Fynbos Nama-karoo

Family: Archidiaceae
Genus: Archidium
Species: muelleranum
Grids: 3318C 3318D 3319A
Distribution in FSA regions:
Endemic CSW
Substrate: Terricolous
Biome: Fynbos
Note:Listed for Zimbabwe (as cf.) by Best (1990).

Family: Archidiaceae
Genus: Archidium
Species: subulatum
Grids: 3318C
Distribution in FSA regions:
CSW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Pottiaceae
Genus: Barbula
Species: microcalycina
Grids: 2828D 2829C 2927B 2928B 2929A 2929C
Distribution in FSA regions: L N O Endemic
Substrate: Terricolous Saxicolous
Biome: Grassland Nama-karoo

Family: Bartramiaceae
Genus: Bartramia
Species: capensis

Grids: 2929D 2930A 2930D 3225D 3318C 3318D 3319C 3319D 3321C 3322C 3418A 3418B 3419B
Distribution in FSA regions: CSW CS CC N Endemic
Substrate: Terricolous
Biome: Grassland Fynbos
Note: Erroneously reported from eastern Africa by Kis (1985), see Magill 1987.

Family: Bartramiaceae
Genus: Bartramia
Species: compacta *var.* macowaniana
Grids: 3225D
Distribution in FSA regions:CC Endemic
Substrate: Terricolous
Biome: Grassland

Family: Brachytheciaceae
Genus: Brachythecium
Species: pinnatum
Grids: 3422B 3423A
Distribution in FSA regions: CS Endemic
Substrate:
Biome: Forest Fynbos

Family: Brachytheciaceae
Genus: Brachythecium
Species: pseudopopuleum
Grids: 3422B
Distribution in FSA regions: CS Endemic
Substrate: ?
Biome: Fynbos

Family: Brachytheciaceae
Genus: Brachythecium
Species: pseudovelutinum
Grids: 3419B
Distribution in FSA regions: CSW Endemic
Substrate: ?
Biome: Fynbos

Family: Brachytheciaceae
Genus: Brachythecium
Species: subrutabulum
Grids: 2230C 2828A 2828D 2927B 2929A 2929B 2930A 3029D 3225D
Distribution in FSA regions:CC O L N TN Endemic
Substrate: Corticolous-Forest litter Terricolous
Biome: Savanna Grassland For

Family: Bartramiaceae

Genus: Breutelia
Species: elliptica
Grids: 3323C 3323D
Distribution in FSA regions: CS Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Bartramiaceae
Genus: Breutelia
Species: substricta
Grids: 2828D 2829A 2929C 3018A 3219C 3219D 3225D 3318C 3318D 3319A 3319B 3319C 3319D 3321A 3321B 3321C 3321D 3322A 3322B 3322C 3322D 3323C 3418B 3419A 3420A
Distribution in FSA regions: CNW CSW CS CC L O N Endemic
Substrate: Terricolous Saxicolous
Biome: Grassland Fynbos Succulent

Family: Bartramiaceae
Genus: Breutelia
Species: tabularis
Grids: 3318C 3418B
Distribution in FSA regions: CSW Endemic
Substrate: Terricolous Saxicolous
Biome: Fynbos

Family: Orthotrichaceae
Genus: Cardotiella
Species: secunda
Grids: 2731B 2731D 3129B 3227C 3228C 3318C 3322C 3322D 3323C 3418A 3418B 3419B 3419C 3424B
Distribution in FSA regions: CSW CS CE T Z Endemic
Substrate: Corticolous Saxicolous
Biome: Savanna For Fynbos Forest

Family: Catagoniaceae
Genus: Catagonium
Species: nitens ssp maritimum
Grids: 2330C 2430A 2531C 2631A 2828D 2829C 2830D 2929C 2930D 3128B 3129B 3130A 3218B 3226D 3228C 3318C 3320C 3320D 3321C 3322C 3322D 3323C 3323D 3326B 3418A 3418B 3419A 3421A 3422B 3423A 3423B

Distribution in FSA regions:
CSW CS CE N S TE TN
Endemic
Substrate: Corticolous
Terricolous Saxicolous Forest
litter Humicolous
Biome: For Fynbos Forest
Grassland Savanna
Note:(= Leucodon maritimus) -
Lin (1984); Catagoniaceae -Buck
& Ireland (1985)
The species is also known from
eastern Africa, New Guinea,
Australia, New Zealand, the
Mascarenes, the subantarctic,
central and south America, and
Swaziland-Lin (1984).

Family: Gigaspermaceae
Genus: Chamaebryum
Species: pottioides
Grids: 2615C 2716C 2716D
2718C 2816B 2816D 2817A
2817C 2823B 2917B 2917D
2918B 2918C 2919A 2921A
3017B 3017D 3018A 3025C
3118C 3118D 3119A 3119C
3218B 3218D 3219C 3221B
3318C 3318D 3319A 3320B
3320C 3322C 3419B 2616C
3018D

Distribution in FSA regions:
SWA CNW CSW CS CC Cn
Endemic
Substrate: Terricolous
Biome: Savanna Fynbos
Succulent Nama-karoo

Family: Pottiaceae
Genus: Crossidium
Species: spiralifolium
Grids: 2716D 2922D
Distribution in FSA regions:
SWA CC Endemic
Substrate: Terricolous
Biome: Nama-karoo Succulent

Family: Funariaceae
Genus: Cygnicollum
Species: immersum
Grids: 3119A
Distribution in FSA regions:
CNW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Dicranaceae
Genus: Dicranella
Species: rigida
Grids: 3118D 3318C 3318D
3418B

Distribution in FSA regions:
CSW CNW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Dicranaceae
Genus: Dicranoloma
Species: Entabeniense
Grids: 2230C
Distribution in FSA regions: TN
Endemic
Substrate: Saxicolous
Biome: Savanna For

Family: Pottiaceae
Genus: Didymodon
Species: Jackvancei
Grids: 2928D 2929C
Distribution in FSA regions: L
Endemic
Substrate: Terricolous
Saxicolous
Biome: Grassland
Note:(= Husnotiella plicata) -
Zander (1993)

Family: Pottiaceae
Genus: Didymodon
Species: xanthocarpus
Grids: 2628A 2817A 2817C
2917D 2928B 2929A 3017B
3017D 3018A 3019C 3118D
3119A 3119C 3119D 3124B
3217D 3218A 3218B 3218D
3219C 3318C 3318D
3319C 3319D 3320A 3320B
3320C 3320D 3321A 3321B
3321D 3322A 3322C
3323B 3323D 3324D 3325A
3325C 3325D 3326B 3418A
3418B 3419C 3419D
3420A 3421A 3421B 3422A
3423A
Distribution in FSA regions:
CNW CSW CS CE CC L N -
Locality not precise TS Endemic
Substrate: Terricolous
Saxicolous
Biome: Savanna Nama-karoo
Grassland Fynbos Succulent

Family: Fabroniaceae
Genus: Dimerodontium
Species: africanum
Grids: 2430D 2831C 3227C
3318C 3318D 3322C
Distribution in FSA regions:
CSW CS CE Z TE Endemic
Substrate: Corticolous
Biome: Fynbos Savanna

Family: Hookeriaceae
Genus: Distichophyllum
Species: mniifolium *var.* taylorii
Grids: 3322D
Distribution in FSA regions: CS Endemic
Substrate: Corticolous
Biome: Fynbos For

Family: Entodontaceae
Genus: Entodon
Species: natalensis
Grids: 2430D 2530A 2530D 2927D 2929A
Distribution in FSA regions: L N TE Endemic
Substrate: Terricolous Saxicolous
Biome: Grassland Savanna

Family: Ephemeraceae
Genus: Ephemerum
Species: diversifolium
Grids: 3324D
Distribution in FSA regions: CS Endemic
Substrate: Terricolous
Biome: Savanna

Family: Ephemeraceae
Genus: Ephemerum
Species: namaquense
Grids: 2817A 2917D 3018A 3118D 3218B 3319B 3319C
Distribution in FSA regions: CNW CSW Endemic
Substrate: Terricolous
Biome: Succulent Fynbos

Family: Erpodiaceae
Genus: Erpodium
Species: coronatum *subsp.* transvaaliense
Grids: 1917B 1917D 1918A 1918C 2229D 2328C 2427B 2428C 2429A 2526C 2527A 2527B 2527C 2527D 2528B 2528C 2830C
Distribution in FSA regions: SWA N TC TW TN Endemic
Substrate: Corticolous
Biome: Savanna
Note:(= E.transvaaliense) Magill & Van Rooy (1998)
The species has a African-Neotropical distribution pattern

Family: Fabroniaceae
Genus: Fabronia
Species: breutelii
Grids: 3218C

Distribution in FSA regions:
CSW Endemic
Substrate:
Biome: Fynbos

Family: Fabroniaceae
Genus: Fabronia
Species: eckloniana
Grids: 3225D
Distribution in FSA regions:CC Endemic
Substrate: ?
Biome: Nama-karoo

Family: Fabroniaceae
Genus: Fabronia
Species: perciliata
Grids: 2430C 2527D 2528C 2530A 2531C 2919B 2929A 2930A 3318C
Distribution in FSA regions: CNW CSW N TC TE Endemic
Substrate: Saxicolous
Biome: Fynbos Savanna Nama-karoo Grassland

Family: Fabroniaceae
Genus: Fabronia
Species: wageri
Grids: 3318C 3318D

Distribution in FSA regions:
CSW Endemic
Substrate: Corticolous
Biome: Fynbos

Family: Fissidentaceae
Genus: Fissidens
Species: aciphyllus
Grids: 2528C 2529C 2828D 2829C 2832C 2930C 3029D 3129D 3228B
Distribution in FSA regions: T N Z O TC Endemic
Substrate: Terricolous Saxicolous
Biome: Grassland Savanna For

Family: Fissidentaceae
Genus: Fissidens
Species: capriviensis
Grids: 1723C
Distribution in FSA regions:
SWA Endemic
Substrate: Corticolous
Biome: Savanna

Family: Fissidentaceae
Genus: Fissidens
Species: fasciculatus
Grids: 2430D 3318C 3318D 3319A 3319C 3320C 3320D

3322C 3323C 3323D 3418A 3418B 3419A 3419B 3420B 3422A 3423A
Distribution in FSA regions: CSW CS N-Locality not precise TE Endemic
Substrate: Terricolous Saxicolous Semi-aquatic
Biome: Fynbos Grassland Forest For

Family: Fissidentaceae
Genus: Fissidens
Species: wageri
Grids: 2531C 2630D 2831C 2832A 2930C 3030B 3129C 3228A 3228B
Distribution in FSA regions: T N Z TE Endemic
Substrate: Terricolous
Biome: Savanna Grassland For
Note:Close to F. amazonicus in the Neotropics (species pair) - Pursell *et al.* (1992)

Family: Funariaceae
Genus: Funaria
Species: bergiana
Grids: 2115D 2217C 2230C 2430C 2828D 2829C 2917D 2928B 2929A 2929C 2930A 3027C 3219A 3224B 3318C 3318D 3319C 3421A
Distribution in FSA regions: SWA CNW CSW CS CC CE L O N TE TN Endemic
Substrate: Terricolous
Biome: Grassland Savanna Nama-karoo Fynbos Succulent

Family: Funariaceae
Genus: Funaria
Species: clavata
Grids: 2919A 3017B 3119A 3218B 3318A 3318C 3319A 3319C 3418A 3421A
Distribution in FSA regions: CNW CSW CS Endemic
Substrate: Terricolous
Biome: Nama-karoo Fynbos Succulent

Family: Funariaceae
Genus: Funaria
Species: rhomboidea:
Grids: 2116D 2216D 2416D 2417C 2417D 2730A 2926A 3224B
Distribution in FSA regions: SWA CC O TE Endemic
Substrate: Terricolous

Biome: Grassland Nama-karoo Savanna
Note: Recorded as cf. for Zimbabwe -Best (1990).

Family: Funariaceae
Genus: Goniomitrium
Species: africanum
Grids: 2528C 2526C 2718B 2720C 2816B 2816D 2817A 2822C 2917A 2917D 2918C 2922D 2926A 2928B 3017B 3017D 3018A 3018C 3022A 3023A 3024B 3025C 3119A 3119D 3218B 3220D 3320B
2616C 2716C
Distribution in FSA regions: SWA CNW CSW CC Cn O L TC TW Endemic
Substrate: Terricolous
Biome: Savanna Grassland Nama-karoo Succulent

Family: Pottiaceae
Genus: Gymnostomum
Species: Bewsii
Grids: 2430d 2729d 2828d 2829c 2928a 2928b 2929a 2929c 2929d 3027c 3027d 3028a 3028b
Distribution in FSA regions: CE L N O TE T Endemic
Substrate: Terricolous Saxicolous
Biome: Nama-karoo Grassland For

Family: Pottiaceae
Genus: Gymnostomum
Species: lingulatum
Grids: 2329D
Distribution in FSA regions: TN Endemic
Substrate: Saxicolous
Biome: Grassland For

Family: Fabroniaceae
Genus: Helicodontium
Species: lanceolatum
Grids: 2430D 2831C 3327B 3318C 3322C
Distribution in FSA regions: CSW CS CE Z TE Endemic
Substrate: Corticolous
Biome: Fynbos Savanna

Family: Hypnaceae
Genus: Isopterygium
Species: leucopsis
Grids: 2527D 2530B 2531C 2732A

Distribution in FSA regions: N - Locality not precise Z TE TC Endemic
Substrate: Terricolous Corticolous
Biome: Savanna For

Family: Hypnaceae
Genus: Isopterygium
Species: punctulatum
Grids: 2527D 2831C 2930C 3318C 3318B 3419A
Distribution in FSA regions: CSW N Z TC Endemic
Substrate: Saxicolous Corticolous
Biome: Grassland Savanna Fynbos

Family: Hypnaceae
Genus: Isopterygium
Species: strangulatum
Grids: 3218B 3325C 3418A 3419A 3419B
Distribution in FSA regions: CSW CS T -Locality not precise Endemic
Substrate: Terricolous, Semi-aquatic Wet Places
Biome: Savanna Fynbos

Family: Hypnaceae
Genus: Isopterygium
Species: taxithelioides
Grids: 2831C
Distribution in FSA regions: Z Endemic
Substrate: Corticolous
Biome: Grassland

Family: Hypnaceae
Genus: Isopterygium
Species: taylorii
Grids: 3319C 3322D
Distribution in FSA regions: CSW CS Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Leskeaceae
Genus: Leskeella
Species: zuluensis
Grids: 2831C
Distribution in FSA regions: Z Endemic
Substrate: Corticolous
Biome: Savanna

Family: Dicranaceae
Genus: Leucobryum
Species: rehmannii

Grids: 3323C 3323D 3324C 3423A
Distribution in FSA regions: CS Endemic
Substrate: Terricolous Corticolous
Biome: Forest Fynbos For

Family: Dicranaceae
Genus: Leucoloma
Species: sprengelianum
Grids: 2330C 2430D 2530B 2531C 3218B 3318C 3318D 3319C 3320C 3321C 3323D 3418A 3418B 3419A 3419B 3420A 3420B
Distribution in FSA regions: CSW CS TE TN Endemic
Substrate: Terricolous Saxicolous Corticolous Forest litter
Biome: Grassland Savanna Fynbos For

Family: Grimmiaceae
Genus: Leucoperichaetium
Species: eremophilum
Grids: 2716D
Distribution in FSA regions: SWA Endemic
Substrate: Saxicolous
Biome: Succulent

Family: Leskeaceae
Genus: Lindbergia
Species: viridis
Grids: 2230C 2430C 2527D 2528C 2530B 2530D 2631A 2730D 2926A 2929C 2930C 3228A
Distribution in FSA regions: T O N S TC TE TN Endemic
Substrate: Saxicolous Corticolous
Biome: Savanna Grassland

Family: Orthotrichaceae
Genus: Macrocoma
Species: lycopodioides
Grids: 2229D 2230C 2329A 2329D 2330A 2330C 2429B 2430A 2430D 2530C 2631A 2730A 2731B 2731C 2828D 2829A 2831C 2929A 3029D 3030C 3128B 3129C 3226D 3227C 3318D 3320C 3322D 3323C 3324D 3326D 3418A 3419B 3419C 3420A 3423A 3423B 2530B
Distribution in FSA regions: CSW CS CE T O N Z S TE TC TN Endemic

Substrate: Corticolous
Saxicolous
Biome: Savanna Grassland For
Forest Fynbos
Note: It's occurrence in Angola and Zimbabwe (Kis 1985) not confirmed by Magill & Vitt (1981), Van Rooy & Van Wyk (1992) or Magill & Van Rooy (1998)

Family: Orthotrichaceae
Genus: Macrocoma
Species: pulchella
Grids: 3318C 3318D 3319C
Distribution in FSA regions:
CSW Endemic
Substrate: Corticolous
Biome: Fynbos
Note: It's occurrence in Zimbabwe and Kenya (Kis 1985) not confirmed by Magill & Vitt (1981), Van Rooy & Van Wyk (1992) or Magill & Van Rooy (1998)

Family: Orthotrichaceae
Genus: Macromitrium
Species: lebomboense
Grids: 2732A 2732C 2831D 2832A 2832C 2930A 3030B 3129B 3227C 3228B 3228C 3326B 3326D
Distribution in FSA regions: CE T N Z Endemic
Substrate: Corticolous
Saxicolous Swamp
Biome: Savanna For Grassland

Family: Orthotrichaceae
Genus: Macromitrium
Species: macropelma
Grids: 3320D 3322C 3423A
Distribution in FSA regions:
CSW CS Endemic
Substrate: Corticolous
Saxicolous
Biome: Fynbos Forest

Family: Sematophyllaceae
Genus: Meiothecium
Species: fuscescens
Grids: -Locality not precise (3318c)
Distribution in FSA regions:
CSW Endemic
Substrate: ?
Biome: Fynbos

Family: Pottiaceae

Genus: Microbryum
Species: davallianum *var.* conicum
Grids: 2820C 3118D 3224B 3225B 3225D
Distribution in FSA regions: CNW Cn CC Endemic
Substrate: Terricolous
Biome: Succulent Nama-karoo
Note:(= Pottia macowaniana) Zander (1993)

Family: Pottiaceae
Genus: Microbryum
Species: rufochaete
Grids: 2824D 3119A 3118D 3218B
Distribution in FSA regions: CNW CSW Cn Endemic
Substrate: Terricolous
Biome: Succulent Savanna
Note:(= Acaulon rufochaete) - Zander (1993)

Family: Pottiaceae
Genus: Microbryum
Species: subplanomarginatum
Grids: 2416C 3118D 3224B 3318D 3326D 3418B
Distribution in FSA regions: CNW CSW CC CE SWA Endemic
Substrate: Terricolous
Biome: Fynbos Savanna Nama-karoo
Note:(= Pottia subplanomarginata) -Zander (1993)

Family: Pottiaceae
Genus: Microcrossidium
Species: apiculatum
Grids: 3118D
Distribution in FSA regions: CNW Endemic
Substrate: Terricolous
Biome: Succulent
Note:(= Crossidium apiculatum) -Cano *et al.* (1993) ; Zander (1993)

Family: Bryaceae
Genus: Mielichhoferia
Species: subnuda
Grids: 2730D 2827A 2828D 2829C 2829D 2929A 2929B 2929C 2929D 2930A 2930C 3227C
Distribution in FSA regions: CE L O N Endemic

Substrate: Terricolous
Biome: Grassland Nama-karoo

Family: Polytrichaceae
Genus: Oligotrichum
Species: afrolaevigatum
Grids: 2929A 2929B 2929C
2929D 2930C
Distribution in FSA regions: L N
Endemic
Substrate: Terricolous
Biome: Nama-karoo Grassland

Family: Polytrichaceae
Genus: Oligotrichum
Species: capense
Grids: 2929C 3319A 3319C
Distribution in FSA regions:
CSW N Endemic
Substrate: Terricolous
Biome: Fynbos Grassland

Family: Polytrichaceae
Genus: Oligotrichum
Species: tetragonum
Grids: 3219A
Distribution in FSA regions:
CSW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Polytrichaceae
Genus: Oligotrichum
Species: wageri
Grids: 2828D 2929C
Distribution in FSA regions: N O
Endemic
Substrate: Terricolous
Biome: Grassland

Family: Orthotrichaceae
Genus: Orthotrichum
Species: armatum
Grids: 3226D
Distribution in FSA regions: CE
Endemic
Substrate: Corticolous
Biome: Grassland

Family: Orthotrichaceae
Genus: Orthotrichum
Species: incurvomarginatum
Grids: 2817A 3018A 3119A
3218B 3219A 3219C 3318C
Distribution in FSA regions:
CNW CSW Endemic
Substrate: Corticolous
Biome: Succulent Fynbos

Family: Orthotrichaceae
Genus: Orthotrichum
Species: oreophilum

Grids: 2828D 2928B 2929C
Distribution in FSA regions: L
Endemic
Substrate: Saxicolous
Biome: Nama-karoo

Family: Orthotrichaceae
Genus: Orthotrichum
Species: transvaalense
Grids: 2329D 2729C 2730A 2730D 2927A 2930B
Distribution in FSA regions: O N TN Endemic
Substrate: Corticolous
Biome: Grassland

Family: Brachytheciaceae
Genus: Oxyrrhynchium
Species: confervoideum
Grids: 3318D 2930C
Distribution in FSA regions: CSW N Endemic
Substrate: Terricolous
Biome: Fynbos Grassland

Family: Brachytheciaceae
Genus: Oxyrrhynchium
Species: subasperum
Grids: 2230C 2330C 2430A 2430D 2528C 2831D 2930C 2930D 3029D 3129D 3227C 3318C 3326A
Distribution in FSA regions: CSW CE T N Z TC TE TN
Endemic
Substrate: Terricolous Saxicolous Corticolous Forest litter
Biome: Grassland Savanna For

Family: Bartramiaceae
Genus: Philonotis
Species: comosa
Grids: 3318C 3319C 3322C 3418B
Distribution in FSA regions: CSW CS Endemic
Substrate: Terricolous
Biome: Fynbos
Note:(= Bartramidula)

Family: Funariaceae
Genus: Physcomitrellopsis
Species: africana
Grids: 3228B
Distribution in FSA regions: N - Locality not precise T Endemic ?
Substrate: Terricolous
Biome: Savanna For

Note: Reported as cf. from Eastern Africa -Bizot & Pocs (1974); uncertain in Tanzania - Kis (1985), O'Shea (1995).

Family: Funariaceae
Genus: Physcomitrium
Species: spathulatum *var.* sessile
Grids: 3025C 3224B
Distribution in FSA regions:CC Endemic
Substrate: Terricolous
Biome: Nama-karoo

Family: Plagiotheciaceae
Genus: Plagiothecium
Species: membranosulum
Grids: 2430D 2930D 3318C 3319C 3321A 3418A
Distribution in FSA regions: CSW CS N TE Endemic
Substrate: Terricolous Saxicolous
Biome: Fynbos Grassland

Family: Pottiaceae
Genus: Plaubelia
Species: involuta
Grids: 1816D 2023B
Distribution in FSA regions: SWA B Endemic
Substrate: Saxicolous
Biome: Savanna
Note:(= Weisiopsis involuta) Zander (1993)

Family: Ditrichaceae
Genus: Pleuridium
Species: papillosum
Grids: 3218B
Distribution in FSA regions: CSW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Polytrichaceae
Genus: Pogonatum
Species: borgenii
Grids: 2931A
Distribution in FSA regions: N Endemic
Substrate: ?
Biome: Grassland
Note: = P. capense -Hyvonen (1989)

Family: Pottiaceae
Genus: Pottia
Species: Namaquensis
Grids: 2817A 2817C 2917D
Distribution in FSA regions: CNW Endemic

Substrate: Terricolous

Biome: Succulent

Family: Leskeaceae

Genus: Pseudoleskeopsis

Species: unilateralis

Grids: 3127A

Distribution in FSA regions: CE Endemic

Substrate: Saxicolous

Biome: Grassland

Family: Pterobryaceae

Genus: Pterobryopsis

Species: rehmannii

Grids: -Locality not precise (2930C)

Distribution in FSA regions: N Endemic

Substrate: Corticolous

Biome: ?

Family: Ptychomitriaceae

Genus: Ptychomitriopsis

Species: africana

Grids: 2230C 2830A

Distribution in FSA regions: N TN Endemic

Substrate: Saxicolous

Biome: Grassland Savanna

Family: Ptychomitriaceae

Genus: Ptychomitriopsis

Species: aloinoides

Grids: 2016B 2016D 2017A 2116D 2117C 2217C 2317A 2318D 2718B 2718C 2827D 2918B

Distribution in FSA regions: SWA CNW Cn -Locality not precise O Endemic

Substrate: Saxicolous Terricolous

Biome: Succulent Savanna Grassland

Family: Ptychomitriaceae

Genus: Ptychomitrium

Species: depressum

Grids: 2430C 2631A 2730B 2829C 2830C 2830D 2831D 2927A 2929B 2930A 2930C 3128B 3227C 3228A 3320D 3420A

Distribution in FSA regions: CSW CE T O N Z S TE Endemic

Substrate: Saxicolous

Biome: Savanna Grassland For Fynbos

Family: Ptychomitriaceae

Genus: Ptychomitrium

Species: diexaratum
Grids: 2828D 2829C 2927A 2928B 2928C 2929C 3028A
Distribution in FSA regions: L N Endemic
Substrate: Saxicolous
Biome: Grassland Nama-karoo
For

Family: Ptychomitriaceae
Genus: Ptychomitrium
Species: exaratifolium
Grids: 2431D 2531A 2531C 2632A 2731D 2732C
Distribution in FSA regions: Z S TE Endemic
Substrate: Saxicolous
Biome: Savanna

Family: Rhizogoniaceae
Genus: Pyrrhobryum
Species: vallisgratiae
Grids: 3218B 3318C 3318D 3319A 3319C 3320C 3322C 3323D 3418A 3418B 3419A 3419B
Distribution in FSA regions: CSW CS Endemic
Substrate: Terricolous Saxicolous Corticolous
Biome: Fynbos

Family: Bartramiaceae
Genus: Quathlamba
Species: debilicostata
Grids: 2929C
Distribution in FSA regions: L N Endemic
Substrate: Terricolous
Biome: Grassland Nama-karoo

Family: Brachytheciaceae
Genus: Rhynchostegium
Species: subbrachypterum
Grids: 2831C 3227C
Distribution in FSA regions: CE Z Endemic
Substrate: Corticolous
Biome: Grassland

Family: Brachytheciaceae
Genus: Rhynchostegiella
Species: sublaevipes
Grids: 2831C
Distribution in FSA regions: Z Endemic
Substrate: Corticolous
Biome: Grassland

Family: Orthotrichaceae
Genus: Schlotheimia
Species: rufopallens

Grids: 2329D 2429A 2731C
2828D 2831C 2832A 2930C
3029D 3226D 3227C 3228B
3318C 3321C 3322C 3323C
3423A 3423B
Distribution in FSA regions:
CSW CS CE T N Z TC TN
Endemic
Substrate: Saxicolous
Corticolous Forest litter Swamp
Biome: Grassland For Savanna
Fynbos Forest

Family: Sematophyllaceae
Genus: Sematophyllum
Species: zuluense
GRIDS: 2430D 2831C 2831D
3322C
Distribution in FSA regions: CS
Z TE Endemic
Substrate: Saxicolous
Corticolous
Biome: Grassland Fynbos For

Family: Orthotrichaceae
Genus: Stoneobryum
Species: mirum
GRIDS: 2730D 2829C 2929A
2929B 2929C 2930A 2930C
Distribution in FSA regions: N
Endemic
Substrate: Corticolous
Biome: For Grassland

Family: Pottiaceae
Genus: Streptocalypta
Species: pulchiretis
Grids: 2828D
Distribution in FSA regions: N
Endemic
Substrate: Saxicolous
Biome: Grassland
Note:(= Weisiopsis pulchiretis)
Zander (1993)

Family: Pottiaceae
Genus: Syntrichia
Species: austroafricana
Grids: 2928D 3028A 3224A
Distribution in FSA regions:CC
L Endemic
Substrate: Terricolous
Saxicolous
Biome: Grassland

Family: Pottiaceae
Genus: Tetrapterum
Species: tetragonum
Grids: 3118D 3218B 3219C
3318C 3318D 3319A 3319B
3319C 3320B

Distribution in FSA regions:
CNW CSW Endemic
Substrate: Terricolous
Biome: Fynbos Succulent

Family: Pottiaceae
Genus: Tortula
Species: splachnoides
Grids: 2917D 3018A 3018C 3222D 3318C 3320C
Distribution in FSA regions:
CNW CSW CC Endemic
Substrate: Terricolous
Biome: Succulent Nama-karoo Fynbos
Note:(= Pottia splachnoides) - Zander (1993)

Family: Dicranaceae
Genus: Trematodon
Species: pillansii
Grids: 3219A 3318C 3318D 3319A 3319C 3320C 3418A
Distribution in FSA regions:
CSW Endemic
Substrate: Saxicolous Terricolous
Biome: Fynbos

Family: Orthotrichaceae
Genus: Ulota
Species: ecklonii
Grids: 3318C 3418B
Distribution in FSA regions:
CSW Endemic
Substrate: Corticolous
Biome: Fynbos

Family: Wardiaceae
Genus: Wardia
Species: hygrometrica
Grids: 3318B 3318C 3318D 3319A 3319C 3320C 3418A 3418B 3419A 3419B
Distribution in FSA regions:
CSW Endemic
Substrate: Saxicolous Semi-aquatic
Biome: Fynbos For

Family: Pottiaceae
Genus: Weissia
Species: cucullata
Grids: 3419B
Distribution in FSA regions:
CSW Endemic
Substrate: Terricolous
Biome: Fynbos

Family: Pottiaceae
Genus: Weissia
Species: dieterleniae

Grids: 2727B 2827D 2828C
2928B 3027C 3027D 3028A
Distribution in FSA regions: CE
L O Endemic
Substrate: Terricolous
Saxicolous
Biome: Grassland

Family: Pottiaceae
Genus: Weissia
Species: humicola
Grids: 3128B 3225D
Distribution in FSA regions:CCT
Endemic
Substrate: Terricolous
Biome: Grassland
Note: O'Shea (1995) erroneously reports this from Tanzania and Zimbabwe

Family: Orthotrichaceae
Genus: Zygodon
Species: dixonii
Grids: 2929A
Distribution in FSA regions: N
Endemic
Substrate: Saxicolous
Biome: Grassland

Family: Orthotrichaceae
Genus: Zygodon
Species: leptobolax
Grids: 3318C
Distribution in FSA regions:
CSW Endemic
Substrate: Corticolous
Biome: Fynbos For?

4. Centres of endemism

The Centres of Endemism formally described here are based on the number of moss endemics per ½° grid square in southern Africa (Fig. 14). Many of these centres coincide with the Centres of Diversity (Fig. 9) and should be read in conjunction with them.

Main centres of moss endemism in southern Africa

1. South-western Cape Centre of Endemism
2. KwaZulu-Natal Centre of Endemism
   2.1 Drakensberg Subcentre of Endemism

2.2 Midlands Subcentre of Endemism

2.3 Zululand Subcentre of Endemism

Secondary centres of moss endemism in southern Africa

3. Cederberg Centre of Endemism
4. Kamiesberg Centre of Endemism
5. Outeniqua Centre of Endemism
6. Amathole Centre of Endemism
7. Mpumalanga Centre of Endemism
8. Soutpansberg Centre of Endemism

a) Main centres of endemism

Areas where more than 15 endemics are concentrated are arbitrarily treated as main centres of endemism (Fig. 15).

1. South-western Cape Centre of Endemism

This is by far the largest and most important centre of moss species endemism in southern Africa (Fig. 15). The Cape Town or Table Mountain grid (3318 C) contains the highest number of endemics (35) in southern Africa while the grids covering the Cape Fold Mountains directly to the east (3318 D, 3319 C) contains 21 and 18 endemics respectively (Fig. 14).

This centre has been described as the South-western Centre (Weimarck 1941) and the Caledon Centre (Croizat 1965, Nordenstam 1969) and falls into the Cape Floristic Region or centre of vascular plant diversity and endemism (Rebelo 1994; Cowling & Hilton-Taylor 1994, 1997; Van Wyk & Van Wyk 1997; Fig. 4). It overlaps with the South-western Cape Centre of Diversity (see discussion there).

Grid 3320 C (Langeberg Mountains north of Swellendam) is provisionally included in this centre but may actually represent a separate centre or subcentre of moss species endemism (Fig. 15), described as the Lange Berg Centre by Weimarck (1941).

2. KwaZulu-Natal Centre of Endemism

This centre of moss species endemism covers more or less the same area as the KwaZulu-Natal Centre of Diversity (see discussion there, and compare Figs. 9 & 15). The grid squares with the highest number of endemics are 2828 D (Mont aux Sources area) with 17 and 2929 C (Sani Pass-Sehlabathebe area) with 19 endemics (Fig. 14). At present it can be subdivided into 3 subcentres.

The KwaZulu-Natal Centre of Endemism overlaps with parts of the Maputaland-Pondoland Region as defined by Van Wyk (1994), the Drakensberg Afromontane Regional System as described by Beentje *et al.* (1994), as well as the Drakensberg Alpine Region of plant diversity and endemism (Killick 1994). The location of these centres are shown in Fig. 4.

2.1 Drakensberg Subcentre of Endemism

This centre comprises the KwaZulu-Natal Drakensberg as well as the highlands of north-eastern Lesotho, from Witsieshoek or Phuthaditjhaba (2828 D) in the north, to Sehlabathebe (2929 C) in the south (Fig. 15).

It overlaps with the Drakensberg Subcentre of Diversity (see discussion there and Fig. 9).

2.2 Midlands Subcentre of Endemism

Consists of grid 2930 A (Karkloof area) with nine endemics recorded, and 2930 C (Pietermaritzburg) with 12 endemics (Figs. 14 & 15).

This subcentre of endemism overlaps with the Midlands Subcentre of Diversity (see discussion there and Fig. 9).

2.3 Zululand Subcentre of Endemism

At present grid 2831 C (Nkandla-Eshowe), with 12 endemics recorded, is sufficiently separated from the Midlands Subcentre of Endemism to recognise a separate subcentre (Figs. 14 & 15). The Zululand forests also stand out as a centre of moss species diversity (see discussion under the Midlands Subcentre of Diversity). Geologically this area is quite complex (Visser 1984) and different from the rest of the KwaZulu-Natal Centre of Endemism.

b) Secondary centres of endemism

Areas with a maximum of 14 endemics, but not less than eight, are included here (Fig. 15).

3. Cederberg Centre of Endemism

Extends from the northern part of the Cederberg Mountains (3218 B) to the Bokkeveldberge between Vanrhynsdorp (3118 D) and Nieuwoudtville (3119 A) (Fig. 15). It is more or less restricted to quartzitic sandstones of the Table Mountain Group.

This centre of endemism overlaps with the Cederberg Centre of Diversity (see discussion there and Fig. 9), previously described as the Cederberg Centre (of endemism) by Weimarck (1941).

4. Kamiesberg Centre of Endemism

Occurs on the higher lying areas of Namaqualand (Fig. 15). The highest number of endemics has been recorded from the Springbok grid (2917 D) but the Kamieskroon (3017 B) and Kamiesberge (3018 A) grids are also part of

this centre (Fig. 14). Geologically this centre is associated with gneisses of the Okiep Group and the Little Namaqualand, Spektakel, and Hoogoor Suites.

The moss centre of endemism overlaps with the Kamiesberg Centre of vascular plant diversity and endemism (Weimarck 1941; Hilton-Taylor 1994,1996; Van Wyk & Van Wyk 1997; Fig. 4).

5. **Outeniqua Centre of Endemism**

This centre occupies the same area as the Outeniqua Centre of Diversity (see discussion there and Fig. 9). Grid squares 3322 (Wilderness-Sedgefield), 3323 C (Knysna Forest), 3423 A (Knysna-Plettenbergbaai), and 3323 D (The Tsitsikamma) contain between eight and 14 endemic species (Figs. 14 & 15).

Weimarck (1941) described this area as the Zitzikamma subcentre of the South-eastern centre of endemism.

6. **Amathole Centre of Endemism**

Nine endemic species have been recorded from the Afromontane forests in grid 3227 C, situated in the Keiskammahoek-KingWilliam's Town-Stutterheim area (Figs. 14 & 15).

This centre of endemism overlaps with the Amathole Centre of Diversity (see discussion there and Fig. 9).

7. **Mpumalanga Centre of Endemism**

Not as pronounced and extensive as the Mpumalanga Centre of Diversity (Fig. 9) with which it overlaps. This centre of endemism is restricted to the Blyderivierspoort-Graskop area (grid 2430 D) Where a total of 10 endemics has been recorded (Figs. 14 & 15).

Also known as the Wolkberg Centre of endemism (Fig. 4), as described and mapped by Matthews *et al.* (1993), Cowling & Hilton-Taylor (1997), and Van Wyk & Van Wyk (1997). For more details see the discussion under the Mpumalanga Centre of Diversity.

8. Soutpansberg Centre of Endemism

At present this centre consists of a single grid square (2230 C) which contains only 8 endemic species (Figs. 14 & 15).

It overlaps with the Soutpansberg Centre of vascular plant endemism (Beentje *et al.* 1994, Van Wyk & Van Wyk 1997, Fig. 4) and the Soutpansberg Centre of (moss) Diversity (see discussion there and Fig. 9).

5. Centres of narrow endemism

Rebelo (1994) found that the optimal reserve configuration for conserving the rich flora of southern Africa are determined by "...the number of narrow endemics and their concordance (congruence in distribution ranges)." In order to determine where the 'irreplaceable hot-spots' are situated, Rebelo (1994: 239) plotted the distribution of narrow endemics (those confined to a single degree grid square) per ¼° grid in the southern African flora. Centres of narrow moss endemism are here determined in the same way except that narrow moss endemics are plotted per ½° grid square. The following list contains the 42 moss endemics which are more or less restricted to an area the size of 1° grid square or c. 110 km x 100 km:

Narrow endemics in the moss flora of southern Africa

Andreaea bistratosa
Archidium andersonianum
Archidium muelleranum
Archidium subulatum
Bartramia compacta *var.* macowaniana
Brachythecium pinnatum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum

Breutelia elliptica
Breutelia tabularis
Cygnicollum immersum
Dicranella rigida
Dicranoloma entabeniense
Didymodon jackvancei
Distichophyllum mniifolium *var.* taylorii
Ephemerum diversifolium
Fabronia breutelii
Fabronia eckloniana
Fabronia wageri
Fissidens capriviensis
Gymnostomum lingulatum
Isopterygium taxithellioides
Leskeella zuluensis
Leucobryum rehmannii
Leucoperichaetium eremophilum
Macrocoma pulchella
Meiothecium fuscescens
Microcrossidium apiculatum
Oligotrichum tetragonum
Oligotrichum wageri
Orthotrichum armatum
Pleuridium papillosum
Pogonatum borgenii
Pseudoleskeopsis unilateralis
Pterobryopsis rehmannii
Quathlamba debilicostata
Rhynchostegiella sublaevipes
Streptocalypta pulchiretis
Ulota ecklonii
Weissia cucullata
Zygodon dixonii
Zygodon leptobolax

The geographic distribution of narrow endemics is shown in Fig. 16. Concentrations (centres) of narrow endemics are found at:

a) The south-western Cape area is the most important centre of narrow endemism in southern Africa (Fig. 16). Eight narrow endemics are found in the Table Mountain grid (3318 C) while 3 narrow endemics have been recorded from the mountains of the Boland (3318 D). This centre overlaps with the south-western Cape centres of moss diversity and endemism. The south-western Cape is also the centre with the most narrow vascular plant endemics in southern Africa. (Rebelo 1994).

b) Three narrow endemics have been recorded from the southern KwaZulu-Natal Drakensberg (2929 C) as well as the Zululand forests (2831 C). These two grids also stand out as centres of narrow vascular plant endemism (Rebelo 1994: 239).

c) Other areas where more than one narrow endemic occurs is the George-Tsitsikamma area (3323 C & D, 3422 B, 3423 A), the Bosberg at Somerset East (3225 D), and the Mont aux Sources area of the northern KwaZulu-Natal Drakensberg (2828 D). The Mont aux Sources area is also a centre of narrow vascular plant endemism (Rebelo 1994: 239).

d) Narrow endemics are also found in (Fig. 16): 1) the winter-rainfall area to the north of Cape Town, between lattitudes 31° S and 33° S, and between the Cape Fold Mountains and the Atlantic Ocean, 2) the escarpment in the winter-rainfall area of southern Namibia (2716 D), 3) the Hogsback area in the Eastern Cape (3226 D), which probably links up with the centre at Somerset East, 4) the southern Drakensberg Mountains near Dordrecht in the Estern Cape (3127 A), 5) the Houtboschberg (2329 D) east of Pietersburg in the Northern Province, and 6) the Soutpansberg (2230 C) near Louis Trichardt in the Northern Province. All of these areas are also rich in narrow vascular plant endemics (Rebelo 1994: 239).

Discussion and hot-spots

Endemism in mosses and vascular plants is compared in Table 13. From these figures it is clear that endemism is significantly lower in the mosses than in the vascular plants (more specifically the flowering plants) of southern Africa at all taxonomic levels. It is generally assumed that the greater dispersability and allegedly greater age of bryophytes are responsible for lower levels of endemism (Gradstein & Pocs 1989; Schofield 1992; Frahm 1993, 1997).

Not only do centres of moss diversity and endemism largely coincide in southern Africa, as was found in the vascular plants (Rebelo 1994, Cowling & Hilton-Taylor 1997, Simmons *et al.* 1998), but there is also a high degree of congruence between moss and vascular plant centres of diversity and endemism. The areas where centres of moss diversity and endemism overlap (compare Figs. 9 & 15), are here formally described as Hot-Spots. These areas are frequently also centres of family and genus diversity (see Figs. 5 & 6), and centres of narrow endemism (Fig. 16). The hot-spots listed here are the only ones that can presently be described with confidence but more hot-spots are likely to show up as additional distribution data becomes available.

Moss hot-spots in the flora of southern Africa area

1. South-western Cape Hot-Spot
2. Cederberg Hot-Spot
3. Outeniqua Hot-Spot
4. Amathole Hot-Spot
5. Drakensberg Hot-Spot
6. Midlands Hot-Spot
7. Zululand Hot-Spot
8. Blyde Hot-Spot
9. Soutpansberg Hot-Spot

1. South-western Cape Hot-Spot

This is by far the largest and most important moss hot-spot in southern Africa. The Cape Town or Table Mountain grid square (3318 C), which includes only a small piece of land, is the richest in southern Africa as far as the number of species (37% of the total number of species), endemics (31% of all endemics), and narrow endemics (19% of the total) are concerned. This grid also counts among the grids with the highest number of moss families (69% of the total number) and genera (46% of the total) in southern Africa.

The South-western Cape Hot-Spot forms part of the area identified as the Cape hot-spot of vascular plant diversity and endemism (Cowling & Hilton-Taylor 1994, 1997; Hilton-Taylor 1996). As far as species diversity and endemism are concerned the Cape has been identified by Myers (1990) as the worlds hottest hot-spot (Cowling & Hilton-Taylor 1994).

2. **Cederberg Hot-Spot**

Relatively high numbers of species, endemics, and narrow endemics overlap in the northern part of the Cederberg mountains near Clanwilliam (3218 B). This centre falls into the Cape hot-spot of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).

3. **Outeniqua Hot-Spot**

The Afromontane area of the southern Cape, roughly between Mosselbaai (grid 3422 A) in the west and Port Elizabeth (grid 3325 C) in the east, is rich in moss families, genera, species, endemics, and narrow endemics. This area has been included in the Cape hot-spot of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).

4. **Amathole Hot-Spot**

Although this centre of moss diversity and endemism is here called the Amathole Hot-Spot, it probably extends far beyond this mountain range. Relatively high levels of diversity and endemism are found all along the escarpment of the eastern Cape, roughly from Stutterheim (3227 C) in the east to Somerset East (3225 D) in the west. Afromontane forests are found throughout this area. The Amathole Hot-Spot falls outside the Albany hot-spot of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).

5. **Drakensberg Hot-Spot**

The Drakensberg and Maloti mountains of KwaZulu-Natal and north-eastern Lesotho are exceptionally rich in moss families, genera and species, as well as moss endemics. The Drakensberg hot-spot is not restricted to the Afromontane forests on the mountain

slopes but extends right onto the high altitude plateau of Lesotho. This hot-spot overlaps with the eastern part of the Eastern Mountain hot-spot of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).

6. **Midlands Hot-Spot**

The KwaZulu-Natal Midlands in the Pietermaritzburg-Karkloof area (grids 2930 A & C) stands out as a hot-spot of moss diversity and endemism.

7. **Zululand Hot-Spot**

The Zululand forests between Qudeni and Empangeni (grids 2830 D, 2831 C & D) represent centres of diversity as well as endemism. This area is also rich in moss families and genera and stand out as a centre of narrow endemism. It is separated from the Midlands Hot-Spot by the Tugela River valley.

8. **Blyde Hot-Spot**

The Mpumalanga Drakensberg escarpment, from Blyderivierspoort (2430 D) in the north to Nelspruit (2530 B) in the south, and in particular the Blyderivierspoort-Graskop area, is exceptionally rich in moss families, genera and species, but less so in endemic species. This hot-spot overlaps with the Wolkberg hot-spot of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).

9. **Soutpansberg Hot-Spot**

This hot-spot is not as rich as some of the others but species diversity and endemism nevertheless overlap along this mountain range, in particular in the Entabeni area (grid 2230 C). Although recognised as a local centre of vascular plant diversity and endemism (Van Wyk & Van Wyk 1997, Fig. 4), this area has not been included in the southern African hot-spots of Cowling & Hilton-Taylor (1994, 1997) and Hilton-Taylor (1996).