Diversity and phytogeography of the moss flora of southern Africa

Part 1 Text

by

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CHAPTER 1

INTRODUCTION

Chapter Outline

Phytogeography, or the study of the geographic distribution of plants, can be divided into **descriptive** and **historic plant geography** (White 1970, 1971). The descriptive part of plant geography "...is concerned with devising adequate and useful classifications of biogeographical patterns based on known distributions of taxa within the geographical area of interest." (Birks 1987), while historic plant geography "...attempts to explain present-day distributions in terms of historic events..." (White 1971). McLaughlin (1994) refers to descriptive phytogeography as **floristic plant geography,** which he defines as that part of plant geography concerned with global, contemporary patterns in floristic assemblages.

The two main concepts of floristic plant geography or descriptive phytogeography are **floristic areas** or **regions**, and **floristic elements** (for definitions see Myklestad & Birks 1993; McLaughlin 1994; *Key definitions*, this chapter; and *Numerical techniques*, Chapter 2). In **quantitative descriptive phytogeography** numerical techniques are used to detect patterns in the data in a more or less objective, repeatable way.

This study ventures beyond the descriptive phase of phytogeography by employing numerical techniques to identfiy gradients in the data which can be related to environmental variables. However, no attempt is made to relate patterns in the moss distribution data to historical events.

A. Twentieth Century Milestones in the Taxonomy of Southern African Bryophytes

A sound taxonomic basis is a prerequisite for any phytogeographic study. The taxonomy of tropical bryophytes has generally lagged behind that of the northern hemisphere (Touw 1974, Argent 1979, Richards 1984, O'Shea 1997). However, in contrast to most of Africa, considerable progress has been made in the taxonomy of southern African bryophytes (Buck & Thiers 1989, O'Shea 1997). The following publications stand out as 20th Century milestones in the taxonomy of the bryophytes.

Twentieth Century milestones: the taxonomy of southern African bryophytes.

1. Early checklists of: a) the bryophytes by Sim (1915), and b) the mosses by Wager (1917).

2. *The Bryophyta of South Africa*, the first bryophyte flora for the subcontinent, was published in 1926 by T.R Sim, who might be regarded as the 'father' of southern African bryology (Bayer 1971, Gunn & Codd 1981). This work was prepared in consultation with H.N. Dixon, the well known British bryologist.

3. The *Hepaticae of South Africa* by S. Arnell (1963), a Swedish bryologist who also collected in South Africa (Martensson 1972), is a comprehensive account of the liverworts of the region.

4. Magill & Schelpe's *The bryophytes of southern Africa. An annotated checklist.* (Magill & Schelpe 1979) provided an up to date list of taxa, recent and selected synonymy, and literature references.

5. The moss *Flora of Southern Africa* is a modern taxonomic treatment of about 80% of mosses on the subcontinent. It currently consists of 3 fascicles: fascicle 1 (Sphagnaceae–Grimmiaceae) published in 1981 (Magill 1981), fascicle 2 (Gigaspermaceae–Bartramiaceae) published in 1987 (Magill 1987), and fascicle 3 (Erpodiaceae–Hookeriaceae) published in 1989 (Magill & Van Rooy 1989).

6. The PRECIS checklists, which started with the *List of species of southern African plants* by Gibbs Russell *et al.* (1984), followed by a second edition which included literature and synonyms (Gibbs Russell *et al.* 1985), and culminating in the *Plants of southern Africa: names and distribution*, which included species distributions by province (Perold 1993, Van Rooy 1993). Updates of these lists were published in *Bothalia* (Van Rooy 1986, 1988, 1989, 1990, 1991). The bryophyte component of these computer generated lists incorporated taxonomic and nomenclatural name changes since the Magill & Schelpe (1979) checklist.

7. The *Checklist of the mosses of sub-Saharan Africa* by O'Shea (1995) includes southern African mosses based on the latest PRECIS checklist (Van Rooy 1993) but incorporating new synonymy and records as well as distribution data.

8. Wiggington & Grolle's *Catalogue of the Hepaticae and Anthocerotae of sub-Saharan Africa* (Wiggington & Grolle 1996), with extensive synonymy and selected literature references for each country, is largely based on the latest authoritative taxonomic revisions.

9. In *Taxonomic literature of southern African plants*, Perold (1997) and Van Rooy (1997) provide up to date lists of moss and liverwort families and genera as well as literature references most useful in the identification of southern African bryophytes.

10. The first fascicle of the Hepatophyta volume in the *Flora of Southern Africa* series, written by S.M. Perold (1999), has recently been published. It is a taxonomic treatment of the Subclass Marchantiidae of the Marchantiopsida (thallose liverworts).

In addition to the publications listed above there have been many taxonomic monographs, revisions, notes, reports of new taxa and new records, and other papers dealing with bryophytes which occur in southern Africa. Most of these have been cited by Magill & Schelpe (1979), Magill (1981, 1987), Perold (1997), Van Rooy (1997), Magill & Van Rooy (1989), and Perold (1999) while others are listed in Appendix I.

Despite all the taxonomic work on the bryophytes of southern Africa there has never been an analysis of the diversity, endemism or geographic distribution of this plant group. It was therefore decided to present such an analysis for my Ph.D. thesis. As the taxonomy and distributions of southern African mosses will certainly change in future the results obtained here are not definitive but merely a first approximation or an exploratory study of the distribution patterns within the FSA area.

B. Aims and Objectives

1. The main objective of this study is to identify, classify and describe floristic regions and floristic elements within the *Flora of Southern Africa* (FSA) area by means of repeatable numerical techniques.

2. A secondary objective is to use an indirect gradient or ordination technique to produce hypotheses about possible environmental factors causing the observed gradients in the data.

3. This study also aims to explore how well numerical techniques most commonly used in ecology as well as phytogeography perform in identifying broad-scale patterns and gradients in the distribution data of southern African mosses.

4. Another important objective is to compare the bryogeographic classifications generated in this study, as well as hypotheses about the possible determinants of such patterns, with those proposed for vascular plants of the region.

5. The distributions (MOSS) database (see *Data Compilation* in Chapter 2) has made it possible to include the following objectives:

   - to enumerate diversity and endemism within the moss flora;
   - to identify and describe centres of moss diversity and endemism in the FSA area;
   - to compare these centres with those described for vascular plants;
   - to identify 'hot-spots' in the distribution of southern African mosses.

6. Basic phytogeographic information is increasingly regarded as the theoretical basis for the protection of the worlds plants (Takhtajan 1986; Birks 1987; Siegfried 1989; McLaughlin 1994; Cowling & Hilton-Taylor 1994, 1997). This study therefore aims to contribute to the conservation of southern Africa's rich biodiversity.

7. It was also felt that a classification of bryogeographic regions of southern Africa would contribute towards a new bryogeographic classification of the world as proposed by Ochi (1973), Lewis (1990) and Schofield (1992).

C. Key Definitions

Inadequate definition and inconsistent use of phytogeographic terms have led to confusion in southern African phytogeography, as will be demonstrated in the chapters to follow. It is therefore very important to provide, right at the start, clear and precise definitions of some of the most important terms used in this study. White (1993), in a synopsis of his chorological work in Africa, explained his interpretation of many of the terms listed here and also referred to other literature on the subject.

1. Centre of diversity

A centre of diversity is an area with a high concentration of taxa (usually species) within the total geographic distribution of a particular flora. The size of the centre may vary from a ¼° grid square (or smaller) to a province, country or subcontinent, depending on the extent of the study.

2. Endemic

A taxon is endemic to a certain area or phytogeographic region when it is only known from that area or region. A southern African endemic, for example, only occurs in the FSA area. A **narrow endemic** is a taxon of very limited geographic distribution, e.g. restricted to particular degree grid square. It all depends on scale as the narrow endemic *Pseudoleskeopsis unilateralis* (Leskeaceae), only known from a single locality in the Dordrecht area of the Eastern Cape Province of South Africa, may also be regarded as endemic to South Africa, and endemic to Africa.

3. Centre of endemism

A centre of endemism is an area with a high concentration of taxa with limited geographic distributions (endemics). A centre of endemism is therefore a concentration of taxa (usually at the level of species) in the geographic distribution area of an endemic element, in this case the endemic element of the (moss) *Flora of Southern Africa* (FSA).

A clear distinction should be drawn between this centre of endemism and a phytogeographic region characterised by high endemism, the so called Regional centre of endemism of White (1976, 1983, 1993). Each phytogeographic region has its own endemics (sometimes absent), and might therefore be regarded as a centre of high or low endemism, whatever the case may be. However, unlike a true centre of endemism, a phytochorion such as a Region or Domain is not based on or delimited by endemics only, as sometimes advocated in the literature (White 1983, Linder 1990), but by all taxa in the region or, in other words, by the floristic composition of the area. It can therefore be misleading to include 'centre of endemism' in the name of a phytochorion as was done by White (1976, 1983, 1993), even if a definition of 'centre of endemism' has originally been provided by the author, as a name is often used out of its context. Centres of endemism have also been described within phytogeographic regions, e.g. the centres of endemism recognised within the 'Afrotemperate Region' by Linder (1990). These centres of endemism are determined by the endemic component or element of the flora of a particular floristic region.

Oliver *et al.* (1983) employed numerical techniques to delimit 6 floristic areas or regions within the 'Cape Floral Region'. Unfortunately they called these areas 'elements' and added to the confusion with their statement "On the whole, these centres agree with the centres defined by Weimarck (1941).", when the two are clearly not comparable. Likewise, Hilton-Taylor (1987) described subdivisions of the Karoo-Namib Region, "...below the domain level...", as centres of endemism. Under the same heading he refers to these 'phytogeographic centres' as areas. However, 'centre' is not a recognised category for a floristic area or region (White 1970, Takhtajan 1986, McLaughlin 1994) and has traditionally been applied to areas of high species concentrations within floristic elements (see *Phytogeographic element*).

As mentioned in the previous paragraph, phytogeographic centres have usually been described within phytogeographic elements, e.g. the 'endem centres' described within the Cape element of Weimarck (1941). If a floristic element is based on endemic taxa only, as in the case of Weimarck (1941) then the centres within that element might be called 'centres of endemism'. However, in this case 'Cape centres of endemism' would probably have been a better name. These centres may or may not coincide with centres of endemism based on all southern African endemics or the endemic element of southern Africa.

A centre of narrow endemism is a concentration of endemics with very limited geographic distributions, for example species restricted to one ½° grid square.

To summarise, 3 kinds of centres are important in this study, and in phytogeography in general:

> **The phytogeographic centre.** This centre represents a high concentration of species in the geographic distribution area of a **floristic element.**
>
> **The centre of diversity.** A high concentration of species (or taxa of higher rank) in the geographic distribution area of a **flora** is called a centre of diversity.
>
> **The centre of endemism.** This is a high concentration of species (endemics) in the geographic distribution area of the **endemic element** of a flora.

4. Hot-spot

Hot-spots are geographic areas where centres of diversity and centres of endemism overlap. These areas are frequently also centres of family and genus diversity, and centres of narrow endemism (see Rebelo 1994 and Chapter 3). My definition of hot-spots agrees largely with that of Myers (1990) except that the southern African moss hot-spots are not necessarily threatened by habitat modification and transformation.

5. Phytogeographic (floristic) region

A group of grids (areas) of similar floristic composition. A phytogeographic region (floristic area) can also be described as a natural area with a characteristic flora (McLaughlin 1994). Phytogeographic regions or floristic areas can not overlap geographically but they may share a number of taxa. In phytogeographic regions it is the grids (reléves) or areas which are classified according to their floristic compositions. A phytogeographic region is therefore a geographic area. See also discussion of R- and Q-mode analysis under *Numerical Analysis*, Chapter 2.

6. Phytogeographic (floristic) element

A group of taxa of similar geographic distribution. The distributions of phytogeographic elements may overlap geographically but a taxon (usually species/infraspecific taxa) can only belong to one element. In the case of phytogeographic elements it is the taxa (species) which are classified according to their geographical distributions. A phytogeographic element is therefore a group of taxa (species). See also discussion of R- and Q-mode analysis under *Numerical Analysis*, Chapter 2.

In a phytogeographical analysis of the evergreen forests of Malawi, White (1970) has described a number of elements within his phytogeographic regions. Friis (1990) referred to these elements in a study of the distribution patterns of *Ficus* in tropical north-eastern Africa. It must be realised, however, that these elements described by White (1970) are not subdivisions of his phytogeographic regions and may only exist within a particular phytogeographic region.

Areas of high species concentration within the geographic distribution of floristic elements have traditionally been described as centres and subcentres (e.g. Weimarck 1941, Stuckenberg 1962). These centres or subcentres are not necessarily subdivisions of the elements (see *General Discussion and Conclusions*, Chapter 6).

7. Phytochorion

A phytochorion is a phytogeographic (floristic) region or area of any rank. A chorion is therefore a geographic area.

D. Layout of the Thesis

The thesis is divided into two main parts: Part 1 comprising the main text, and Part 2 containing the tables, figures and appendices.

Part 1 can be subdivided into three section: 1) the first section consisting of a table of contents, and lists of tables and figures, 2) the core of the study comprising six chapters, each starting with an outline of the contents, and 3) the last section containing an English and Afrikaans summary, a list of literature references, acknowledgements, and a curriculum vitae. The introductory chapter (Chapter 1), which includes a list of Twentieth Century milestones in the taxonomy of southern African bryophytes, the aims and objectives of this study, as well as key definitions, is followed by a chapter on materials and methods of study. This chapter (Chapter 2) describes several aspects of the study area, the data sets, and the numerical techniques employed in the analysis of the moss distribution data. Chapter 3 starts with a short historical review of diversity and endemism studies in southern Africa, followed by an enumeration of moss diversity and endemism. This chapter also includes formal descriptions of moss centres of diversity and endemism as well as 'hot-spots' in the distribution of southern African mosses.

Both Chapters 4 an 5 start with historical reviews of the different phytogeographic classifications of southern Africa. Chapter 4 describes the numerical (TWINSPAN) classification of grid squares and provides a formal classification and description of the bryofloristic Regions and Domains of southern Africa. The chapter includes an analysis of the compositional gradients identified by the (DECORANA) ordination which leads to a hypothesis about the environmental factors causing the observed gradients in the data. Chapter 5 is concerned with the other main concept in floristic plant geography, i.e. floristic (bryogeographic) elements. The distribution patterns of mosses within the FSA area are formally classified and described as four bryofloristic Elements, subdivided into eight Subelements. As in the previous chapter, (distributional) gradients in the data are identified and correlated with environmental factors. The last chapter, Chapter 6, is a general discussion and summary of the main conclusions. It also highlights needs and prospects for future phytogeographic research in southern Africa.

In Part 2 of the thesis the tables and figures are followed by three appendices. Appendix 1 is a checklist of all southern African mosses included in the database. This list includes the latest synonymy and selected literature references. Appendix 2 lists the moss species/infraspecific taxa found in each of the bryofloristic Regions and Domains while Appendix 3 lists the species that make up each floristic Element and Subelement in southern Africa.

CHAPTER 2

MATERIALS AND METHODS

Chapter Outline

A. Study Area

References to useful literature on several aspects of the study area are listed in Table 1. Many of these topics are discussed and illustrated in the *Reader's Digest Illustrated Atlas of southern Africa* (Reader's Digest 1994). In his recently published *South African Atlas of Agrohydrology and -Climatology* Schulze (1997a) provides maps of many climatic parameters as well as some physical features of the study area. Unfortunately these two publications only cover the Republic of South Africa. The recently published *Biological diversity in Namibia: a country study* (Barnard 1998), provides useful and up to date information on physiographic, climatic and ecological features of Namibia.

1. Geographic limits

The study area occupies the southern tip of the African continent or Africa south of the Cunene, Okavango and Limpopo Rivers (Fig. 1). It includes the countries of South Africa, Swaziland, Lesotho, Namibia and Botswana and covers an area of c.2.7 million km² (Cowling *et al*. 1997a). The Indian Ocean forms the boundary on the eastern and southern sides while the Atlantic Ocean runs along the west coast. The northern border is not entirely natural as it follows the political boundaries between Namibia and Angola, Namibia and Zambia, Botswana and Zimbabwe, South Africa and Zimbabwe, and South Africa and Mozambique (Reader's Digest 1994).

2. Geology and geomorphology

Geological maps of the region have recently been compiled by Visser (1984) for South Africa, and Hammerbeck & Allcock (1985) for the whole of southern Africa. The geology of South Africa has been summarised in simple terms by Day & King (1995). The handbooks *The Geomorphology of Southern Africa* by Moon & Dardis (1988) and *Biological Diversity in Namibia* by Barnard (1998) have been freely drawn upon in the compilation of the following account.

The geological development of southern Africa can be divided into five major phases or stages (Tankard *et al*. 1982). In the first or Archean crustal development stage the granitic basement of the subcontinent (e.g.the Barberton Sequence) was formed. This phase lasted to the end of the Archean Eon c. 2500 million years ago. The second stage is kown as the Early Proterozoic supracrustal development stage and lasted from 2500 to c. 1500 Ma. During this stage the crystalline basement was covered by sediments and volcanic rocks of the Pongola, Transvaal and Griqualand West sequences, the Witwatersrand and Ventersdorp Supergroups, and the Waterberg and

Soutpansberg Groups. The Bushveld Igneous Complex was formed on top of the transvaal Sequence. During the third phase Proterozoic orogenic activity disturbed the crystalline and cover rocks in the south and west of the subcontinent. Deformation was accompanied by intrusion of granitic rocks from the mantle and partial melting of older crust. Rifting of the crust resulted in the opening of a proto-South Atlantic Ocean which closed again c. 700 Ma. Stage four is known as the Gondwana era. Deposition of the Cape Supergroup sediments was followed by glaciation as Gondwana moved across the south polar region. The Karoo basin was filled with sediments of the Ecca and Beaufort Groups, and the Molteno, Elliot and Clarens Formations, capped by thick lavas of the Drakensberg Formation. The Karoo volcanicity lasted to about 105 Ma. Deformation of the Cape Supergroup rocks gave rise to the Cape fold belt. Fragmentation of Gondwana occured during the fifth and most recent stage of crustal development, known as the Post-Gondwana era. Pitman *et al.* (1993) provided an useful account of the fragmentation of Pangea and Gondwana.

The southern African land-mass achieved its present general outline during the break-up of Gondwana (Moon & Dardis 1988). At that time the subcontinent had an absolute elevation of 2350 m (Lesotho) to 1800 m (Kimberley). The eastern coastline was formed by rifting which started between 142 and 133 million years ago and the south Atlantic was formed when South America started drifting away from Africa c. 127 Ma. Because of the high elevation of southern Africa at the time of rifting, a substantial escarpment was created as the adjoining continental masses drifted away. An erosional face was soon produced by rivers operating to the newly created oceanic base levels. Partridge & Maud (1987) have summarised the geomorphic development of southern Africa since the Mesozoic as follows:

The principal geomorphic events in southern Africa since the Mesozoic (Partridge & Maud 1987)

1. The break-up of Gondwana through rift faulting (Late Jurassic/early Cretaceous).
2. African cycle of erosion (Late Jurassic/early Cretaceous to end of early Miocene).
3. Moderate uplift of 150-300 m (End of early Miocene, ~ 18 Ma).
4. Post-African I cycle of erosion (Early mid-Miocene to late Pliocene).
5. Major uplift, up to 900 m in eastern marginal areas. (Late Pliocene, ~ 2,5 Ma).
6. Post-African II cycle of major valley incision, especially in southeastern coastal hinterland.
7. Climatic oscillations and glacio-eustatic sea-level changes. (Late Pliocene to Holocene).

The present land surface of South Africa, Lesotho and Swaziland has been divided into a number of categories (see maps in Reader's Digest 1994, and Schulze 1997a), each of which is classified according to its height above sea level and its surface form. The subcontinent is characterised by a high interior plateau, bounded on 3 sides by the Great Escarpment. The plateau is tilted to the west and consists of elevated mountain massifs like the Lesotho Highlands, exceeding 3000 m in places, and large basins such as the Kalahari and Transvaal Bushveld. The escarpment comprises a number of distinct mountain ranges such as the Kamiesberg of Namaqualand, the Roggeveld and Nuweveld of the Karoo, and the Drakensberg of KwaZulu-Natal, Mpumalanga and the Northern Province. Below the escarpment lies the coastal plain or Marginal Zone, 50 to 200 km wide, in places deeply dissected by river gorges. The Cape Fold Mountains in the south-western corner of the subcontinent provide for the highest altitudes in this zone.

Namibia, with a land area of 823,988 km², can be divided into 4 main geophysical zones (Barnard 1998):

1. the Namib Desert and coastal plain
2. the Namib escarpment
3. the central plateau
4. the Kalahari sandveld

The Namib desert and coastal plain occupies a narrow strip of land between the Atlantic Ocean in the west and the Namib escarpment, 80-200 km to the east. The eastern border of the Namib roughly coincides with the 100 mm annual rainfall isohyet and the 1000 m altitude contour (see maps in Barnard 1998). The Namib Desert is subdivided into three broad landforms: 1) the southern Namib with it's dune sea and inselbergs, 2) the central Namib with gravel plains between the Ugab and Kuiseb Rivers, and 3) the northern Namib with mountains and dunefields. Barnard (1998) describes the Namib escarpment as "... a thin, sometimes poorly defined transition zone between the desert and the central highland plateau." It is a deeply dissected region with some of the highest mountains in Namibia. To the east of the escarpment zone, roughly between 1000 and 2000 m altitude, and running the full length of the country, lies the central plateau. It is stony and flat or mountainous, dissected by deep canyons in some places. The Kalahari sandveld flats to the east of the central plateau consists of a thick layer of red or pale sand in the south and brittle alkaline soils in the north.

Colourful maps of the soil zones of South Africa and Namibia have recently been published in Schulze (1997a) and Barnard (1998) respectively.

3. Climate

Southern Africa can be classified as semi-arid with less than 5% of the region recieving an annual rainfall of greater than 800 mm and, on average, more than 90% of rainfall returned to the atmosphere through evaporation (Cowling *et al.* 1997a). Average runoff only constitutes 9% of the total rainfall (Schulze 1997a). The average mean annual rainfall for South Africa is only c.500 mm, compared to a world mean of

860 mm (Reader's Digest 1994). There is a steep climatic gradient from the hyper-arid and foggy Namib desert along the west coast, to the hot and humid climate along the east coast of southern Africa. There is also a steep gradient from the semi-arid Karoo basin to the wet winter-rainfall mountains of the Cape. The study area can be divided into a *winter rainfall* region in the south-western corner, stretching along the west coast to southern Namibia, an *all year rainfall* area along the southern Cape coast, and a *summer rainfall* region covering the largest part of southern Africa. These climatic patterns are largely the result of the temperate-tropical convergence zone, the cold Benguela Current along the west coast and warm Agulhas Current along the east coast, and the varied topography described under the preceding heading.

Schulze (1997) identified light, temperature and moisture as the climatic factors of greatest importance in vegetation development. Maps of these as well as other climatic parameters in South Africa can be found in Schulze (1997, 1997a).

In Namibia the climatic gradient runs from tropical semi-humid in the northeast to hyper-arid in the west. Overall, 69% of the country is regarded as semi-arid and the remaining 16% as arid (Barnard 1998). Average annual rainfall is c. 250 mm of which about 83% evaporates and 14% is transpired by plants. Only c. 2% enter drainage systems. Mean annual rainfall varies from c. 700 mm in the eastern Caprivi to less than 50 mm along the coast. Temperatures can be extremely variable with greatest fluctuations in the hyper-arid zone. Mean water deficit (mean annual rainfall minus mean annual evaporation) is greatest in the south-eastern part of Namibia. The convergence of the cold Benguela (subantarctic) upwelling and the hot subtropical interior is responsible for the arid conditions in the Namib Desert. It has been established that the Namib and adjacent plateaus have been arid or semi-arid for 55 to 80 million years (Barnard 1998).

4. Flora and vegetation

For a predominantly warm temperate, semi-arid region, southern Africa is exceptionally rich in vascular plants. It contains approximately 21137 indigenous species in 1930 genera and 226 families (Cowling & Hilton-Taylor 1997). The south-western Cape, 'mesic parts of the Tongaland-Pondoland Region' and the Afromontane areas in the north-east of the study area are particularly rich in vascular plants. Species density (species/km^2) in the Cape Region is amongst the highest in the world. At 80% vascular plant species endemism is unusually high for a continental region (Cowling & Hilton-Taylor 1994, 1997). The flora is also characterised by numerous large genera, most of which are centred in the Cape region. Species/genus ratios in southern Africa and the Cape Region are consequently among the highest in the world, comparable with those of oceanic islands (Goldblatt 1978 in Cowling & Hilton-Taylor 1997). Centres of vascular plant diversity and endemism in the FSA area are discussed in detail under *Historical perspective*, Chapter 3.

In the preface to *Vegetation of southern Africa*, Cowling *et al.* (1997a) provide a short overview of the vegetation classifications of the region. The most important works were written or edited by Pole Evans (1936), Adamson (1938), Acocks (1953), Werger (1978c) and White (1983). The most recent works on the region's vegetation were edited by Low & Rebelo (1996) and Cowling *et al.* (1997a). The vegetation maps provided by Acocks (1953) and Low & Rebelo (1996) only cover the Republic of South Africa (as well as Lesotho and Swaziland) while White (1983) mapped the vegetation types of the whole continent.

Rutherford & Westfall (1986) and Rutherford (1997) identified seven biomes in southern Africa (Fig. 2) in accordance with dominance or codominance of plant life forms at the biome scale: 1) Desert, 2) Grassland, 3) Succulent Karoo, 4) Forest, 5) Nama-Karoo, 6) Savanna, and 7) Fynbos biomes. The Desert Biome is only found in Namibia while the Grassland and Fynbos Biomes are restricted to South Africa. Grassland covers the Highveld, from Mpumalanga in the north down to the Eastern Cape in the south.

Savanna vegetation covers a large area in the north and a narrow strip along the east coast, as far south as Port Elizabeth in the Eastern Cape. Fynbos vegetation is largely restricted to the Cape Fold Mountains in the extreme south-west of the study area.

Low & Rebelo (1996) added an 8th biome, the Thicket Biome, consisting of subtropical thicket vegetation in the dry river valleys of the south-eastern Marginal Zone, roughly from Melmoth in KwaZulu-Natal to Port Elizabeth in the Eastern Cape, and inland to Ladismith in the Klein Karoo.

The Namibian terrestrial biome classification of Irish (1994) differs only slightly from that of Rutherford (1997). Both schemes distinguish four biomes in Namibia: 1) Desert, 2) Succulent Karoo, 3) Nama-Karoo, and 4) Savanna. At a finer scale the classification of Giess (1971), who divided the area into 14 major vegetation types, are widely accepted (Barnard 1998). The annual precipitation determines the three main vegetation zones of Namibia: 1) desert, 2) savanna, and 3) woodlands, while environmental variables such as temperature, seasonality of rainfall, and topography and soil are responsible for the 14 major subdevisions of these zones (Barnard 1998). The Namib can be subdivided into true Namib to the north of Lüderitz and the Succulent Steppe vegetation zone in the southern, winter rainfall area. To the east of the Namib is a Semi-desert – savanna transition zone. Most of Namibia is covered by thorny shrub and tree savanna. Forest Savanna and Woodlands cover the moist northeastern region. The Southern African Bird Atlas Project (SABAP) used a biome map of four major and two minor biomes, divided into nine Avi-vegetational Zones, to explain bird distribution and abundance in Namibia (Barnard 1998). However, the major biomes of this scheme do not differ significantly from those of Irish (1994).

B. Data Compilation

The MOSSLIT and MOSS databases were set up specifically for this study using the ISI Sci-Mate (Anon 1985) personal computer program:

1. MOSSLIT database

This searchable literature database contains more than 2000 references to publications on the taxonomy, nomenclature, ecology and phytogeography of bryophytes, with particular emphasis on African and southern African mosses. The following fields were entered for each record:

- **Author:** Name of the author(s).
- **Date:** Date of publication.
- **Title:** Title of the article or book.
- **In**: Name(s) of the editor(s).
- **Public:** Name of the journal or book in which the article appeared.
- **Publishr:** Publisher of the book and place of publication.
- **Keyword:** The keywords and phrases used are not very extensive but include major categories of scientific, mostly botanical, research (e.g. *phytogeography, taxonomy*, *ecology*, *nomenclature, geology*), important research topics (e.g. *species, monograph, mountains, classification, ordination, DNA*), scientific names of taxa, and geography (continents, regions, countries etc.). All words entered for a specific record, and not only the keywords, determine whether a record is retrieved during a search.
- **Notes:** Notes such as the whereabouts of the publication or reprint.

2. **MOSS database**

This database contains the names and distributions of mosses recorded and accepted for the FSA area and is also fully searchable. Information has been entered in the following fields:

- **Family:** Name of the family.
- **Genus:** Name of the genus.
- **Species:** Name of the species and infraspecific taxon.
- **Grids:** The ½° grid squares (Edwards & Leistner 1971) in which the moss has been collected. The grids were recorded directly from specimens in PRE (incorporating specimens from NH, Compton ex SAMH, and STE on permanent loan), specimens in other southern African herbaria (see Magill 1980), and type

specimens received on loan from other herbaria such as BM, C, E, G, H, NY etc. (see Holmgren *et al.* 1990 for herbarium acronyms). The PRECIS database (Morris & Manders 1981, Magill *et al.* 1983, Arnold 1997) contained too many errors at the time (Rebelo & Cowling 1991, Rebelo 1994) to be useful in this regard. The bryophyte distribution data in PRECIS has since been checked and should now be more reliable.

- **Dist SA:** The FSA distribution of the taxon according to the geographic regions in the *Moss Flora of Southern Africa* (Magill 1981, 1987).
- **Dist Wo:** The total or world distribution of the taxon by region (e.g. Europe), country (e.g. Zimbabwe) and occasionally subdivisions of a country (e.g. western Australia). The most important and most recent checklists and related publications consulted for the world distributions of southern African mosses are listed in Table 2. In addition to these, many monographs, revisions and taxonomic notes were also consulted (see Van Rooy, 1997 for useful taxonomic literature).
- **Subs:** The substrate recorded on the specimen label (e.g. terricolous).
- **Alt:** The altitude recorded on the specimen label in metres.
- **Biome:** The Biome/s (Rutherford & Westfall 1986) in which the taxon has been recorded.
- **Comment:** References to literature on the taxonomy, phytogeography and ecology of the taxon.
- **Synonym:** The most important and most recent synonymy.

3. Data sets

Choice of taxa: The binary or presence/absence data of all the mosses recorded in southern Africa (see Appendix I) were used in the numerical analysis of distribution patterns. White (1965) has argued that a total analysis of the entire flora would tend to blur the picture, and that studies of selected dominant species of the most widespread and characteristic vegetation types would be more profitable. However, Wohlgemuth (1996), in a numerical analysis of the distribution patterns of Swiss plants, found that although a reduced number of species can result in a successful delimitation of floristic regions under certain circumstances, results were best when high numbers of species were used.

Choice of grids: It is usually assumed that if the grids or (the grain) used in a phytogeographic study are too small (too fine), problems of uneven recording (collecting) will introduce 'noise' into the data. If, on the other hand, the grids are large (grain too coarse), it will result in the detection of broad-scale patterns only (Jardine 1972, Birks 1987, Meentemeyer & Box 1987, Wiens 1989, Myklestad & Birks 1993). However, Kadmon & Heller (1998), in a multivariate analysis of faunal responses to climatic gradients, tested the effect of varying the grid size (the grain) in their species x grid data matrix and found that the main patterns of faunal variation were highly consistent over a range of grid square sizes.

Wiens (1989) has noted that "For logistic reasons, expanding the extent of a study (the study area) usually also entails enlarging the grain." of an investigation. However, no matter how large the study area, the grain will effect the accuracy of borders between the floristic regions: the coarser the grain the less accurate the borders will be, which will ultimately effect the floristic composition of the regions. Simmons *et al.* (1998) claims that the use of ½° grid squares in distribution data sets of Namibian plants and birds reduced the effect of sampling (collecting) bias.

I have subjectively chosen the ½° grid square, c. 52 km x 50 km (Edwards & Leistner 1971) for this study to keep the data set within the parameters required for the numerical analysis and to set the grain as fine as possible. All the grid squares considered, and all those eventually included in the complete data set are shown in Fig. 7.

In addition to the complete data set two more data sets were subjected to numerical analyses (see Fig. 3 and the *Discussion* under *TWINSPAN complete classification*, Chapter 4):

Data sets

1. **TWINSPAN Complete:** Data set containing all southern African grid squares in which mosses have been recorded. The presence/absence data matrix consists of 503 species/infraspecific taxa and 416 grid squares.

2. **TWINSPAN 3+:** Data set of grid squares containing three or more species/infraspecific taxa. The data matrix consists of 501 species/infraspecific taxa and 298 grid squares. The two endemics *Pseudoleskeopsis unilateralis* and *Plaubelia involuta* are absent from this data set.

3. **TWINSPAN 5+:** Data set of grid squares containing five or more species/infraspecific taxa. The presence /absence data matrix consists of 501 specie/infraspecific taxa and 251 grid squares. The two endemics *Pseudoleskeopsis unilateralis* and *Plaubelia involuta* are absent from this data set.

4. Shortcomings in the data sets

- There was no standardisation of collecting effort and the number of specimens per grid varies from a single collection (representing a single species) made on a casual visit, to several hundred specimens (representing many species) collected over many years. The geographic distributions therefore tend to reflect historical ranges and collecting biases (Lawes & Piper 1998). However, for the purpose of conservation planning it may actually be desirable to include historical distribution ranges of taxa in biodiversity databases (Van Jaarsveld *et al.* 1998).
- Some grid squares are totally undercollected, e.g. those covering the Afromontane (inland) forests of the former Transkei (Eastern Cape Province) of which grid 3128 A with five species, 3128 C with 0 species and 3127D with three species

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recorded are good examples. Gibbs Russell *et al.* (1984) estimated that some grids have records for only 17% of their flora. The percentage is likely to be lower for bryophytes.

Other grid squares are reasonably well collected because they were incorporated in study areas, e.g. the Mariepskop area (grid 2430 D) on the 'eastern Transvaal' or Mpumalanga escarpment (Vorster 1970, 1990). Uneven coverage of the FSA-area by the PRECIS database has been demonstrated by Gibbs Russell *et al.* (1984) and Rebelo (1994).

- The grid squares gradually decrease in size from north to south (Edwards & Leistner 1971) and some only contain a piece of land (along the coastline) or a piece of the study area (along the northern borders).
- Incomplete, imprecise, and incorrect collecting localities on PRE herbarium labels (Rebelo 1994). For example *Drepanocladus sendtneri* and *Meiothecium fuscescens* only known from the 'Cape', and *Pterobryopsis rehmannii* only recorded from 'Natal'. Another example is the mixed localities on *Wager* specimen labels (Magill 1982).
- The taxonomic treatment of the mosses is not quite uniform between groups and between areas. The taxonomy of the pleurocarpous families Fabroniaceae – Polytrichaceae (see conspectus of classification in Magill & Van Rooy 1998) lag behind that of the other families as they have not yet been revised for the FSA. Recently collected areas such as the Eastern Cape Wild Coast between the Kei and Mtamvuna Rivers, parts of the KwaZulu-Natal Drakensberg, and some of the Zululand forests, are better represented by acrocarpous taxa in the 1st three fascicles of the the moss *Flora of Southern Africa* (Magill 1981, 1987) as specimens belonging to the 4th fascicle (Orders Thuidiales, Hypnobryales and Polytrichales) are awaiting identification as part of the revision process.

Despite many shortcomings, binary (presence/absence) data sets have been used successfully in many biodiversity and phytogeographic studies and will for the foreseeable future remain the only source of information for broad-scale analysis of plant and animal distributions, not only in southern Africa but also in other parts of the world (Kadmon & Heller 1998, Van Jaarsveld *et al.* 1998).

A measure of abundance, e.g. the number of specimens of each taxon collected in a grid, normally included in phytosociological databases, is not generally considered practical for 'museum type data sets' (Oliver *et al.* 1983).

C. Numerical Analysis

1. Introduction

Quantitative approaches or numerical techniques have been used extensively in plant ecology, and comparatively less often, but increasingly, in phytogeography (Birks 1987, Myklestad & Birks 1993, McLaughlin 1994, Heikkinen *et al.* 1998). Recent examples of quantitative approaches at the fine-scale vascular plant community or phytosociological level in southern African include studies by Coetzee *et al.* (1995), Richards *et al.* (1995), Hill (1996), Van Wyk *et al.* (1996), Brown *et al.* (1997), Eckhardt *et al.* (1996, 1996a, 1997), Sullivan & Konstant (1997), Smit *et al.* (1997), Cilliers & Bredenkamp (1998), Malan *et al.* (1998) and Rubin (1998).

Numerical techniques have proven most useful in delimiting phytogeographic or broad-scale units in many parts of the world (Birks 1987, McLaughlin 1994, Heikkinen *et al.* 1998). The merits of using numerical techniques as opposed to visual pattern detection in biogeography have been pointed out by Jardine (1972), Birks (1987) and Pederson (1990). The following are recent examples involving vascular plants and ferns: Gill *et al.* (1985), Pederson (1990), Myklestad & Birks (1993), Dzwonko & Kornas (1994), Oksanen & Virtanen (1995), Andersson & Weimarck (1996) and Heikkinen *et al.* (1998). One of the most recent developments in quantitative biogeography is the integration of geographic information system (GIS) tools with standard multivariate techniques (Kadmon & Heller 1998).

Quantitative approaches to bryophyte ecology and geography up to the early nineteen 80's have been reviewed by Bates (1982) and Slack (1982, 1984). Additional examples at the bryophyte community level include studies by: Van Reenen & Gradstein (1983), Gignac & Vitt (1990), Duda *et al.* (1990), Vitt (1991), Forbes (1994), Belland & Vitt (1995), Karttunen & Toivonen (1995), Kürschner (1995), Sillett (1995), Nicholson & Gignac (1995), Jonsson (1996), and Odasz (1996). Bryophytes are sometimes included in predominantly vascular plant databases, for example those of Odland *et al.* (1990), Bjarnason (1991) and Dirkse *et al.* (1991).

One of the first numerical analysis of bryophyte distribution patterns at a broad (regional or subcontinental) scale was carried out on British liverworts by Proctor (1967). Proctor combined classification and ordination techniques to describe the relationships between the 25 vice-county groups and the 47 species groups or elements (Proctor 1967). Other examples of quantitative bryogeographic studies include:

1. The analysis of liverwort distribution patterns in Puerto Rico (Bryant *et al.* 1973).
2. Phytogeographic analyses of the moss flora in the Gulf of St. Lawrence region (Belland 1987, 1989).
3. The analysis of bryophyte distribution patterns in Britain (Hill & Dominguez Lozano 1994, Bates 1995).
4. The analysis of bryophyte distribution patterns in different parts of Australia (Eldridge & Tozer 1997, Fensham & Streimann 1997).

Bryophytes are increasingly used in the development of bioclimatic models (Birks *et al.* 1998); for example the peatland studies in the Mackenzie River Basin, Canada by Gignac *et al.* (1998, 1998a).

Quantitative analyses of African bryophyte distributions are virtually unknown. A few liverworts and mosses were included in a factor analysis of plant distributions in tropical and subtropical Africa by Denys (1980). Kürschner (1995, 1995a) studied floristic discontinuities in epiphytic bryophyte communities along an altitudinal gradient from the eastern Congo basin to the mountains of the Rift Valley and related these to environmental factors.

2. Numerical techniques

Given a presence /absence matrix for a number of taxa in a number of areas (such as grids or relevés) two major types of quantitative analyses are recognised (Jardine 1972, Bryant *et al.* 1973, Pielou 1984, Myklestad & Birks 1993, McLaughlin 1994, Heikkinen *et al.* 1998). The two forms of analysis have been termed R-mode analyses and Q-mode analyses but, as McLaughlin (1994) has recently pointed out, these two terms have been used inconsistently in biogeography to distinguish between the two forms of analysis. The definition of Bryant *et al.* (1973), Sneath & Sokal (1973) and Birks (1987) is followed here:

- **R-mode analyses**. Analysis of the affinities between distributional patterns of taxa. This results in the delimitation of phytogeographic (floristic) elements or groups of taxa with similar geographic distributions. See the definition of a phytogeographic element under *Key Definitions* in Chapter 1.

- **Q-mode analyses**. Analysis of the affinities between the floristic composition of geographic areas. This results in the description of phytogeographic (floristic) regions or groups of areas with similar floristic compositions (floras). See also the definition of a phytogeographic region under *Key Definitions* in Chapter 1.

2.1 Classification

The distribution data in all three data sets were subjected to classification by the FORTRAN computer program TWINSPAN (Hill 1979). TWINSPAN is a divisive, hierarchical classification technique which detects overall patterns of differences in biological data. Although the reliability of this approach has been questioned under certain conditions (Van Groenewoud 1992, Belbin & McDonald 1993, Van der Maarel 1996) TWINSPAN was chosen for its proven combination of effectiveness, robustness and relative objectivity, as well as its availability and speed (Gauch & Whittaker 1981, Myklestad & Birks 1993, Van Der Maarel 1996). Gauch & Whittaker (1981) found that certain advantages "...make TWINSPAN the best general purpose method, especially when a data set is complex, noisy, large or unfamiliar", as in the case of the moss distribution data sets used in this study.

The original TWINSPAN and DECORANA computer programs, also used in this analysis, were recently found to be susceptible to instability and it is recommended that "strict" and "debugged" versions be used (Oksanen & Minchin 1997). How to use these modified versions of TWINSPAN and DECORANA is explained on the web site: http://www.helsinki.fi/~jhoksane/softhelp/readcep.htm by P.R. Minchin. However, Gignac *et al.* (1998) found that the classification of peatlands in Canada by the modified version of TWINSPAN did not vary significantly from that of the original TWINSPAN classification.

Default settings were used for all TWINSPAN parameters. The results of the different TWINSPAN classifications (TWINSPAN Complete, 3+ and 5+ classifications of grid squares, and TWINSPAN 3+ classification of species) are presented as dendrograms, plotted on distribution maps, and listed in the appendices. The regions or elements at the different levels of TWINSPAN division have been numbered from left to right on the dendrograms in the order of the two-way matrix.

2.2 Indirect gradient analysis (ordination)

An indirect gradient analysis or ordination is an exploratory approach which aims to produce hypotheses about possible environmental factors causing the observed gradients in the data. However, a suspected correlation between distribution patterns and environmental factors is no proof of a cause-effect relationship and should ideally be tested by experimentation (Bates 1982, 1995; Heikkinen *et al.* 1998, Birks *et al.* 1998).

A detrended correspondence analysis (DCA) ordination was carried out on the moss distribution data in the TWINSPAN 3+ and TWINSPAN 5+ data sets by using the FORTRAN computer program DECORANA (Hill 1979a). Default options were employed and no downweighting took place. The advantages of using DCA are discussed by Gauch (1982), Slack (1984) and Michael Palmer on the Oklahoma State University Web page (http:www.okstate.edu/artsci/botany/ordinate/DCA.htm).

Both TWINSPAN and DECORANA are widely accepted programs and often used in combination in quantitative community ecology as well as phytogeography (Gauch & Whittaker 1981, Gauch 1982, Slack 1984, Pederson 1990, Hill 1996) (see examples listed under *Numerical Analysis*, this chapter). The two programs have the added advantage of performing classification or ordination on grid squares and species simultaneously. They are compatible as both use a reciprocal averaging procedure to derive their results but TWINSPAN divides the grids (and species) according to differences, while the ordination technique tends to group the grids (and species) according to their similarities. Therefore a clustering of grid squares (or species) in ordination space is indicitave of a floristic similarity (or shared geographic distribution) among them.

The distribution of TWINSPAN 5+ grid squares in ordination space was plotted along the 1st and 2nd DCA ordination axes, the two axes with the highest eigen-values (Fig. 40). The same was done with the ordination of TWINSPAN 3+ species (Fig. 66). TWINSPAN groupings of grid squares at the level of Region, and species at the level of Element were then superimposed on the resultant scatter plots.

The geographic trends in the compositional gradients of the grids were also studied in another way: For each axis of the TWINSPAN 3+ and 5+ ordinations the grid (sample) scores were divided into five and 10 equal intervals respectively. The grids were then assigned to groups (represented by different colours) according to these intervals and plotted on distribution maps (Figs. 41–48). Only the five-interval maps are presented here as both intervals showed basically similar patterns and colour separation on the 10-interval maps became difficult.

The length of the ordination axes or gradient lengths as well as the grid and species scores are given in *average standard deviation of species turnover* or *standard deviation* (SD) units (Gauch 1982).

The geographic trends in the floristic composition of the moss regions, as well as the distributions of the moss elements, were then related to a range of environmental, in particular climatic, variables. With DCA, environmental (climatic) gradients are not studied directly as only the floristic data is ordinated. Care was taken not to propose correlations of variables which are likely to be fortuitous.

2.3 Two-way table

The relationships between the broad scale floristic regions and floristic elements delimited by the TWINSPAN 3+ analysis were studied by summarising the re-ordered data-matrix in a two-way table (Fig. 65). The abundance of each Subelement in each Domain (represented by different sized dots in the figure) was estimated as follows: The total number of species in a particular Subelement was multiplied by the total number of grids in a specific Domain. The actual number of occurrences of the Subelement in the Domain was then counted and the percentage calculated. The percentages were then grouped into 10 classes represented by different-sized dots in the table.

2.4 Distribution maps

The distribution maps presented in Part 2 of this thesis were prepared by hand and scanned into a computer programme for further manipulation. The number of species that occur in each grid square was added to some of the diversity maps and all of the distribution maps of the elements in order to determine main distribution areas and centres.

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 km^2) 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, situated 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).

CHAPTER 4

BRYOGEOGRAPHIC REGIONS OF SOUTHERN AFRICA

Chapter Outline

A. Historical Perspective

Phytogeographic classifications have generally been based on the distribution of vascular plants only. The global phytogeographic classifications of Engler & Diels (1936), Good (1974) and Takhtajan (1986) have recently been compared by **McLaughlin** (1994). Detailed accounts of the history of phytogeographic divisions of (southern) Africa are given by **Monod** (1957), **Werger** (1978), **Denys** (1979), **Friis** (1986) and **Iversen** (1991). The latter provided an useful list of the most important phytogeographic classifications of Africa. A short synopsis for the southern African region is provided by **Cowling & Hilton-Taylor** (1997). **Hilliard & Burtt** (1987) reviewed the phytogeographic divisions of the southern KwaZulu-Natal Drakensberg. Some of the most important global and regional, contemporary classifications of floristic regions are briefly discussed here while regional subdivisions are generally considered under the relevant Regions and Domains (section C of this chapter). A distinction is made between phytogeographical classifications largely based on the geographic distribution of vascular plants and those based on the distribution of bryophytes.

I. Vascular plants

Known for his important plant collections, including bryophytes, from southern Africa (Dixon & Gepp 1923, Bayer 1971, Magill 1980, Gunn & Codd 1981, Codd & Gunn 1982), **Antoni Rehman's** contribution to the phytogeography of the region is not always appreciated (Zemanek & Zemanek 1990). In 1880 Rehman published *Phytogeographical conditions in South Africa* (Rehman 1880, in Polish) in which he described and mapped seven phytogeographic provinces in southern Africa (see map in Werger 1978):

The phytogeographic provinces of Rehman (1880)

Kalahari
Highveld
Monsoon Area
Forest Region
Roggeveld
Karoo
S.W. Cape

Frank White (1927-1994) of Oxford, United Kingdom (Gunn & Codd 1981, Angus & Chapman 1996) dominated the phytogeographic scene in Africa for the past 30 years. His early classifications (White 1965, 1970, 1971) were hierarchical and recognised six Regions in southern Africa, some of them represented by Domains:

Phytogeographic regions of southern Africa according to the hierarchical classification of White (1965, 1970, 1971)

1. Sudano-Zambezian Region, represented by the Zambezian Domain
2. Guineo-Congolian Region represented by the Usambara-Zululand Domain
3. Afro-montane Region
4. Afro-alpine Region (not mapped)
5. Karoo-Namib Region
6. Cape Region.

In 1976 White departed from a hierarchical classification system and introduced the rather confusing concepts of Regional centres of endemism, Archipelago-like centres of endemism, Regional mosaics, and Regional transition zones (White 1976). These phytogeographic categories are characterised as follows:

1) A regional centre of endemism has more than 50% of its species restricted to it and a total of more than 1000 endemic or near endemic species.
2) An archipelago-like regional centre of endemism only differs from the other regional centres of endemism in its fragmented distribution.
3) Regional transition zones separate regional centres of endemism and are characterised by less than 1000 endemic species, representing less than 50% of the total flora.
4) Regional mosaics cannot be categorized as any of the preceding and consist of a mosaic of distinct vegetation types and ".. a small amount of intermingling of otherwise distinct floras." (White 1993).

In 1976 White (1976) also introduced a 7th phytochorion, the Kalahari-Highveld regional transition zone. In his publication *The Vegetation of Africa* (White 1983), which White himself called "A milestone in the history of African botany...", he described the vegetation types of Africa and Madagascar "...within a regional chorological framework" (White 1983). With this publication White emphasized the similarities between the structural and floristic classifications of plants in the subregion. The following non-hierarchical phytochoria 'of equal rank' were now recognised by White (1976, 1983), see Fig. 17:

The non-hierarchical phytochoria of southern Africa according to White (1976, 1983).

Regional centres of endemism:

1. Zambezian
2. Karoo-Namib
3. Cape

Archipelago-like centres of endemism

1. Afro-montane
2. Afro-alpine (not mapped)

Regional mosaic

Tongaland-Pondoland

Regional transition zone

Kalahari-Highveld

The phytochorological classification of Africa by White (1976, 1983) is today widely accepted and forms the basis of other contemporary classifications, e.g. those of Goldblatt (1978) and Cowling & Hilton-Taylor (1997).

I largely agree with Linder (1990), who criticized the following aspects of White's phytochorological classifications:

1) The phytochoria are based on dominant taxa only.
2) The classification is influenced by historical developments in African phytogeography.

To these I would like to add that White's phytochorological classification is largely subjective and does not satisfy the current requirements of objectivity and repeatability.

Good (1974) recognised six Kingdoms (Boreal, Palaeotropical, Neotropical, South African, Australian, Antarctic) and 37 Regions in his phytogeographical classification of the world. His South African Kingdom, restricted to the south-western tip of Africa, contained a single Region, the Cape Region. The rest of southern Africa was covered by the South African and East African Steppe Regions, both of the Palaeotropical Kingdom. The South African Region is more or less restricted to the study area and described by Good (1974) as a transition zone between the 'tropical African flora' and the 'southern Mediterranean flora'. Good's East African Steppe Region is restricted to the north-eastern corner of South Africa and is characterised by savanna vegetation. The South African Region is subdivided into five 'parts' (Good 1974).

Phytogeographical division of southern Africa by Good (1974)

South African Kingdom
 Cape Region

Paleotropical Kingdom

East African Steppe Region

South African Region

High veldt of the Transvaal and the Orange Free State

The Kalahari

The Karroo

Namaqualand and Damaraland

Natal and the eastern Cape Province.

In *A Classification of the Biogeographical Provinces of the World*, based on similarities in floral, faunal and ecosystem composition, **Udvardy** (1975) divided the world into eight biogeographic Realms instead of Kingdoms:

The Biogeographic Realms of Udvardy (1975)

Palaearctic Realm

Nearctic Realm

Africotropical Realm

Indomalayan Realm

Oceanian Realm

Australian Realm

Udvardy's (1975) Afrotropical Realm (Fig. 18) covers the whole of sub-Saharan Africa and is subdivided into 29 biogeographic Provinces, largely based on the classification of **Dasmann** (1974). Udvardy's biogeographical classification of Africa was followed in *The IUCN Directory of Afrotropical Protected Areas* (**IUCN/UNEP** 1987). It appears that 6 of these provinces are present in the FSA area (Fig. 18):

1) South African Woodland/savanna Province in the northern and eastern parts of the study area.

2) Cape Sclerophyll Province along the Cape Fold Mountains.

3) Namib Province along the Namibian coast.

4) Kalahari Province in the northern interior.

5) Karroo Province along the Cape west coast and interior.

6) South African Highlands covering Lesotho and the high altitude plateau along the eastern escarpment.

Werger (1978) analysed the phytogeographic divisions of Africa up to the mid 1970s and came up with a composite classification for southern and south-eastern Africa (Fig. 19). The whole area was divided into two main units: 1) Capensis restricted to the south-western corner and 2) the Palaeotropis Subkingdom in the remainder of the subcontinent. The following regions are recognised in the FSA area:

1) The Indian Ocean Coastal Belt represented by the Tongaland-Pondoland Regional Mosaic.
2) Sudano-Zambezian Region represented by the Zambezian Domain.
3) Afromontane Region.
4) Afro-alpine Region represented by the Austral Domain.
5) Karoo-Namib Region subdivided into four Domains and one Subdomain.
6) Capensis.

The first more or less objective, numerical phytogeographic classification of tropical and subtropical Africa was presented by **Denys** (1979, 1980). She based her classification on a factor analysis of plant distributions mapped in the *Distributiones Plantarum Africanarum* series, edited by P. Bamps (Denys 1979, 1980). This purely floristic approach included the liverwort family Frullaniaceae and the moss family Thuidiaceae. Denys (1980) identified the following Regions, Subregions and Domains in tropical Africa (Fig. 20):

The phytogeographic divisions of Denys (1980)

Guineo-Congolian Region

Upper-Guinea Domain

Lower-Guinea Domain

Congo Basin Domain

Guinea-Congolia/Sudania Transition Region

Sudanian Region

Southern Subregion

Northern Subregion

Region of the Central African Lakes

Guinea-Congolia/Zambezia Transition Region

Zambezian Region

Region of the Indian Ocean Coastal Belt

Afromontane Region

Madagascan Region

Occidental Domain

Oriental Domain

Denys's classification largely confirmed the phytochoria of White (1983) but without clear support for his regional mosaics. Unfortunately her study excluded the largest part of southern Africa and only the Afromontane Region and a small part of the Zambezian Region is mapped in this area. The Afromontane Region was subdivided by Denys (1980) into seven Domains (see *Discussion* under the *Afromontane Region*, this chapter, and Fig. 21).

In a numerical analysis of the geographical distribution of Cape taxa **Oliver** *et al.* (1983) identified six phytogeographic areas or regions in the 'Cape Floral Region'. These regions, or 'elements' as they were called, were compared with the endem-centres of Weimarck (1941), which are not floristic regions but distribution centres within the Cape element. The six areas delimited by Oliver *et al.* (1983) are: 1) the Northern Centre, 2) the Peninsula Centre, 3) the South-western Centre, 4) the West Coast Centre, 5) the Bredasdorp Centre, and 6) the Southern Centre. These areas are generally below the level of Domain.

Takhtajan (1986) divided the world into six kingdoms:

1) Holarctic Kingdom (Holarctis).
2) Paleotropical Kingdom (Paleotropis).
3) Neotropical Kingdom (Neotropis).
4) Cape Kingdom (Capensis).
5) Australian Kingdom (Australis).
6) Holantarctic Kingdoms (Holantarctis).

The Cape Kingdom is the smallest of the six and restricted to the southernmost tip of Africa. The rest of sub-Saharan Africa is covered by the 'Paleotropical' Kingdom. The whole of southern Africa is divided into four of Takhtajan's 35 Regions, subdivided into subregions and provinces:

The phytogeographic subdivision of southern Africa by Takhtajan (1986)

1). The Cape Region in the extreme south-west represented by a single Cape Province.
2). The Karoo-Namib Region along the arid western coast, subdivided into 4 provinces (Namib, Namaland, Western Cape and Karoo) similar to the KarooNamib domains of Werger (1978).
3). The Sudano-Zambezian Region occupies subtropical Africa and is subdivided into a northern Sahelo-Sudanian Subregion and a southern Zambezian Subregion. The latter is represented in southern Africa by a single province, the Zambezian Province, which occupies much of the central and northern parts of the study area
4) The Uzambara-Zululand Region which runs along the southeastern coast of Africa and consists of a northern Zanzibar-Inhambane Province (not present in the study area) and a southern Tongoland-Pondoland Province.

In order to determine the conservation status of the Fynbos and Karoo Biomes **Hilton-Taylor & Le Roux** (1989) provided a combined structural and floristic classification of this area. Their map shows 25 "...biogeographic areas of the fynbos, succulent karoo and Nama-karoo biomes.". They explained that "The boundaries are based on Weimarck (1941), Oliver *et al.* (1983) and Hilton-Taylor (1987) with modifications based on Acocks (1953, 1975)", therefore a mixture of floristic regions (Oliver *et al.* 1983, Hilton-Taylor 1987), floristic elements and distribution centres (Weimarck 1941), and vegetation types (Acocks 1953, 1975).

Phytogeographic patterns in the Coryciniae, a group of orchids mainly distributed in southern Africa, were determined by **Kurzweil** *et al.* (1991). A numerical analysis of the data set "...to determine the relationships among the degree squares ..." revealed three main floristic regions in southern Africa, which Kurzweil *et al.* (1991) referred to as 'centres'. They are: 1) the Namaqualand area, 2) the Cape Floristic Region, and 3) the Drakensberg. They also identified a number of floristic elements or 'centres of endemism' which are listed in Chapter 5 under *Historical Perspective.*

Oliver (1994) studied geographic distribution and endemism in the largely southern African subfamily Ericoideae (Ericaceae). Similarities and differences among the ericaceous floras of 12 subjectively chosen 'centres' were analysed using Jaccard's coefficient and the classification program TWINSPAN respectively. Oliver (1994) recognised five main areas or regions with distinct Ericiodeae floras and high levels of species endemism which he called 'Regional Centres of Endemism'. He suggested that the Cape Centre be included in a broad Afrotemperate Region.

Regional Centres of Endemism based on the distribution of the subfamily Ericiodeae (Ericaceae)

Cape Centre
Drakensberg Centre
Tropical Afromontane Centre
Madagascan Centre
North African/European Centre

In a recent review of the phytogeography of southern Africa **Cowling & Hilton-Taylor** (1997) adopted the floristic regions of **Goldblatt** (1978), who followed White (1976, 1978) with minor changes to the boundaries of the Cape Region. Goldblatt (1978) and Cowling & Hilton-Taylor (1997) have given their phytochoria the rank of Region except for the Kalahari-Highveld phytochorion which they called a Transition Zone after White (1976, 1978, 1983). Although the Afro-alpine Region is included within the Afromontane Region, Cowling & Hilton-Taylor (1997) admit that such an approach remains problematic. They recognise the following 6 regional phytochoria (see Fig. 22):

The phytogeographic regions of Goldblatt (1978) and Cowling & Hilton-Taylor (1997)

Zambezian Region
Kalahari-Highveld Transition Zone
Karoo-Namib Region
Tongaland-Pondoland Region
Afromontane Region
Cape Region

II. Bryophytes

Werger (1978), in his historical review of phytogeographic divisions in Africa, mentioned the bryogeographic classifications of Herzog (1926) and Ochi (1973). These, as well as other bryogeographic classifications published since 1978, are briefly reviewed here.

Herzog (1926) provided the first comprehensive analyses of bryophyte distribution patterns in his *Geographie der Moose*. He did not include a map of his bryogeographic regions but Miller (1982) created a map from Herzog's descriptions (Fig. 23). The following six kingdoms were recognised by Herzog (1926):

Herzog's Florenreiche (Herzog 1926)

Holarktisches Florenreich

Neotropisches Florenreich

Paläotropische Florenreich

Australisches Florenreich

Austral-antarktisches Florenreich

Südafrikanisches Florenreich

According to the map in Miller (1982), Herzog's Südafrikanisches Florenreich included the whole of the FSA area. The recent vascular plant Kingdoms of Good (1974) and Takhtajan (1986) are remarkably similar to Herzog's Florenreiche.

Ochi (1973) based his bryogeographic division of Africa and adjacent islands on the geographic distributions of mosses in the subfamily Bryoideae (family Bryaceae). He took the geographic recording system of Van der Wijk *et al.* (1969) as a starting point to divide the area into four main regions (Fig. 24):

1) Afr I in the north (Sahara).
2) Afr II covering tropical and subtropical Africa, the west African islands, and eastern Indian Ocean islands including Madagascar, the Seychelles and the Mascarenes.
3) Afr III in the south.
4) KERG for the subAntarctic islands of Kerguelen, Prince Edward and Crozet.

Afr I was subdivided into two subregions and Afr II into five. The boundary between Afr II and Afr III is rather artificial but seems to enclose the whole of the study area in Afr III.

Miller (1982) adopted Good's classification of Floristic Regions (Good 1974) in his discussion of the phytogeography of the bryophytes. He found that the "...austral nature..." and "...high endemism rate" of the Cape bryoflora could not be explained satisfactorily by contemporary hypotheses. Miller (1982) proposed that the Cape Fold Mountains represents a Gondwana island which caught up with the African mainland in the late Cretaceous or early Tertiary. Migration in and out of the unique flora of the "...long separated Cape Island" was supposed to be limited by ecological processes.

The rest of the study area is covered by the whole of Miller's South African Region and the southernmost tip of his East African Steppe Region, both classified under the African Subkingdom of the Palaeotropical Kingdom (Miller 1982).

Schofield's tentative Bryophyte floristic kingdoms (Schofield 1992) are essentially those of Herzog (1926), modified by incorporating recent distribution data. The floristic kingdoms are based on "...floristic similarity, with emphasis on families and genera unique to the Kingdoms, and on the degree of endemism, at the species level" (Schofield 1992). The following six bryofloristic kingdoms are recognised (Fig. 25):

Bryophyte floristic kingdoms of Schofield (1992)

Holantarctic kingdom
South African kingdom
Australian kingdom
Neotropical kingdom
Palaeotropical kingdom
Holarctic kingdom

Almost the whole of the FSA area is included in the South African Kingdom, the smallest of the six kingdoms. This kingdom was found to contain a "...highly distinctive bryoflora, especially in the mosses." and is characterised by "...the endemic monotypic family Wardiaceae and at least 10 endemic genera, most of which are monotypic." Schofield (1992) also pointed out that many of the endemic genera are small, short-lived mosses adapted to arid conditions, similar to many genera in the Australian flora. He found that the (Schofield 1992) "Affinities of the South African flora are predominantly with continental Africa....".

III. Phytogeographic categories

The following phytogeographic categories, in descending order, are widely used in hierarchical classifications of the world (See White 1970, Takhtajan 1986 and McLaughlin 1994):

1. Kingdom or Realm
2. Region
3. Province or Domain
4. District

Subdivisions of the main categories, viz. subkingdom, subregion, subprovince and subdistrict, are also used. The formal categories of Region and Domain are assigned to the bryogeographic regions described in this study.

B. TWINSPAN Classification of Grid Squares

TWINSPAN classification of grid squares into southern African floristic or phytogeographic regions (floristically homogeneous geographic areas or areas of similar floristic or species composition within southern Africa).

I. TWINSPAN Complete classification

The TWINSPAN Complete data set, consisting of the presence/absence of the 503 moss species/infraspecific taxa in each of the 416 grid squares, was divided into 11 groups after the 6th level of TWINSPAN division. The dendrogram resulting from the TWINSPAN Complete classification is shown in Fig. 26.

1. **First level of division**

   The first and major TWINSPAN Complete division separated grids 1816 D in northern Namibia and 2023 B near Maun in northern Botswana (Figs. 26 & 27, region 1/2 or end group 11) from the rest of the grids in the study area. These two grid squares are under-collected and contain a single species, *Plaubelia involuta* (Pottiaceae), a southern African endemic restricted to end group (or floristic region) 11.

2. **Second level of division**

   At the second level of division, grid 3127 A in the Dordrecht area of the Eastern Cape province (Figs. 26 & 27, region 2/1 or end group1) is split off from the remainder of the grids. This grid is distinguished by the narrow endemic *Pseudoleskeopsis unilateralis* (Leskeaceae), the only species recorded.

3. **Third level of division**

   At the 3rd level of division grid 2818 B in southern Namibia was distinguished as floristic region (end group) 10 (Figs. 26 & 27) on the presence of the narrow endemic *Archidium dinteri* (Archidiaceae). Only this single species has so far been recorded from the locality.

4. **Fourth level of division**

   It is only at the fourth level of division that the TWINSPAN classification divides the remaining grids into two main groups (Fig. 26). Region 4/2 (fourth level of division group 2, consisting of end groups 2-5) represents the largest group of 287 grids that occupies the eastern part of southern Africa. Region 4/3 (end groups 6-9) form the smaller group of 135 grids, concentrated in the semi-arid to arid western and central parts of the study area (Fig. 28).

   The groups have adjacent grids more or less grouped together along the eastern, southern and western borders of the study area. In the central and northern parts, however, the grids are non-contiguous, partly as a result of the many empty grids. The division line between the two groups is not very clear, mainly as a result of outliers and empty grid squares (Fig. 28).

5. **Fifth level of division**

At this level of division, region 5/2, consisting of 17 non-contiguous grids in the northern parts of southern Africa (Figs. 26 & 29), is separated from the rest of the eastern group (region 5/3). On the other side of the main division line region 5/5, consisting of 11 non-contiguous grids scattered down the centre of Namibia, from Otjiwarongo in the north to Augrabies in the south (Figs. 26 & 29), is split off from the western group (region 5/4).

After the fifth level of division the majority of grids still belong to one of the two main groups distinguished at the fourth level.

6. **Sixth level of division**

At the sixth and final level of division the grid squares have been divided into 11 end groups or regions (Fig. 26). Region 1 (grid 3127 A) has already been split off at the second level of division. At the first dichotomy TWINSPAN separates end group or region 3 (three grids in northern Botswana and two grids in the north-eastern corner of the Northern province) from end group 2, consisting of grids scattered across the northern parts of the study area (Fig. 30). Region 3 is characterised by *Erpodium beccarii* (Erpodiaceae), a woodland epiphyte which occurs in all five of the grids. The next dichotomy separates a single grid square as region 4 from the rest of the grids in the large eastern group or region 5 (Fig. 30). This grid (2429 C) contains a single species, *Weisiopsis plicata* (Pottiaceae), which is restricted to three grids in the Northern province of South Africa .

Region 5, the largest floristic region distinguished by the TWINSPAN Complete classification of grid squares, has several outliers in the central and northern regions of the study area (Fig. 30). These outliers are species poor grids, many with single species recorded from them (e.g. 1712 B, 1712 D, 1914 D, 1915 C, 1922 C, 2716 A, 2917 C, 2919 B and 3112 D), and are most probably under-collected. The rest of the grids in region 5 are more or less contiguous along the eastern and southern borders of the study area, from the Soutpansberg in the north to Table Mountain in the south-west (Fig. 30).

The other major group distinguished by TWINSPAN at the 5th level of division (region 5/4), spread over the western and central parts of South Africa, is here subdivided into an eastern and a western region (Fig. 26). Region 6 is situated along the West Coast, roughly from Lüderitz on the Namibian Coast in the north to Malmesbury in the south and extending eastwards along the southern edge of the Great Karoo (Fig. 30). Several outlying grids to the east and north (e.g. 2117 D, 2217 D, 2516 A, 2525 C, 2616 C, 2624 C, 2720 C, 2926 B etc.) represent less than three species each. Region 7 is a high-altitude, low July and annual mean temperature area, scattered over the central parts of South Africa, from the Lesotho Highlands eastwards (Fig. 30).

The last dichotomy at the 6th level (Fig. 26) divides the already non-continuous region 5/5 into a northern group (region 8) and a southern group (region 9). Most of the grid squares in these two regions have less than three species recorded from them (2016 D, 2117 C, 2317 A, 2318D, 2426 D, 2417 C, 2417 D. 2718 B and 2820 C), while one grid contains less than five species (2216 D), and another (2116 D) six species (Fig. 30).

Discussion

From the results of the TWINSPAN Complete classification it is clear that TWINSPAN is sensitive to species-poor grids, especially those containing single narrow endemics or taxa of limited geographic distribution in the study area. This phenomenon, where instead of a first division in the middle, small groups of sample points are split off by TWINSPAN from the main data set, was also reported by Gauch & Whittaker (1981) and Van Groenewoud (1992). The latter blamed the problem on the displacement of sample points along the ordinations (Van Groenewoud 1992) while in the case of Gauch & Whittaker (1981) it could have been caused by the presence of outliers. I therefore decided to remove some of the outliers from the TWINSPAN Complete data set by deleting grids which contain less than three species, resulting in the TWINSPAN 3+ data set, and grids with less than five species, resulting in the TWINSPAN 5+ data set. The results of these two TWINSPAN classifications are discussed next.

II. TWINSPAN 3+and TWINSPAN 5+ classifications

For the TWINSPAN 3+ data run 128 grid squares with less than three species/infraspecific taxa each (Fig. 3) were deleted from the complete data set of 426 grids. An additional 47 grids with only three or four species/infraspecific taxa recorded (Fig. 3) were deleted for the TWINSPAN 5+ data run. Fortunately only two FSA endemics, *Plaubelia involuta* (Pottiaceae) and *Pseudoleskeopsis unilateralis* (Leskeaceae), restricted to two of the grids deleted for both data runs, were lost in the process.

The presence/absence data of 501 species/infraspecific taxa in 298 grid squares in the TWINSPAN 3+ data set was classified into 45 end groups or floristic regions (Fig. 31). The 251 grids in the TWINSPAN 5+ data set were divided into 39 floristic regions or end groups (Fig. 35). The results of the two TWINSPAN classifications are very similar and although the empty spaces increased compared to the TWINSPAN Complete classification, the floristic groups became more geographically homogeneous and the number of outliers decreased.

1. First level of division

The first and major TWINSPAN 3+ (and TWINSPAN 5+) division divides the grid squares into two main groups (Figs. 31 & 35), similar to the groups distinguished at the 4th level of division of the TWINSPAN Complete classification. Region 1/1 (end groups or regions 1-24 of the TWINSPAN 3+ classification) occupies the eastern and southern parts of the study area while region 1/2 (regions 25-45) is scattered over the arid and semi-arid western and central parts (Figs. 31 & 32). The only region 1/1 outliers that remain after the TWINSPAN 5+ classification are three grids in the Korannaberg and Langeberge of the Northern Cape Province, two grids in northern Namibia (Otjiwarongo-Otavi area) and two grids in the swamps of the Caprivi strip and northern Botswana (Fig. 36). The fate of these grids will only be decided by classifications based on more data from under-collected areas but I suspect that these areas will eventually prove to be continuous with the main areas occupied by region 1/1.

Region 1/2 is now more homogeneous than region 4/3 of the TWINSPAN Complete classification due to the ellimination of species poor outliers. It has actually expanded, from the TWINSPAN Complete to TWINSPAN 3+ to TWINSPAN 5+, along the eastern and southern borders (Compare Figs. 28, 32 & 36). In central Namibia, however, the group has been reduced to four outliers. Many of the species-poor grids in the arid central parts of the study area have been deleted for the TWINSPAN 3+ and 5+ classifications and only two are left: grid 2822 C in the southern Langberge of the Northern Cape Province and grid 2824 D where the town of Kimberley is situated (Fig. 36).

2. **Second level of division**

At the second level of division regions1/1 and 1/2 are subdivided into two groups each (Figs. 31 & 35). Region 1/1 is split into a large, more or less geographically coherent group (region 2/2) of 160 grids distributed along the southern and eastern parts of the study area, from Table Mountain in the south to the Soutpansberg in the north and a smaller group (region 2/1) of 64 grids scattered throughout the northern parts (Fig. 33). After the TWINSPAN 5+ classification region 2/1 extend as far south as KwaZulu-Natal (grid 3030 B) and the eastern Cape Province (grid 3224 D) with more outliers in The Okavango Swamps of Botswana, The Langeberg Mountains in the Northern Province and two grids in Namibia (Fig. 37).

The other dichotomy splits TWINSPAN region 1/2 into an eastern (region 2/4) and a western (region 2/3) group (Fig. 31). Most of the eastern region 2/4 grids are spatially continuous in and around the Highlands of Lesotho and the southern Free State, extending as far south as the mountains between Graaff-Reinet, Middelburg and Cradock in the Eastern Cape Province (Fig. 33). The remainder of the region 2/4 grids are scattered to the west of the main distribution with four outliers (grids 2822 C, 3221 B, 3119 B and 2416 A) remaining after the TWINSPAN 5+ classification (Fig. 37). Region 2/3 consists of 59 grids in the arid winter rainfall region, more or less contiguous along the south-western Cape coast as far north as Lüderitz in Namibia, with outliers to the east and north of the main area (Fig. 33).

3. Third level of division

Eight groups are distinguished at this level (Figs. 31 & 35). The first dichotomy splits eight grids in the extreme north of the study area (region 3/1) from the remainder of the northern group (region 3/2) (Fig. 34). The other dichotomy divides the large eastern group (region 2/2) into a small southern group of 18 grids (region3/4) and a large northern group of 127 grids (region 3/3). Region 3/4 grids are centered in the south-western corner of the study area with outliers scattered to the east as far as the Eastern Cape Province (grid 3224 A) and north-eastern KwaZulu-Natal (2732 D). With the TWINSPAN 5+ classification the grids in this group have actually increased to 21, all of them more or less continuous along the southern Cape Fold Mountains (Fig. 38). The KwaZulu-Natal outlier has been deleted and the Eastern Cape grid re-classified.

The large northern group of the TWINSPAN 3+ classification (region 3/3) stretches from the Outeniqua Mountains in the south-western Cape to the Soutpansberg in the north (Fig. 34). The TWINSPAN 5+ equivalent is even more geographically homogeneous and starts at the Alexandria grid to the east of Port Elizabeth (Fig. 38).

On the other side of the main division line the first dichotomy splits off a few northern grids (region 3/6) from the rest (region 3/5). The other dichotomy divides region 2/4 into an eastern (region 3/7) and a western (region 3/8) group (Figs. 34 & 38). The eastern group (region 3/7) is centered in the Highlands of Lesotho, with outliers to the south-west, while the adjacent western group (region 3/8) is most contiguous in the southern Free State with several outliers to the south and west.

TWINSPAN goes on to classify the TWINSPAN 3+ and TWINSPAN 5+ grid squares into 45 and 39 end groups respectively after the 6th level of division (Figs. 31 & 35). However, it is at the 2nd and 3rd levels of division that the groups are comparable with phytochoria at the subcontinental or regional scale.

Further discussion of the TWINSPAN classification will therefore centre around the first three levels of division.

Discussion

Most of the bryogeographical regions identified by the TWINSPAN 3+ and 5+ classifications are fairly geographically homogeneous with adjacent grids being grouped together. This suggests that there are clear geographically coherent patterns in the data. The increased homogeneity of the regions, from the TWINSPAN Complete to the TWINSPAN 5+ classification, suggests that the TWINSPAN 5+ data set has resulted in the best classification of moss distribution patterns.

Unfortunately the removal of outliers from the TWINSPAN Complete data set has resulted in the deletion of most grid squares in the arid north-western sector of the study area or the countries of Namibia and Botswana. This has made it impossible to present a clear picture of bryogeographic regions in this area. However, the DCA ordination made it possible to interpret the most obvious compositional gradients present in the data.

The first and major TWINSPAN division line is not clearly distinguishable, especially in the central and northern parts of the study area, mainly due to the many empty grid squares but also as a result of the size of the grids or the grain chosen for this study (Figs. 32 & 36). This is to be expected in an exploratory, broad-scale analysis where the general pattern of division is more important than the precise boundaries between groups. However, the main discontinuity in the data appears to coincide with sections of major geological, geomorphological, climatic, and vascular plant vegetation and phytogeographic division lines in southern Africa.

Starting in the south, the main division begins at Table Mountain in the Cape Peninsula, turning slightly northwards up to 33° 30' latitude where it turns east to follow the northern boundary of the Cape Super Group (Truswell 1979, Kent 1980, Visser *et al.* 1984), the east-west axis of the southern Cape Fold Mountains (King 1963, Dingle *et al.* 1983, Partridge 1997), the boundary the Fynbos Biome (Rutherford & Westfall 1986, Low & Rebelo 1996, Rutherford 1997, Cowling &

Holmes 1992, Cowling *et al*. 1997) and the Cape (Floristic) region (Werger 1978, Cowling & Holmes 1992, Goldblatt 1978, Cowling & Hilton-Taylor 1997). From Port Elizabeth on the eastern Cape coast, where the first division line is interrupted by the dry Sunday's River Valley, it turns north to link up with and to follow the Great Escarpment (Wellington 1955, King 1963, Partridge & Maud 1987) and the continental watershed between drainage to the Indian Ocean and drainage to the Atlantic Ocean (Walton 1994). This line continues along the Great Escarpment of the Drakensberg Mountains, more or less coinciding with the border between the Afro-alpine and Afromontane regions (Werger 1978) all the way to the Maloti Mountains in northern Lesotho.

From the north-eastern Free State the division turns west to coincide with the border between the Nama-Karoo and Savanna Biomes (Rutherford & Westfall 1986, Low & Rebelo 1996, Rutherford 1997, Palmer & Hoffman 1997, Van Wyk & Van Wyk1997) or Ecozone (McCullum 1994) and the boundary between the Karoo-Namib and Kalahari-Highveld regions (White 1983, Goldblatt 1978, Cowling & Hilton-Taylor 1997) or the boundary between the Karoo-Namib and Sudano-Zambezian regions (White 1965, 1971; Takhtajan 1986) right up to the northern border of Namibia.

The north-eastern part of the main division more or less coincides with the eastern limit of the karoo vegetation (see maps in Acocks 1953 and Nordenstam 1969). It also seems to follow, from the central part of the Northern Province all the way to the Angolan border, the general direction of the mean summer rainfall and mean annual rainfall isohyetes (see rainfall maps in: Anon 1957; Le Roux 1967; Schulze & McGee 1978; Schulze 1997, 1997a; Barnard 1998), and the continental watershed between the inland drainage region or Kalahari Basin and the Atlantic Ocean drainage region (Walton 1994). It is most likely that in Namibia the 1st division line also coincides with the Great Escarpment (compare with physiographic maps in Barnard 1998) but this will only become clear once more sample points or grids are incorporated in the classification.

This main line therefore divides southern Africa into a temperate or austral moss flora (the Southern Flora of Acocks, 1971) represented by the the Karoo-Namib and

Highlands Regions on the one side, and a subtropical or palaeotropical moss flora (the Tropical Flora of Acocks, 1971) represented by the Zambezian and Afromontane (including the Cape) Regions on the other (Figs. 33 & 37). Whether this line represents the border between two Kingdoms, or the border between phytochoria of a lower rank, is not clear at this stage and should be determined by a much broader study including the whole of Africa and other southern temperate areas.

The main southern African division line of contemporary phytogeographic schemes (e.g. Good 1974, Miller 1982 Takhtajan 1986, Werger 1978, Jürgens 1991) is drawn much further south than the main TWINSPAN division and generally follows the boundary of the Cape Region (Goldblatt 1978, Cowling & Hilton-Taylor 1997) and the Fynbos Biome (Rutherford 1997). This line generally divides southern Africa into a Cape phytochorion (Kingdom) in the south and a Palaeotropical phytochorion (Kingdom) covering the rest of sub-Saharan Africa to the north. Herzog (1926) and Schofield (1992) on the other hand draw their main bryofloristic division line to include almost the entire study area in their southern division, the South African Kingdom.

The proposed subdivision of southern Africa into a Greater Cape Flora (Floristic Kingdom) in the south-west, including the western part of the Karoo-Namib region, the Cape region, and " afromontane regions further east...", as opposed to a Palaeotropis or Palaeotropical Kingdom in the rest of the area (Jürgens 1991), is not supported by this study. The whole of the Karoo-Namib Region is here included in the temperate or austral 'kingdom' while the fynbos and forest part of the Cape phytochorion belongs to a (sub)tropical or palaeotropical kingdom. I also don't agree with Linder (1990) who argued that the temperate African phytochorion consists of the Afroalpine, Afromontane and Cape phytochoria (see discussions under the *Afromontane Region*). The temperate Afro-alpine region (Drakensberg Alpine Domain of this study) is clearly not closely related to the Afromontane region (including the Cape region) which belongs to the (sub)tropical phytochoria of Africa.

C. Classification of the Bryogeographic Regions of Southern Africa

I. Introduction

The brygeographic classification presented here is based exclusively on the results of the TWINSPAN 3+ and TWINSPAN 5+ analyses. The classification is of course hierarchical and can be presented as a dendrogram (Fig. 39).

Most phytogeographic classifications have been hierarchical, as McLaughlin (1992) states: "...for reasons of convenience, not because analyses of plant distributions have revealed geographic patterns that are inherently hierarchical and hence best described by a hierarchical system." McLaughlin (1992), however, through analysis of 101 local floras of the western United States of America, has shown that a hierarchical classification system is not only an useful, but also a natural way of depicting floristic relationships.

The names assigned to the Regions and Domains are provisional because of the regional nature of this study but most of the names, especially those of the Regions, are well established and are not expected to change much. The floristic diversity and endemism in each of the phytochoria are summarised in Tables 14 & 15.

Hierarchical classification of the bryogeographic regions of southern Africa

1. Zambezian Region

1.1 Caprivi Domain

1.2 Bushveld Domain

2. Afromontane Region

2.1 Drakensberg Domain

2.2 Cape Domain

3. Karoo-Namib Region

3.1 Western Cape Domain

3.2 Namaqua Domain

4. Highlands Region

4.1 Drakensberg Alpine Domain

4.2 Upper Karoo Domain

II. Descriptions of Regions and Domains

1. Zambezian Region

Area

In southern Africa the Zambezian Region is at present most continuous in the Bushveld of the Northern Province with disjunctions in the Northern Cape, Eastern Cape, northern Botswana and Namibia (Fig. 37). This bryogeographical region seems to be associated with woodland, savanna or bushveld vegetation (White 1983, Low & Rebelo 1996, Scholes 1997) and therefore is largely restricted to the Savanna Biome (Rutherford & Westfall 1986, Low & Rebelo 1996, Rutherford 1997), or the Temperate Xerophytic Woods/Scrub biome (Olson *et al.* 1983).

The Zambezian Region consists of 39 grid squares (TWINSPAN 5+), largely discontiguous because of the many empty grids in the northern parts of the study area (Fig. 37). Significant outliers include grids 3030 B (Mkomazi River on the KwaZulu-Natal South Coast), 3224 D (Jansenville in the Eastern Cape), and 2722 A, 2722 D, & 2822 B (Langberge mountains the Northern Cape). These areas are known to have Bushveld or Thicket vegetation types (Low & Rebelo 1996) and fall in the Savanna Biome of Rutherford & Westfall (1986).

Several aspects of this phytochorion, such as the geology, physiography, climate, phytogeography, borders with other phytochoria, and vascular plant flora and vegetation, have recently been described by White (1965, 1983) Werger & Coetzee (1978) (in part), and Denys (1980). Useful synopses or reviews of the Zambezian Region have been provided by Goldblatt (1978), White (1993), Beentje *et al.* (1994) and Cowling & Hilton-Taylor (1997).

Composition of the moss flora

The moss flora (TWINSPAN 5+) of the Zambezian Region consists of 136 species/infraspecific taxa (27% of mosses in southern Africa) in 74 genera and 31 families which makes it the smallest of the regional floras (Appendix II,1). The largest family in this Region is Bryaceae with 21 species in seven genera. The second and third largest families are Pottiaceae with 17 species/infraspecific taxa in 10 genera and Dicranaceae with 15 species in five genera. *Fissidens* (Fissidentaceae) with 13 species, *Bryum* (Bryaceae) with 12 species and *Campylopus* (Dicranaceae) with 11 species are the largest moss genera in the Zambezian Region.

Characteristic of this flora is the prominence of woodland taxa in the families Fissidentaceae, Dicranaceae, Pottiaceae, Bryaceae, Erpodiaceae, Ptychomitriaceae and Meteoriaceae. The woodland taxa include the diagnostic and important species (see lists) as well as more wide-ranging taxa like *Fissidens erosulus, Aulacopilum trichophyllum, Calymperes rabenhorstii, Octoblepharum albidum, Pseudocrossidium porphyreoneurum, P. replicatum, Syntrichia pagorum, Bryum capillare, Erpodium beccarii and Fabronia pilifera.*

None of the southern African moss families or genera are restricted or endemic to this region. Diagnostic species (species restricted to this Region in southern Africa but which may also occur in other parts of the world) are:

Diagnostic and endemic (*) Zambezian species

Calymperes tenerum,
Erpodium grossirete
*Fissidens capriviensis,

Fissidens capriviensis (Fissidentaceae) is the only true endemic (restricted to the FSA area and to this phytochorion) with *Calymperes tenerum*

(Calymperaceae) pantropical in distribution and *Erpodium grossirete* (Erpodiaceae) ranging northward as far as northeastern Zimbabwe.

Other important species, (species largely confined to this region in southern Africa), also called near-endemic elements by White (1993), include:

Important Zambezian mosses

Archidium acanthophyllum
Barbula eubryum
Erpodium coronatum *subsp*. transvaaliense
Ptychomitrium exaratifolium

Discussion

The Zambezian Region coincides with the southern section of the Zambezian regional centre of endemism of White (1976, 1983, 1993) and the Zambezian Region of Goldblatt (1978) and Cowling & Hilton-Taylor (1997). In the northern provinces of South Africa the bryogeographical region occupies the 'lowlands' in relation to the Soutpansberg, Drakensberg, Magaliesberg and Waterberg mountain ranges which fall in the Afromontane Region.

In Table 16 the numbers of moss taxa and endemics in the southern section of the Zambezian Region are compared with the figures available for vascular plants. Although the bryogeographical region is much smaller and therefore not directly comparable with the whole of the vascular plant region of White (1983) it is nevertheless interesting to look at the trends. Goldblatt (1978) gave a few figures for the southern African section of the phytochorion and these are also listed in Table 16.

Endemism is very low or absent at the family and genus level in both groups. The southern African section of the vascular plant region " is relatively depauperate " with only two endemic genera and few endemic species (Goldblatt 1978). Similarly only 27% of southern African mosses occur in this phytochorion and endemism is even lower with no endemic families or genera and only one endemic species. Vascular plant endemism at the species level is higher (54%) for the whole region (White 1983).

Species of the Eastern Highlands and Afromontane Grassland Elements (distribution patterns) are most abundant in this region (Fig. 65) but none of the bryogeographic elements has its main centre of distribution in the Zambezian Region. As could be expected, species of the Cape Element are relatively scarce.

1.1 Caprivi Domain

Area

This Domain consists of a few grid squares in northern Namibia (TWINSPAN 3+ only), the Caprivi and Okavango swamps of northern Botswana, and the northern Province of South Africa (Figs. 34 & 38).

Composition of the moss flora

Only 22 mosses (4% of southern African mosses) belonging to 15 genera and 12 families make up the flora of the Caprivi Domain (Appendix II,1a.), most of which belong to the acrocarpous orders of Dicranales, Pottiales and Bryales. The orders Andreaeales, Funariales, Hookeriales, Hypnobryales and Polytrichales are not represented in this domain.

The families Dicranaceae, Pottiaceae and Bartramiaceae are the largest with three species each while *Campylopus* (Dicranaceae) and *Philonotis* (Bartramiaceae) with three species each and *Fissidens* (Fissidentaceae), *Archidium* (Archidiaceae) and *Erpodium* (Erpodiaceae) with two species each are the best represented among the genera.

Diagnostic families or genera are absent. Of the two diagnostic species *Fissidens capriviensis* is endemic and *Erpodium grossirete* restricted to this Domain in southern Africa. Both are woodland species growing on the bark of trees.

Discussion

The already non-continuous Zambezian Region is further divided into what seems to be a northern (Caprivi) and a southern (Bushveld) Domain (Figs. 34 & 38). Whether these devisions are real and coincide with any of the vascular plant divisions reviewed by Werger & Coetzee (1978), or whether they are artifacts of insufficient data, remains to be seen. Another possibility is that the Caprivi Domain represents the Guinea-Congolia/Zambezia Transition Region, and the Bushveld Domain the Zambezian Region, both of Denys (1980).

The moss flora of the Caprivi Domain consists mostly of species in the Disjunct Cape Peninsula Subelement while species of the West Coast and Boland Subelements are absent from this area.

1.2 Bushveld Domain

Area

The Bushveld Domain is the largest of the two Zambezian divisions, distributed over 35 (TWINSPAN 5+) savanna grids in the northern provinces of South Africa and Namibia (Fig. 38). In South Africa it surrounds the northern part of the Drakensberg Domain or Afromontane Region. Outliers are discussed under the Zambezian Region.

Composition of the moss flora

The floristic composition of the Bushveld Domain is essentially the same as that of the Zambezian Region (minus *Fissidens capriviensis, Campylopus flaccidus, Octoblepharum albidum, Brachymenium* *systylium, Erpodium grossirete* and *Aerobryopsis capensis*). *Octoblepharum* is the only genus in the flora of the Zambezian Region not shared by the Bushveld Domain. The 130 species/infraspecific taxa, representing 73 genera in 30 families that occur in this domain are listed in Appendix II,1b. The families with the most specie/infraspecific taxa are Bryaceae with 20 species in seven genera, Pottiaceae with 17 species in 10 genera and Dicranaceae with 14 species in five genera. *Fissidens* (Fissidentaceae)and *Bryum* (Bryaceae) with 12 species each, *Campylopus* (Dicranaceae) with 10 species, and *Philonotis* (Bartramiaceae) with four species are the largest genera in the Bushveld Domain.

Calymperes tenerum (Calymperaceae) is the only diagnostic species (restricted to this Domain in southern Africa) but *Archidium acanthophyllum* (Archidiaceae), *Barbula eubryum* (Pottiaceae) and *Ptychomitrium exaratifolium* (Ptychomitriaceae) are also important woodland taxa largely restricted to this Domain. At present the Bushveld Domain lacks endemic moss taxa.

Discussion

As a subdivision of the Zambezian Region this Domain also is dominated by woodland taxa and can be compared with the southern section of the Zambezian regional centre of endemism (Region) of White (1976, 1983, 1993), Goldblatt (1978) and Cowling & Hilton-Taylor (1997). For more details see the discussions under the Zambezian Region and Caprivi Domain.

2. Afromontane Region

Area

The Afromontane Region, consisting of 113 grid squares (TWINSPAN 5+), is by far the largest of the four bryogeographic regions in southern Africa (Fig. 37). This region is most prominent in KwaZulu-Natal with extensions north along the Great Escarpment to the Soutpansberg, and south-west as far as Table Mountain in the Western Cape. The Afromontane Region extends along the orogenic zone of southern Africa (see the map at Mountain Forum web site: www2.mtnforum.org/mtnforum/resources/stlas/atorafri.htm). The vascular plant vegetation of the southern Afromontane region "...is characterised by a recurring pattern of forest 'islands' in a 'sea' of grassland or heathland..." (Meadows & Linder 1993).

In the north the Afromontane Region runs along the Soutpansberg, Drakensberg and Magaliesberg mountain ranges, with an outlier in the Waterberg mountains of the Northern Province (Fig. 37). It continues south along the Great Escarpment and fans out in KwaZulu-Natal, reaching the Indian Ocean in the vicinity of Lake St. Lucia on the Zululand coast. In KwaZulu-Natal and the eastern Cape it occupies the Marginal Zone, more or less from the upper margin of the forests below the Great Escarpment down to the Indian Ocean. Near Port Elizabeth on the Eastern Cape coast this region is interrupted by a dry corridor along the Sundays River Valley (Cowling 1983) before it continues down the coast, covering the area between the sea and the top of the first mountain ranges, southward to the vicinity of Groot Brakrivier. In the south-western Cape the Afromontane Region is more or less restricted to the forest and mountain fynbos vegetation on the Cape Fold Mountains, as far west as Table Mountain in the Cape Peninsula and probably north to the Cederberg Mountains (TWINSPAN 3+, Fig. 33). The southern part of this region is therefore broken up into a series of isolated areas or Afromontane 'islands', surrounded by the Karoo-Namib Region along the drier river valleys and low-lying areas.

In general it can be said that all areas with indigenous forest, large or small, belong to the Afromontane Region. However, small Afromontane patches to the west of the main north-south axis (White 1978, Werger 1983) will probably not show up at a broad or macroregional scale.

Recent literature on the (southern) Afromontane region included discussions on the following topics: geology, physiography and climate (White 1978, 1983; Van Wyk 1994), phytogeography (White 1978, 1981; Van Wyk 1994, Cowling & Hilton-Taylor 1997), vascular plant flora and vegetation (White 1978, 1983; Denys 1980; Linder 1990; Van Wyk 1994) and the origin, evolution and relationships of the vascular plant flora (White 1981, 1983a; Werger 1983; Linder 1990, 1994; Iversen 1991; Meadows & Linder 1993). Useful reviews and summaries of the Afromontane Region were published by Goldblatt (1978), Meadows & Linder (1993), White (1993), Beentje *et al.* (1994) and Cowling & Hilton-Taylor (1997).

Composition of the moss flora

The Afromontane Region has the largest and most diverse moss flora of the four bryogeographic regions in southern Africa with 481 species/infraspecific taxa or 96% of the total moss flora (Appendix II,2). These species/infraspecific taxa are classified into 197 genera and 54 families. The largest families in the Afromontane Region, Pottiaceae with 61 species/infraspecific taxa in 24 genera, Dicranaceae with 48 species\infraspecific taxa in 14 genera, and Bryaceae with 40 species in nine genera are also the largest families in the study area. The genera *Fissidens* (Fissidentaceae) with 28 species, *Bryum* (Bryaceae) and *Campylopus* (Dicranaceae) with 19 species each and *Funaria* (Funariaceae) with 10 species are the most species-rich in this region.

Characteristic of this bryogeographic region is the abundance of pleurocarpous mosses in the Orders Isobryales, Hookeriales, Thuidiales and Hypnobryales. Most of the taxa in these groups occur in the forests, forest patches and wooded kloofs (White 1978, 1983; Cooper 1985; Geldenhuys & MacDevette 1989; McKenzie *et al.* 1990, Von Breitenbach 1990; Cooper & Swart 1992; Midgeley *et al.* 1997) that give the Afromontane region it's unique character. Although the forests represent a small area of this region, at least 48% of mosses in the Afromontane Region (MOSS database) has been collected in forests or forest patches. It is generally accepted that these mesic environments favour mosses with a pleurocarpous growth form (Vitt 1979, 1984; Buck & Vitt 1986).

None of the moss families in southern Africa is endemic to any of the bryogeographical regions. The only moss family endemic to southern Africa, the monotypic Wardiaceae, is found in both the Afromontane and the Karoo-Namib Regions but is largely restricted to the Afromontane Region. The following 11 families (phylogenetically arranged) are restricted to, and therefore diagnostic for the Afromontane Region:

Diagnostic families

Seligeriaceae – Dicranales
Splachnaceae – Funariales
Eustichiaceae – Bryales
Rhachitheciaceae – Orthotricales
Rhabdoweisiaceae – Orthotricales
Fontinalaceae – Isobryales
Cryphaeaceae – Isobryales
Prionodontaceae – Isobryales
Trachypodaceae – Isobryales
Pterobryaceae – Isobryales
Rigodiaceae – Thuidiales

The Isobryales is the best represented at the family level with five of it's 12 families diagnostic for the region.

The 70 genera (34% of the total number of genera in southern Africa) restricted to the Afromontane Region in southern Africa are listed in Appendix II,5 (alphabetically and then phylogenetically arranged by family). Prominent among the orders, with regard to the number of diagnostic genera, are the Isobryales (13 or 48% of genera in this order), Hookeriales (5 or 63%), Thuidiales (11 or 55%) and Hypnobryales (14 or 48%). The families

Ditrichaceae (4), Pottiaceae (4), Pterobryaceae (5), Hookeriaceae (5), Amblystegiaceae (5) and Hypnaceae (4) are the best represented as far as the number of diagnostic genera is concerned.

Physcomitrellopsis of the family Funariaceae and *Quathlamba* of the Bartramiaceae are the only endemic genera. At a finer scale of analysis *Quathlamba* will probably be endemic to the Drakensberg Alpine Domain (Highlands Region) (see discussion under the Drakensberg Alpine Domain) while *Wardia* of the monotypic and endemic family Wardiaceae, now shared with the Karoo Namib Region, may actually be endemic to the Afromontane Region.

A total of 188 species/infraspecific taxa, or 39% of taxa in the Afromontane Region, is restricted to the region (Appendix II,6). Many of these may actually be endemic to the broader Afromontane Region. Some of the more widespread diagnostic species are:

A selection of widespread Afromontane diagnostic species (see Appendix II,6 for a complete list)

Callicostella tristis,
Cyclodictyon vallis-gratiae
Cyrtohypnum versicolor,
Ectropothecium regulare
Leucoloma rehmannii
Lopidium pennaeforme
Mittenothamnium pseudoreptans
Oxyrrhynchium subasperum
Pterobryopsis hoenelii
Sematophyllum subpinnatum

True Afromontane endemics (mosses that are restricted to the southern African section of the Afromontane Region) are:

Afromontane endemics

Archidium andersonianum
Archidium julicaule
Archidium subulatum
Brachythecium pinnatum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Breutelia elliptica
Breutelia tabularis
Dimerodontium africanum
Distichophyllum mniifolium *var.* taylorii
Ephemerum diversifolium
Fabronia eckloniana
Fabronia perciliata
Fabronia wageri
Fissidens aciphyllus
Gymnostomum lingulatum
Helicodontium lanceolatum
Isopterygium leucopsis
Isopterygium taxithelioides
Isopterygium taylorii
Leskeella zuluensis
Leucobryum rehmannii
Macrocoma pulchella
Macromitrium macropelma
Meiothecium fuscescens
Mielichhoferia subnuda
Oligotrichum afrolaevigatum
Oligotrichum wageri
Orthotrichum armatum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Philonotis comosa
Physcomitrellopsis africana
Pogonatum borgenii
Pterobryopsis rehmannii
Ptychomitriopsis africana
Quathlamba debilicostata
Rhynchostegiella sublaevipes
Rhynchostegium subbrachypterum
Sematophyllum zuluense
Stoneobryum mirum
Streptocalypta pulchiretis
Ulota ecklonii
Weissia cucullata
Weissia humicola
Zygodon dixonii
Zygodon leptobolax

Species which are largely confined to, and widespread in the Afromontane Region include:

A selection of widespread Afromontane mosses

Aerobryopsis capensis	Neckera valentiniana
Atrichum androgynum	Pilotrichella pandurifolia
Brachymenium pulchrum	Pogonatum capense
Bryum andicola	Porothamnium stipitatum
Bryum viridescens	Porotrichum madagassum
Campylopus stenopelma	Racopilum capense
Ditrichum brachypodum	Rhodobryum commersonii
Entodon macropodus	Rhodobryum umbraculum
Funaria limbata	Schlotheimia ferruginea
Haplocladium angustifolium	Sematophyllum sphaeropyxis
Haplohymenium pseudo-triste	Squamidium brasiliense
Hypopterygium laricinum	Syrrhopodon gaudichaudii
Leucobryum acutifolium	

Discussion

The archipelago-like Afromontane Region was formally recognised as a separate phytochorion by White (1965). Later White (1978) divided his Afromontane archipelago-like regional centre of endemism into seven regional mountain systems. Denys (1980) adopted White's nomenclature for her seven Mountain Domains, which largely coincide with White's regional mountain systems.

The Afromontane regional mountain systems of White (1978) and the Mountain Domains of Denys (1980).

1) West African regional mountain system (Domain)
2) Ethiopian regional mountain system (Domain)
3) Kivu-Ruwenzori regional mountain system (Domain)
4) Imatongs-Usambara regional mountain system (Domain)
5) Uluguru-Mlanje regional mountain system (Domain)
6) Chimanimani regional mountain system (Domain)

7) Drakensberg regional mountain system (Domain)

The bryogeographic Region largely coincides with White's southernmost division of the Afromontane archipelago-like regional centre of endemism, the Drakensberg regional mountain system (White 1978), especially if the Magaliesberg extension and other satellite populations and transition zones are included. It also coincides with the Drakensberg Domain of Denys (1980), which includes two isolated areas in the southern and the southwestern Cape, and the Drakensberg Afromontane Regional System of Beentje *et al.* (1994), described as a regional centre of diversity in Davis *et al.* (1994). In KwaZulu-Natal and the Transkei the Afromontane Region, as described here, coincides with the Maputaland-Pondoland Region of Van Wyk (1994), extending from the Olifants-Limpopo Rivers (24°S) in the north to just beyond the Great Kei River (33°S) in the south. The bryogeographical Region is, however, more extensive and continuous than the vascular plant phytochoria and also displays a number of other important differences.

The Afromontane Region presented here includes, for the first time, much of the 'Capensis' or Cape (Floristic) region of Werger (1978), Taylor (1978), White (1976, 1983), Goldblatt (1978), Cowling & Richardson (1995), and Cowling & Hilton-Taylor (1997). A 'Cape' phytochorion is here only distinguished at the level of Domain (see 2.2, the Cape Domain). On the basis of strong floristic and ecological links between the Cape and Afromontane phytochoria (Levyns 1964, Goldblatt 1978, Cowling 1983, Hilliard & Burtt 1987, Cowling & Richardson 1995), Linder (1990), and later Oliver (1994), proposed the establishment of a combined Afrotemperate Region, supporting an earlier suggestion by Wild (1964). However, until now this combined region has not been formally described or mapped.

The high plateau of Lesotho, or the Afro-alpine region, has generally been included in the Afromontane Region (Goldblatt 1978, Denys 1980, White 1983, Cowling & Hilton-Taylor 1997), or a combined Cape-Afromontane (Afrotemperate) phytochorion (Linder 1990, 1994; Oliver 1994). However, the Afromontane Region recognised here excludes the high altitude areas on the Lesotho plateau or the Afro-alpine region. These areas form part of the temperate Highlands Region (see discussion under the *Drakensberg Alpine Domain*).

The bryogeographic classification does not support the recognition of a separate Tongoland-Pondoland regional mosaic (Region) or Province along the east coast of southern Africa, as described by Werger (1978), Goldblatt (1978), White & Moll (1978), White (1983), Takhtajan (1986) and Cowling & Hilton-Taylor (1997). According to the TWINSPAN classification the southern part of this vascular plant phytochorion falls into the Afromontane Region while the part north of Lake St. Lucia belongs to the Zambezian Region. This bryogeographic boundary is congruent with the southernmost Afromontane/Zambezian boundary of Denys (1980). The results of this study also doesn't support the notion put forward by Cawe *et al.* (1994) that the distinction between the 'subtropical' and 'afrotemperate' forests in the Transkei region of the Eastern Cape is indicative of two separate phytochoria, a 'subtropical region' along the coast and an 'afrotemperate region' further inland.

On the basis of the TWINSPAN classification of moss distributions I predict that the Afromontane Region, when mapped at a broad or (sub)continental scale, will prove to be more extensive and continuous throughout Africa than the archipelago-like region shown by White (1976, 1978), Goldblatt (1978), Denys (1980), or Cowling & Hilton-Taylor (1997). It may well form an almost continuous band, only interrupted by dry river valleys such as the Limpopo and Zambezi river valleys, from the Cape to Eritrea, and from Dar es Salaam to Luanda (Zaire-Zambezi watershed) with substantial outliers in west Africa, Madagascar and Yemen.

In Table 17 the Afromontane Region of this study is compared with two sets of vascular plant data: 1) The Afromontane archipelago-like regional centre of endemism of White (1983) (figures are not available for White's Drakensberg regional mountain system or the Drakensberg Afromontane Regional System of Beentje *et al.* 1994), and 2) the Maputaland-Pondoland Region of Van Wyk (1994).

Endemism at the family level is low in both groups (much higher for vascular plants if the Cape Region is included) but endemism at the genus and species level is much higher for vascular plants than for mosses. The latter may of course change when the mosses of the whole Afromontane region are taken into account.

According to the TWINSPAN classification (Fig. 39) the Afromontane Region, dominated by 'tropical' vascular plant taxa (White 1978), is closely related to the Zambezian Region which consists of savanna vegetation, a tropical vegetation type (Scholes 1997). Together they form a (sub)tropical phytochorion distinct from the temperate or austral phytochorion consisting of the Karoo-Namib and Highlands regions on the other side of the main TWINSPAN devision line. Goldblatt (1978), Linder (1990), Oliver (1994), and Cowling & Hilton-Taylor (1997) included the temperate Afro-alpine flora (see the *Highlands Region*) in their Afromontane Region and that is probably why they regarded the Afromontane Region as temperate rather than subtropical. The (sub)tropical affinity of the Afromontane Region is therefore in contrast to the suggestion by Linder (1990) that the combined Afromontane/Cape phytogeographic region be called the 'Afrotemperate Region'.

Three of the four bryogeographic elements (Cape, Afromontane Grassland, Afromontane Forest) have their main centres of distribution in the Afromontane Region (Fig. 65). The fourth element (Eastern Highlands) is also well represented in this region by secondary centres.

2.1 Drakensberg Domain

Area

This Domain represents the northern and largest division of the Afromontane Region, consisting of 92 grids of the TWINSPAN 5+ classification (Fig. 38). The position of the southern boundary differs between the TWINSPAN 3+ and 5+ classifications. In the TWINSPAN 3+ classification the Drakensberg Domain extends as far south as the forests around George in the Western Cape Province (Fig. 34) while the TWINSPAN 5+ classification draws the border with the Cape Domain between Port Elizabeth and Grahamstown in the Eastern Cape Province (Fig. 38).

The vascular plant flora of the Drakensberg Domain is described in Denys (1980). Otherwise the literature references given under the Afromontane Region also apply here.

Composition of the moss flora

The 409 species/infraspecific taxa that occur in the Drakensberg Domain are listed in Appendix II,2a. These mosses belong to 179 genera in 50 families. As with the Afromontane Region, the families Pottiaceae (53 species/infraspecific taxa in 21 genera), Dicranaceae (40 species\infraspecific taxa in 13 genera) and Bryaceae (36 species in eight genera) are the largest in the moss flora of the Drakensberg Domain.

In southern Africa the following eight families (16% of families in this domain) are diagnostic (restricted to this domain in southern Africa) for the Drakensberg Domain:

Diagnostic families

Seligeriaceae – Dicranales

Splachnaceae – Funariales
Eustichiaceae – Bryales
Rhachitheciaceae – Orthotricales
Rhabdoweisiaceae – Orthotricales
Prionodontaceae – Isobryales
Trachypodaceae – Isobryales
Rigodiaceae – Thuidiales

The genera *Fissidens* (Fissidentaceae) with 24 species, *Bryum* (Bryaceae) with 18 species and *Campylopus* (Dicranaceae)with 17 species are the largest in this Domain. The following 45 genera (25% of genera in this Domain) are restricted to the Drakensberg Domain:

Diagnostic genera

Abietinella	Levierella
Aongstroemiopsis	Micropoma
Astomiopsis	Orthostichopsis
Blindia	Physcomitrellopsis
Callicostella	Pinnatella
Campyliadelphus	Plagiobryum
Chrysohypnum	Plagiopus
Conostomum	Platyhypnidium
Cratoneuron	Prionodon
Entodontopsis	Pterobryopsis
Eustichia	Quathlamba
Herpetineuron	Rauiella
Hyophila	Rhabdoweisia
Jaegerina	Rhachithecium
Lepidopilidium	Rhacopilopsis
Leptoischyrodon	Rigodium
Leptoterigynandrum	Saelania
Leskeella	Sanionia

Stoneobryum
Streptocalypta
Tayloria
Trachypodopsis
Trachypus
Trichosteleum
Tristichium
Vittia
Weisiopsis

The genus *Physcomitrellopsis* (Funariaceae), endemic to the Afromontane Region, is also endemic to the Drakensberg Domain. The 153 species/infraspecific taxa restricted to this Domain (the diagnostic species) represents 37% of the mosses in this domain and are listed in Appendix II,2c. Of these the following 28 species (7%) are endemic to the Drakensberg Domain:

Drakensberg endemics

Archidium julicaule
Dimerodontium africanum
Fabronia eckloniana
Fabronia perciliata
Fissidens aciphyllus
Gymnostomum lingulatum
Helicodontium lanceolatum
Isopterygium leucopsis
Isopterygium taxithelioides
Leskeella zuluensis
Mielichhoferia subnuda
Oligotrichum afrolaevigatum
Oligotrichum wageri
Orthotrichum armatum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Physcomitrellopsis africana
Pogonatum borgenii
Pterobryopsis rehmannii
Ptychomitriopsis africana
Quathlamba debilicostata
Rhynchostegiella sublaevipes
Rhynchostegium subbrachypterum

Sematophyllum zuluense	Streptocalypta pulchiretis
Stoneobryum mirum	Weissia humicola
	Zygodon dixonii

Quathlamba debilicostata (Bartramiaceae), here listed as endemic to the Drakensberg Domain, may actually be endemic to the Highlands Region and the Drakensberg Alpine Domain (see discussion under the Highlands Region).

Discussion

This phytochorion is most similar to the Drakensberg regional mountain system of White (1978) including the Magaliesberg extension and the transition zone in KwaZulu-Natal but excluding the satellite populations and islands of Afromontane vegetation in the south-western Cape. It also coincides with, and is named after, the northern part of Denys's Drakensberg Domain (Denys 1980), excluding the two Cape 'islands' in the southern and south-western Cape.

The border between the two Domains of the Afromontane Region is situated in the south-eastern Cape, a geological, topographic, climatic and vegetation transition zone known for its phytogeographic complexity (Goldblatt 1978, Werger 1978a, Werger & Coetzee1978, Gibbs Russell & Robinson 1981, White 1983, Cowling 1983, Kopke 1988, Nicol 1988, Palmer 1990, Hoffman & Cowling 1991). It is a region of convergence for five vascular plant phytochoria (Cowling & Hilton-Taylor 1997), all four of the bryogeographic Regions (Figs. 33 & 37), and six of the eight bryogeographic Domains (Figs. 34 & 38). It is therefore not surprising that the phytogeographic delimitation of the area is unsettled (Cowling & Hilton-Taylor 1997), and that the brygeographic boundaries differ between the TWINSPAN 3+ and TWINSPAN 5+ classifications. However, the TWINSPAN 5+

classification (Fig. 38), which is perhaps the better of the two bryogeographic classifications, draws the main phytogeographic boundary in more or less the same place (along the Sundays River Valley east of Port Elizabeth) as recent classifications based on the distributions of vascular plants (White 1976, 1983; Goldblatt 1978; Werger 1978; Cowling & Hilton-Taylor 1997).

In Table 18 the moss flora of the Drakensberg Domain is compared with the flora of the Maputaland-Pondoland Region (Van Wyk 1994). Although a much greater number of southern African mosses (81%) occurs in this region than vascular plants (29-33%), endemism in the Drakensberg moss flora is rather low (7%) compared to that of vascular plants (c. 20%).

2.2 Cape Domain

Area

The Cape Domain occupies 18 TWINSPAN 3+, or 21 TWINSPAN 5+ grid squares in the mountains of the south-western Cape (see Third level of TWINSPAN 3+, 5+ classification, this chapter, and Figs. 34 & 38). The Cape Region based on vascular plants covers an area of c. 71000 km² (White 1983) or 90000 km² (Bond & Goldblatt1984, Rebelo 1994a, Cowling & Hilton-Taylor 1997), depending on what figure you accept.

The TWINSPAN 5+ phytochorion is not spatially continuous but forms four distinct areas (Fig. 38) along the Cape Fold mountains. In the east around Alicedale and Grahamstown (grids 3326 A & B), where the Cape Supergroup (Hammerbeck & Allcock 1985) disappears beneath the Karoo sediments, the Cape mosses form an 'island', separated from the rest of the Cape Domain by an intrusion of the Western Cape Domain along the drier Sundays River Valley. For a discussion of the phytogeographically complex eastern Cape area, see the *Drakensberg Domain*. The Langeberg Mountains of the Western Cape Province (grids 3320 D and 3321 C) represent another Cape island in a sea of Karoo-Namib or Western Cape mosses along the intermontane, low rainfall valleys of the Klein Karoo (Fig. 38).

The western part of the TWINSPAN 5+ phytochorion falls into the *winter* rainfall region while the eastern part falls into the *all year* rainfall region (see Rainfall Seasonality map in Schulze, 1997). The TWINSPAN 3+ phytochorion (Fig. 34) is largely restricted to the south-western part of the Cape where a mediterranean-type climate (Goldblatt 1978) prevails.

The geology, physiography, climate, vegetation, phytogeography, and composition and origin of the vascular plant flora of the Cape phytochorion have been the subjects of several recent studies and reviews, notably those by White (1976, 1983), Werger (1978), Taylor (1978), Goldblatt (1978), Oliver *et al*. (1983), Bond & Goldblatt (1984), Meadows (1985), Takhtajan (1986), Cowling & Holmes (1992), Cowling *et al.* (1992), Deacon *et al.* (1992), Linder *et al.* (1992), Rebelo (1994a), Cowling & Richardson (1995), and Cowling & Hilton-Taylor (1997). Several aspects of the Fynbos Biome, largely equivalent to the Cape region but based on plant growth form, have been described by Rutherford & Westfall (1986), Low & Rebelo (1996), Rutherford (1997) and Cowling, Richardson & Mustart (1997).

Composition of the moss flora

The moss flora of the Cape Domain consists of 284 species/infraspecific taxa in 127 genera and 44 families (Appendix II,2b). This represents 59% of species/infraspecific taxa in the Afromontane Region and 57% of all the mosses in southern Africa. Pottiaceae (33 species/infraspecific taxa in 17 genera), Dicranaceae (29/11) and Bryaceae (23/7) are the most species-rich among the families in this Domain while *Fissidens* of the family Fissidentaceae with 14 species/infraspecific taxa, *Bryum* (Bryaceae) and *Campylopus* (Dicranaceae) with 13 species each, and *Fabronia* (Fabroniaceae) and *Funaria* (Funariaceae) with eight species each are the largest genera.

The Fontinalaceae (Isobryales), probably introduced from Europe (Magill & Van Rooy 1998), is the only diagnostic family for this domain. The monotypic family Wardiaceae, usually associated with the Cape region, is shared with the Western Cape Domain (see discussion under the Afromontane Region).

The genera *Cheilothela, Ulota, Fontinalis, Distichophyllum, Meiothecium and Polytrichastrum* are restricted to the Cape Domain but none is endemic to the phytochorion. Lists of diagnostic (35) and endemic (19) species/infraspecific taxa follows.

Diagnostic mosses of the Cape Domain

Andreaea nitida
Archidium andersonianum
Archidium subulatum
Barbula calycina
Brachythecium pinnatum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Breutelia elliptica
Breutelia tabularis
Bruchia eckloniana
Bryum donianum
Calymperes levyanum
Campylopus bicolor
Cheilothela chilensis
Distichophyllum mniifolium *var.* mniifolium
Distichophyllum mniifolium *var.* taylorii
Drepanocladus sendtneri
Ephemerum diversifolium
Fabronia wageri
Fissidens splachnifolius

Fissidens stellenboschianus
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa
Isopterygium taylorii
Leucobryum rehmannii
Macrocoma pulchella
Macromitrium macropelma
Meiothecium fuscescens
Philonotis comosa
Philonotis vagans
Polytrichastrum formosum
Ulota ecklonii
Weissia cucullata
Zygodon leptobolax

Cape Domain endemics

Archidium andersonianum
Archidium subulatum
Brachythecium pinnatum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Breutelia elliptica
Breutelia tabularis
Distichophyllum mniifolium *var.* taylorii
Ephemerum diversifolium
Fabronia wageri
Isopterygium taylorii
Leucobryum rehmannii
Macrocoma pulchella
Macromitrium macropelma
Meiothecium fuscescens
Philonotis comosa
Ulota ecklonii
Weissia cucullata
Zygodon leptobolax

Discussion

The remarkable richness of the vascular plant flora in the Cape region (Bond & Goldblatt 1984, Cowling & Holmes 1992, Cowling *et al.* 1992, Cowling & Richardson 1995) has contributed greatly to its recognition as one of the vascular plant (and bryofloristic) Kingdoms of the world (Good 1974; Miller 1982, Takhtajan 1986; Cowling & Holmes 1992, Rebelo 1994a, Cowling & Richardson 1995). However, the Cape phytochorion based on the distributions of southern African mosses is rather less distinctive and is only separated from the rest of the Afromontane Region at the 8-group level, or rank of Domain (Fig. 39).

The Cape Domain is more or less restricted to the Afromontane Forest and Mountain Fynbos vegetation types (Campbell 1985, Low & Rebelo 1996) on the Cape Fold Mountains. Although forest areas in the south-western Cape are usually classified as Afromontane and fynbos areas as Cape, Manders (1991) has challenged the concept of fynbos and forest as distinct and mutually exclusive vegetation types. Goldblatt (1978) included "...a substantial forest element related to the Afromontane forest,..." in his Cape Region but also "...Karoo-Namib elements in the drier valleys", which are excluded here. Furthermore, Fynbos-like vegetation occurs throughout sub-Saharan Africa, Madagascar and the Mascarenes, often in association with Afromontane forest (Cowling & Richardson 1995).

The Cape phytochorion as defined here therefore excludes the renosterveld of the lowlands or coastal plains and the succulent karoo shrubland of the intermontane valleys, which are included in the Karoo-Namib Region. The Cape Domain, as a subdivision of the Afromontane Region, forms part of a (sub)tropical African flora (see Discussions under the *TWINSPAN 3+ and TWINSPAN 5+ classifications* and the *Afromontane Region,* this chapter), and is not closely related to the temperate western part of the Karoo-Namib Region (the Succulent Karoo Region) as proposed by Jürgens (1991).

Although a relatively great number of southern African mosses (57%) occurs in the Cape Domain, endemism is absent at the family and genus levels, and relatively low at the species level (12%) compared to the 68% of vascular plants (Table 19).

3. Karoo-Namib Region

Area

This is the second largest bryogeographical region in southern Africa (Figs. 33 & 37), more or less congruent with the Karoo-Namib regional centre of endemism of White (1983), which extends over an area of 661,000 km². This Region consists of 61 grid squares (TWINSPAN 5+), more or less contiguous in the south-western corner or the winter rainfall arid region of the study area, from Port Elizabeth in the Eastern Cape to Lüderitz in southern Namibia (Fig. 37). Both the TWINSPAN 3+ and 5+ classifications show three northern outliers in central Namibia. In the south the Karoo-Namib Region borders on three Afromontane archipelagos or islands on the Cape Fold mountains and follows the dry intermontane valleys down to the coastal plain between Gansbaai in the west, and Mossel Bay in the east (Figs. 33 & 37).

The geology, physiography, climate, phytogeography, vegetation, and flora, including the origin of the Karoo-Namib flora, have recently been studied or reviewed by Goldblatt (1978), Werger (1978a), White (1983), Takhtajan (1986), Hilton-Taylor (1987, 1994), Jürgens (1991) and Cowling *et al.* (1998, 1999).

Composition of the moss flora

The flora of the Karoo-Namib Region is composed of 196 species/infraspecific taxa (39% of the total moss flora) representing 93 genera and 37 families (Appendix II, 3). Largest among the Karoo-Namib families is the Pottiaceae with 38 species/infraspecific taxa in 19 genera, the Dicranaceae with 19 species/infraspecific taxa in 10 genera and the Bryaceae with 16 species in five genera. The genus *Fissidens* (Fissidentaceae) with 11 species is the best represented in this region followed by *Bryum* (Bryaceae) with 10 species and *Campylopus* (Dicranaceae) and *Funaria* (Funariaceae) with seven species/infraspecific taxa each.

Characteristic of the Karoo-Namib moss flora is the prominence of xerophytic mosses in the families Archidiaceae, Ditrichaceae, Dicranaceae, Pottiaceae, Grimmiaceae, Ephemeraceae, Funariaceae and Bryaceae, adapted to survive life in the (semi) arid conditions of this region. The life strategies as well as morphological and physiological adaptations in arid land mosses have been discussed by During (1979, 1992), Magill (1981, 1987), Vitt (1981, 1984), Bell (1982), Scott (1982), Longton (1988), Frey (1990), Frey & Kürschner (1988, 1991, 1995), Zander (1993), and Eldridge & Tozer (1996). The two main strategies involved are:

1. *Dessication tolerance*. Perennial gametophyte growth, associated with physiological desiccation resistance (poikilohydric mosses). These mosses usually display some of the following morphological features: a) densely papillose leaf surfaces, which allegedly provide capillary channels for rapid uptake and transport of water, b) revolute or involute leaf margins, which may encourage water movement from leaf tip to base, c) robust, thickened costae which provide mechanical support during desiccation and may aid in water uptake, d) hyaline hair points, which increase the water-receiving area, e) hyaline or partly hyaline leaves which act as protective coverings for the green, photosynthetic parts, f) small squarrose leaf cells which reduce the ratio of cell surface area to volume, and g) leaves that change position markedly between dry and wet conditions, often tightly twisted or rolled when dry and squarrose when wet.

These features allow the mosses to maintain physiological processes for extended periods. Perennial mosses in arid regions can also survive in a dehydrated state with low water potentials, considerable heat tolerance and the capability to resume physiological processes very quickly after re-hydration. Examples of mosses in the Karoo-Namib Region that can tolerate the arid conditions are: *Pseudocrossidium*, *Syntrichia* and *Tortula* spp. (Pottiaceae), *Grimmia* spp.(Grimmiaceae), *Bryum argenteum* (Bryaceae) and *Orthotrichum* spp.(Orthotrichaceae).

2. *Dessication avoidance*. Ephemeral life strategy, associated with a reduction in the life cycle and stature of the plants. Rapid production of sporophytes during a short growth period and survival in the form of stress-tolerant diaspores. 'Ephemerals' are characterised by one or more of the following features: a) cleistocarpous, gymnostomous capsules, b) shortened seta, c) small, bulbiform gametophore, d) increased spore size, and e) adaxial leaf growths such as lamellae or filaments.

The following are examples of mosses in the Karoo-Namib Region which posses features characteristic of an ephemeral life style: *Archidium* spp. (Archidiaceae), *Pleuridium* spp. (Ditrichaceae), *Aloina bifrons*, *Acaulon* spp., *Crossidium spiralifolium*, *Phascum peraristatum*, *Pottia* spp.(Pottiaceae), *Bryobartramia novaevalesiae* (Bryobartramiaceae), *Chamaebryum pottioides* and *Gigaspermum repens* (Gigaspermaceae), *Ephemerum* spp. (Ephemeraceae), and *Cygnicollum immersum* and *Goniomitrium africanum* (Funariaceae).

Although the ephemeral life style is probably a recent adaptation to arid conditions (Vitt 1984), in southern Africa brought about by the rifting of Gondwana and the northward drifting of the African plate (Axelrod & Raven 1978, Audley-Charles *et al.* 1981, Pitman III *et al.* 1993, White 1994), many of the acrocarpous families to which these mosses belong show Pangaean distributions (Vitt 1984).

Xerophytic Pottiaceae with bulbiform gametophores, assimilation filaments/-lamellae or thickened costae, hyaline hairpoints, a dimorphic rhizoid system, and reduced peristomes have been classified under the Xeropottioid life syndrome by Frey (1990) and Frey & Kürschner (1988, 1991, 1995). This group of mosses is particularly well represented in the Karoo-Namib Region by species of *Aloina*, *Crossidium*, *Didymodon*, *Pseudocrossidium*, and *Tortula,* all from the Pottiaceae. Many taxa in this group are distributed in mediterranean and temperate to hot, semi-arid to arid areas of the world. This distribution pattern is described as the Xerothermic Pangaean genoelement by Frey (1990).

The genera *Acaulon, Crossidium, Cygnicollum, Leucoperichaetium, Microcrossidium* and *Pottia* are diagnostic for the Karoo-Namib Region. All but two (*Leucoperichaetium* and *Cygnicollum*) belong to the Pottiaceae. Only two genera, *Cygnicollum* of the family Funariaceae and *Microcrossidium* of the Pottiaceae, or 2% of genera in this region, are endemic to this phytochorion.

Of the 14 diagnostic species only *Acaulon leucochaete* (also known from Australia), *Archidium amplexicaule* (present in South America) and *Bruchia queenslandica* (Mexico and Australia) are not true endemics.

Diagnostic and endemic (*) species of the Karoo-Namib Region

Acaulon leucochaete
*Acaulon recurvatum
*Andreaea bistratosa
Archidium amplexicaule,
Bruchia queenslandica
*Crossidium spiralifolium
*Cygnicollum immersum
*Fabronia breutelii

*Leucoperichaetium eremophilum
*Microcrossidium apiculatum
*Oligotrichum tetragonum
*Pleuridium papillosum
*Pottia namaquensis

Other important species which are mainly distributed in this region include:

Important species

Aloina bifrons
Bryobartramia novae-valesiae
Desmatodon longipedunculatus
Hennediella longipedunculata
Ephemerum namaquense
Funaria clavata
Ischyrodon lepturus
Orthotrichum incurvomarginatum
Phascum peraristatum
Tortula splachnoides
Ptychomitrium crassinervium
Tetrapterum tetragonum
Syntrichia chisosa
Ptychomitriopsis aloinoides

Discussion

With increased collecting this bryogeographic region is sure to cover most of the (semi-)arid south-western part of southern Africa. This area "...is in a state of severe water stress even during the rainy season" (Jury *et al.* 1997) and the moss flora is remarkably adapted to survive the harsh conditions. The Karoo-Namib Region, and in particular the Succulent Karoo (Region), supports a very rich vascular plant flora, including "...the world's largest succulent flora..." (Cowling *et al.* 1998).

The Karoo-Namib Region described here more or less coincides with the Karoo-Namib regional centre of endemism (Region) of White (1965, 1971, 1976, 1983), Wickens (1976), Goldblatt (1978), Takhtajan (1986) and Cowling & Hilton-Taylor (1997), or the larger Karoo-Namib Region of Werger (1978). Subdivision of this region is discussed under the Western Cape Domain.

The northern and eastern borders of this Region also coincide with the borders of major vascular plant vegetation types (based on growth form) and 'ecozones' (defined by factors such as geology, rainfall, vegetation and soil). The northern border, situated just north of the Namibian town of Lüderitz, coincides with the boundary between the Succulent Karoo and Desert Biomes (Rutherford & Westfall 1986, Rutherford 1997) or Ecozones (McCullum 1994). However, the outliers in central Namibia might indicate that this Region extends into southern Angola as in the case of the vascular plant phytochorion (Werger 1978, White 1983). The eastern border of the Karoo-Namib Region, which coincides with the border between the Succulent Karoo and Nama-Karoo Biomes (Rutherford & Westfall 1986, Rutherford 1997) or Ecozones (McCullum 1994), runs parallel to the Atlantic coastline, following the Great Escarpment for most of the way. Hilton-Taylor & Le Roux (1989: 203) provided an useful map of the phytogeographic subdivisions or "...the biogeographic areas..." of the Fynbos, Succulent Karoo and Nama-Karoo Biomes in South Africa.

The presence of this bryofloristic region along the dry intermontane valleys and the southern coastal plain of the Cape region might point to a high degree of affinity between the karroid shrublands of the Karoo-Namib Region and the shrublands usually included in the Cape Region (see Hilton-Taylor 1987), particularly the South and South-west Coast Renosterveld of Low & Rebelo (1996). White (1983) recognised that "...large enclaves of Karoo..." vegetation exist within the boundaries of the Cape Region.

Although 39% of southern African mosses occurs in the Karoo-Namib Region compared to the 29% of vascular plants, endemism is much lower in the mosses with only 6% of species restricted to this region compared to the 35–50% of vascular plants (Table 20). Endemism at the genus level is also low in mosses with only two (2%) endemic genera.

The moss flora of the Karoo-Namib Region consists mostly of xerophytic species in the Cape Element, and to a lesser degree the Eastern Highlands Element (Fig. 65). None of the bryogeographic elements has its centre of distribution in this region and the Afromontane Forest Element is poorly represented.

3.1 Western Cape Domain

Area

The largest of the two Karoo-Namib divisions, the Western Cape Domain covers an area of 54 grid squares (TWINSPAN 5+), only seven northern grids less than the Karoo-Namib Region. (Fig. 38). It is more or less restricted to the winter rainfall region (see rainfall seasonality map in Schultze 1997) and is known as a region of unparalleled succulent plant diversity (Hilton-Taylor 1994, Cowling *et al.* 1998).

The geography, flora, vegetation, and phytogeography of the Western Cape Domain (Succulent Karoo) have been discussed by Werger (1978a), Jürgens (1991), Hilton-Taylor (1987, 1994, 1996), Hilton-Taylor & Le Roux (1989), Milton *et al.* (1997), and Cowling *et al.* (1998, 1999).

Composition of the moss flora

The moss flora of the Western Cape Domain is almost identical to that of the Karoo-Namib Region and only six species (*Fissidens subobtusatus, Barbula bolleana, Funaria rhomboidea, Bryum* *capillare, B. cellulare* and *Ptychomitriopsis aloinoides*) are not shared between the two phytochoria. The 190 species/infraspecific taxa in this Domain represent 93 genera and 37 families (Appendix II,3a). This moss flora also is characterised by the presence of a substantial number of mosses with an ephemeral life style (see discussion under the *Karoo-Namib Region*).

As in the case of the Karoo-Namib Region, the families Pottiaceae (37 species/infraspecific taxa in 19 genera), Dicranaceae (19 species in 10 genera) and Bryaceae (14 species in five genera) are the largest families while *Fissidens* (Fissidentaceae) with 10 species, *Bryum* (Bryaceae) with eight species and *Campylopus* (Dicranaceae) with seven species are the largest among the genera.

The genera and species which are diagnostic and endemic to the Karoo-Namib Region are also diagnostic and endemic to the Western Cape Domain. Other important species, mainly distributed in this Domain, are listed under the Karoo-Namib Region.

Diagnostic and endemic (*) genera of the Western Cape Domain

Acaulon
Crossidium
*Cygnicollum
Leucoperichaetium
*Microcrossidium
Pottia

Diagnostic and endemic (*) species of the Western Cape Domain

Acaulon leucochaete
*Acaulon recurvatum
*Andreaea bistratosa

Archidium amplexicaule
*Archidium dinteri
Bruchia queenslandica
*Crossidium spiralifolium
*Cygnicollum immersum
*Fabronia breutelii
*Leucoperichaetium eremophilum
*Microcrossidium apiculatum
*Oligotrichum tetragonum
*Pleuridium papillosum
*Pottia namaquensis

Discussion

Monod (1957) subdivided the Karoo-Namib Region into three domains: the Karoo Domain, Namaqualand Domain and Namib Domain. Subsequent authors (Troupin 1966, Aubréville 1975) have followed this subdivision with adjustments to the boundaries. Werger (1978a) divided the Karoo-Namib Region into the following four domains (called provinces by Takhtajan, 1986) and 1 subdomain:

Domains of the Karoo-Namib Region (Werger 1978a)

1. Namib Domain
2. Namaland Domain
3. Southern Kalahari Subdomain
4. Western Cape Domain
5. Karoo Domain

Jürgens (1991) proposed a new subdivision of the Karoo-Namib Region into 1) a Succulent Karoo Region all along the west coast and 2) a Nama Karoo Region inland from the Succulent Karoo and Cape Floristic Regions. His Nama Karoo Region is further divided into three domains: the Eastern Karoo, Namaland and Damaraland-Kaokoland

Domains, the Namaland Domain in turn into the Namaland and Namib Subdomains, and lastly the Namib Subdomain is divided into a Namib and an Eastern Gariep District (Jürgens 1991). However, the results of this study show that Jürgens's Succulent Karoo Region is not closely related to the fynbos part of the Cape Region and therefore can't form part of a proposed Greater Cape Flora or Floristic Kingdom (see discussions in this chapter under *TWINSPAN 3+ and TWINSPAN 5+ classifications* and the *Cape Domain*).

More moss distribution data is needed to critically compare the bryofloristic and vascular plant subdivision of the Karoo Namib Region but at this stage it appears that the Western Cape Domain of this study coincides with the Succulent Karoo Region of Jürgens (1991) and the Western Cape Domain of Hilton-Taylor (1994). The boundaries of the Western Cape Domain also are more or less congruent with those of the ecologically defined Succulent Karoo Biome (Rutherford & Westfall 1986, Hilton-Taylor 1996, Rutherford 1997, Milton *et al.* 1997).

The Karoo-Namib Region or Western Cape Domain (Succulent Karoo) has been subdivided into a number of small areas or phytochoria with high concentrations of endemic species, so-called centres of endemism (see discussion under *Centre of endemism*, Chapter 1), also referred to as geographical areas, biogeographic areas, or bioregions (Werger 1978, 1978a; Hilton-Taylor 1987, 1994, 1996; Hilton-Taylor & Le Roux 1989; Cowling *et al.* 1999). These are generally below the level of Domain and therefore not considered here.

Although 38% of southern African mosses occur in the Western Cape Domain compared to the 20% of vascular plants, endemism is much lower in the mosses with only 6% of species restricted to this region compared to the 40% of vascular plants (Table 21). Endemism at the genus level is also lower in mosses with only 2% of genera compared to the 8% of vascular plants. Cowling *et al.* (1998) have recently argued that the Succulent Karoo (Region) "...represents a major extratropical centre of plant biodiversity" and "...is home to the world's largest succulent flora...".

3.2 Namaqua Domain

Area

This Domain is scattered over seven grid squares (TWINSPAN 5+) situated in the most arid part of southern Africa (Fig. 38), generally receiving less than 300 mm of rain per annum. As a result of the many empty grids in this area it is not possible to draw exact boundaries for this domain.

The phytogeography, flora and vegetation of the Namaqua Domain have been described by Werger (1978a) and Jürgens (1991).

Composition of the moss flora

The Namaqua Domain has the smallest moss flora (TWINSPAN 5+) of all the domains with only 20 species in 15 genera and 10 families (Appendix II,3b), none of which is diagnostic or endemic to the phytochorion.

The presence of xerophytic taxa and the absence of pleurocarpous taxa is striking. The families Pottiaceae (six species in five genera), Bryaceae (four species in two genera) and Funariaceae (three species of *Funaria*) are the best represented in the region. The genera *Bryum* (Bryaceae) and *Funaria* (Funariaceae) with three species each, followed by *Pseudocrossidium* (Pottiaceae) with two species are the largest in the Namaqua Domain.

Discussion

Although the boundaries of the Namaqua Domain are poorly defined as a result of insufficient collecting or sampling, this domain appears to coincide with, and is therefore named after, the Namaqualand (Namaland) Domain (Province) of Monod (1957), Werger (1978, 1978a), Takhtajan (1986) and Jürgens (1991).

4. Highlands Region

Area

The Highlands Region consists of 39 TWINSPAN 5+ grid squares covering the high altitude areas of the Interior Plateau (Fig. 37). It is almost spatially continuous from the north-eastern Free State, through Lesotho and the southern Free State, to the Sneeuberge mountain range in the Eastern Cape Province. Outliers occur in the Nuweveldberge mountains between Beaufort West and Fraserburg in the Great Karoo, the Hantamsberg mountains in the Northern Cape Province, and the Naukluft mountains in central Namibia. Another isolated and rather low altitude grid square (2822 C) is found in the Northern Cape Province and represents a single collecting locality on the southernmost tip of the Langeberge mountains.

The region has a temperate climate with summer rainfall, hot summers and cold winters with severe frost and occasional snowfalls. The vascular plant vegetation can be classified into alpine and subalpine belts (Killick 1963, 1978). The exact position of the border between the Highlands and Afromontane, and Highlands and Karoo-Namib regions is obscured by the broad-scale used and the many empty grids but it seems to follow the Great Escarpment.

The geology, physiography, climate and vascular plant flora and vegetation of this phytochorion should be more or less the same as that of the Kalahari-Highveld transition zone as described by White (1983) including the

Drakensberg (Afro-alpine) Region of Killick (1978, 1994), summarised by Goldblatt (1978), Beentje *et al.* (1994) and Cowling & Hilton-Taylor (1997).

Composition of the moss flora

The moss flora of the Highlands Region is made up of 152 species/infraspecific taxa (30% of the total moss flora) in 71 genera and 29 families (Appendix II,4). The families Pottiaceae (37 species/infraspecific taxa in 16 genera), Bryaceae (21 species in five genera) and Dicranaceae (11 species in five genera) are the largest in this Region. The largest genera are *Bryum* (Bryaceae) with 15 species, *Fissidens* (Fissidentaceae) with nine species and *Syntrichia* (Pottiaceae) with eight species/infraspecific taxa.

The Higlands moss flora differs from the closely related Karoo-Namib flora mainly in the absence of families such as Sphagnaceae, Bryobartramiaceae, Wardiaceae and ephemerals such as *Bruchia*, *Acaulon*, *Crossidium*, *Microcrossidium*, *Pottia*, *Leucoperichaetium* and *Cygnicollum*, and the presence of families such as the Mniaceae, Thuidiaceae, Amblystegiaceae and additional taxa in the Leskeaceae. The moss flora reflects the severity of the climate and most of the mosses exhibit xeromorphic characters.

There are no diagnostic or endemic families or genera in this region. Two of the three diagnostic species/infraspecific taxa, *Syntrichia austroafricana* (Pottiaceae) and *Physcomitrium spathulatum* var. *sessile* (Funariaceae), are endemic to the Highlands Region while *Pterygoneurum macleanum* (Pottiaceae) is also known from southern and western Australia.

Diagnostic and endemic (*) species/infraspecific taxa

*Syntrichia austroafricana
Pterygoneurum macleanum
*Physcomitrium spathulatum *var.* sessile

There may actually be more diagnostic and endemic taxa than identified by TWINSPAN which, as a result of the scale used, fall into predominantly Afromontane grids covering both sides of the KwaZulu-Natal/Lesotho escarpment. Examples are: *Quathlamba debilicostata* (Bartramiaceae), endemic to the escarpment cliffs at Sani Pass but classified as Afromontane, and *Anomobryum drakensbergense* (Bryaceae), endemic to Highlands (2927 B, 2928 B, 3028A) as well as borderline Afromontane grids (2929 A, 2929 C). Other important species which are mainly distributed in this region are:

Important species

Bryoerythrophyllum recurvirostrum
Bryum turbinatum
Didymodon trivialis
Encalypta ciliata
Encalypta vulgaris
Ptychomitrium cucllatifolium
Ptychomitrium diexaratum
Weissia dieterlenii

Discussion

At the turn of the previous century the high altitude areas of the Central Plateau were included in a Kalahari or a Highveld region by several phytogeographers (Rehman 1880, Phillips 1917). Later on these high altitude areas were included in several subdivisions of the Sudano-Angolan or Sudano-Zambezian Region (e.g. Lebrun 1947, Monod 1957, Troupin 1966, Takhtajan 1986). Werger (1978, 1983) included the eastern part of the Kalahari/Highveld area (excluding the Afro-alpine Region) in his Sudano-Zambezian Region and the western part or the southern Kalahari (Leistner 1967) in his Karoo-Namib Region as the Southern Kalahari Subdomain.

Since the recognition of a separate Afromontane region by White (1965, 1970) the high plateau of Lesotho (Afro-alpine region) has generally been regarded as a subdivision or part of the Afromontane region (Goldblatt 1978; Denys 1980; White 1981, 1983; Cowling & Hilton-Taylor 1997).

In 1976 White re-instated the Kalahari-Highveld region, excluding the Afro-alpine region on the high plateau of Lesotho, as the Kalahari-Highveld transition zone (White 1976, 1978, 1983). This classification has been followed by Goldblatt (1978) and Cowling & Hilton-Taylor (1997).

The Highlands Region identified here (Fig. 37) is very much restricted to (and is named after) the Highlands of Lesotho and surrounding high altitude areas, including the Afro-alpine or Drakensberg Alpine Region of Killick (1978, 1994). It is therefore most unlikely that this region includes the sandy Kalahari basin, or areas below c.1500 m in altitude, as in the case of the Kalahari-Highveld transition zone of White (1978, 1983), Goldblatt (1978) and Cowling & Hilton-Taylor (1997).

To speculate on the full extent of this Region may be premature but I predict that it will be present on all the high altitude, temperate areas throughout Africa, generally above c.1700 m but increasing in altitude towards the equator and decreasing in altitude towards the poles. It is therefore likely that this region occupies a series of isolated high altitude areas forming an archipelago-like region, similar to the Afromontane Region of White (1978) and Denys (1980). In the southern part of Africa this Region may also be present on isolated mountain peaks of the northern Drakensberg of Mpumalanga and the Northern Province, the Eastern Highlands and Limpopo Escarpment in Zimbabwe, Mount Mulanje and the Nyika Plateau in Malawi, the highlands around Windhoek (e.g. the Auas Mountains) and perhaps other isolated peaks in the Erongo and Brandberg mountains of Namibia, and the central or Bié Plateau in Angola.

Killick (1978) listed a number of 'subalpine' areas in the southern part of Africa that could also be included in this phytochorion (e.g. Amatole and Bosberg mountains in the Eastern Cape Province, Chimanimani and

Gorongosa Mountains in Mozambique, and the Zomba plateau in Malawi) but concluded that Mt. Mulanje in Malawi could be "...the only subalpine vegetation in southern Africa outside South Africa". Many of these high altitude areas are under-explored (Touw 1974, Killick 1978, White 1993, O'Shea 1997) and additional collecting, taxonomic studies and phytogeographic analysis should greatly improve the delimitation of the Highveld as well as other phytogeographic regions in Africa.

Udvardy (1975) identified five Highlands provinces in Africa (Fig. 18):

1. Ethiopian Highlands
2. Guinean Highlands
3. Central African Highlands
4. East African Highlands
5. South African Highlands

These phytochoria appear to cover at least some of the high altitude areas in Africa which are likely to form part of an African 'Highlands' region. Udvardy's South African Highlands Province (Fig. 18) covers the high altitude plateau along the eastern escarpment of South Africa, from Mpumalanga down to the Eastern Cape (Udvardy 1975).

From Table 22 it is evident that endemism is extremely low or absent in the mosses as well as the vascular plants of the Highlands Region. Goldblatt (1978) estimates that c.15 genera "...are confined to this region,..." and White (1983) found that "There are very few endemic species and the greater part of the interior has a very poor flora.". Of course the vascular plant flora considered by Goldblatt (1978) and White (1983) does not include the Drakensberg (Afro) Alpine flora (see the *Drakensberg Alpine Domain,* this Chapter) which may change the figures. Endemism may also be higher in the moss flora of this Region (see *Composition of the.moss flora*). The Eastern Highlands Element dominates the moss flora of this region (Fig. 65).

4.1 Drakensberg Alpine Domain

Area

The Drakensberg Alpine Domain consists of 20 high altitude grid squares (TWINSPAN 5+) contiguous on and around the high plateau of Lesotho (Fig. 38). An outlying group of three grids is found in the Sneeuberge mountains between the towns of Graaff-Reinet and Middelburg in the Eastern Cape Province and a single outlier occurs in the Hantamsberg mountains north of Calvinia in the Northern Cape Province (Fig. 38). The TWINSPAN 3+ classification shows another outlier: grid 3322 B in the Swartberg mountains north of De Rust in the Western Cape Province (Fig. 34).

The climate is severe (broadly classified as temperate with summer rainfall) with cool to hot temperatures in summer and cold to freezing in winter. The vegetation of the high plateau of Lesotho (mostly above 2750 m) lies in the Alpine belt (Killick 1963) and has recently been described as tundra (Killick 1997). Geologically this Domain is associated with basalt of the Drakensberg Formation.

The historical background, geology, climate, phytogeography, flora, ecology and vegetation of this region have been described by Killick (1963, 1978, 1990, 1994, 1997) and Schmitz (1984).

Composition of the moss flora

The moss flora of the Drakensberg Alpine Domain consists of 142 species/infraspecific taxa in 67 genera and 27 families (Appendix II,4 a), only 10 species/infraspeific taxa, four genera and two families less than the Highlands Region. The family Pottiaceae is the largest with 36 species/infraspecific taxa in 16 genera followed by Bryaceae with 20 species in five genera and Dicranaceae with 11 species in five genera. *Bryum* (Bryaceae)with 14 species, *Fissidens* (Fissidentaceae) with eight, and *Syntrichia* (Pottiaceae) and *Funaria* (Funariaceae) with seven species each are the largest genera in the Drakensberg Alpine Domain.

Syntrichia austroafricana and *Pterygoneurum macleanum,* both of the family Pottiaceae, are diagnostic for the Drakensberg Alpine Domain with *Syntrichia austroafricana* the only endemic taxon (see *Composition of the moss flora* under the *Highlands Region*). Some taxa now classified as Afromontane endemics may actually belong here (see *Composition of the moss flora* under the *Highlands Region*). Important Highland species (see list there) are also largely restricted to this domain.

Discussion

The recognition of a separate Afro-alpine region is one of the controversies in southern African phytogeography (Killick 1978, Cowling & Hilton-Taylor 1997). Since its proposal by Hauman (1955), based on Hedberg (1951), the existence of a distinct, discontinuous Afro-alpine Region has generally been acknowledged, but often as a subdivision or 'impoverished' part of the Afromontane region (Weimarck 1941; Troupin 1966; White 1976, 1978. 1981, 1983; Goldblatt 1978; Denys 1980; Cowling & Hilton-Taylor 1997). This study clearly shows that the Afro-alpine region, or the Drakensberg Alpine Domain as it is named here, is a distinct temperate phytochorion not closely related to the subtropical Afromontane Region.

The Drakensberg Alpine Domain is more or less congruent with, and is named after, the Afro-alpine and Drakensberg Alpine Regions of Killick (1978, 1994). More or less restricted to areas above 2000 m (see altitude map in Schulze 1997), this domain will probably combine with a couple of closely related domains to occupy the highest mountains of Africa, increasing in altitude towards the equator and decreasing in altitude towards the poles. It is still uncertain at what level this phytochorion will combine with the Afro-alpine Region of east and north-east tropical Africa (Hedberg 1965, 1994). Friis (1994) found that the Afromontane and Afro-temperate floras of the Sudan, Ethiopia and Somalia occupy the 'high land' above c. 1400–1500 m but he did not distinguish between the two.

The Drakensberg Alpine Domain also coincides with the Eastern Moutain Region of Phillips (1917), renamed the South-eastern Mountain Regional Mosaic by Hilliard & Burtt (1987). However, the boundaries of the (South) Eastern Mountain Region were subjectively drawn and are rather artificial (a lower limit of between 1050 m and 1200 m in the case of Phillips, 1917, and 1800 m in Hilliard & Burtt, 1987). This has resulted in the inclusion of (sub)tropical forest elements on the KwaZulu-Natal side of the Drakensberg escarpment which gives the (South) Eastern Mountain region a distinct Afromontane flavour.

If compared to structural classifications of vascular plant vegetation, the Highlands Region occupy more or less the same geographic area as the Steppe biome of Olson *et al.* (1983). The bryogeographic classification also seems to support the inclusion of the high plateau of eastern Lesotho in the Nama-Karoo Biome by Rutherford & Westfall (1986).

Although only about 8% of vascular plant species in southern Africa occur in the Drakensberg Alpine Domain (Region) compared to the 28% of mosses, endemism is much higher at an estimated 30% compared to only 1% in mosses (Table 23).

4.2 Upper Karoo Domain

Area

The Upper Karoo Domain represents the western half of the Highlands Region, scattered over 20 grid squares in the Free State, southern Lesotho, Eastern and Northern Cape Provinces and Namibia (Fig. 38). This domain occupies a lower altitude and lower rainfall area than the Drakensberg Alpine Domain.

Composition of the moss flora

The moss flora of the Upper Karoo Domain is relatively small and consists of 63 species in 32 genera and 15 families (Appendix II,4 b). The families Pottiaceae with 18 specie/infraspecific taxa in 11 genera, Bryaceae with 12 species in two genera and Funariaceae with eight species/infraspecific taxa in three genera are the best represented in this domain. The largest genera are: *Bryum* (Bryaceae) with 11 species, *Funaria* (Funariaceae) with six species and *Fissidens* (Fissidentaceae) with five species.

None of the taxa are diagnostic, endemic or largely restricted to the Upper Karoo Domain. *Pseudocrossidium crinitum*, *Tortula atrovirens* and *Trichostomum brachydontium* of the Pottiaceae, and *Bryum argenteum*, and *B. pycnophyllum* of the Bryaceae are the most widespread, and the most frequently collected taxa in this but also in other domains. *Ptychomitrium cucullatifolium* (Ptychomitriaceae) is widespread and largely restricted to this domain as well as the closely related Drakensberg Alpine Domain.

Of the relatively few pleurocarpous mosses present in the Highlands Region only six species (four in the family Leskeaceae, one in Fabroniaceae and one in Meteoriaceae) remain in this domain. The pleurocarpous Orders Hookeriales and Hypnobryales, as well as the

Sphagnales, Andreaeales and Polytrichales have not been recorded from this domain.

Discussion

The composition of the Upper Karoo moss flora reflects the increasing aridity in the Highlands Region, from the Drakensberg Alpine Domain in the east to the Upper Karoo Domain in the west.

D. Indirect Gradient Analysis (Ordination of Grid Squares)

The DCA ordinations of the TWINSPAN 3+ and TWINSPAN 5+ databases yielded four axes each with eigenvalues as listed in Table 24. These eigenvalues are only relative measures of the variation accounted for by each axis. The gradient length is a measure of change in species composition of the grids along the ordination axis and a full turnover of species composition occurs in about 4 SD (Gauch 1982).

I. Distribution of TWINSPAN regions in the ordination space

Fig. 40 shows the positions of the TWINSPAN 5+ grids squares on DCA ordination axes 1 and 2, the two axes with the highest eigenvalues. Each grid is also classified according to the TWINSPAN Region it belongs to.

The grids are roughly grouped according to the TWINSPAN analysis and the groups show a large degree of coherence but do not display distinct discontinuity. The Zambezian grids are widely dispersed but more or less grouped together in the top left hand corner of the scatter diagram while the Afromontane grids are clustered towards the bottom left hand corner. These two regions overlap along axis 1. The Highlands grids occupy a central position towards the top of the scatter diagram while the Karoo-Namib grids are widely scattered all along the right hand sector of the plot, overlapping with the other regions along axis 2. The Highlands and Karoo-Namib regions overlap along axis 1. The main TWINSPAN division line is only weakly distinguishable along the first axis, dividing the Zambezi and

Afromontane grids on the left of the scattergram from the Highlands and Karoo-Namib grids on the right.

II. Compositional gradients

1. DCA scattergram of TWINSPAN 5+ grids

Axis 1

There is a clear gradient from Zambezi and Afromontane grids with low values on the one hand to Karoo-Namib and Highlands grids with high values on the other (Fig. 40). The main TWINSPAN 5+ division line runs between these two groups but is not clearly distinguishable as a result of some overlap between the groups. The compositional gradient along the first axis is therefore from grids along the northern, eastern and southern border of the study area to inland and western grids.

Axis 2

Afromontane and Karoo-Namib grids, and to a lesser degree Zambezi grids, are widely dispersed along the 2nd axis which causes considerable overlap among the regions (Fig. 40). There is, however, a gradient from Afromontane and Karoo-Namib grids with relatively low scores to Highlands and Zambezi grids with higher values. This represents a compositional gradient from eastern and southern coastal grid squares to inland and northern grids.

The geographic trends of change in the floristic composition along the first 4 DCA axes are further investigated through Figs. 41–48.

2. Geographic trends in the compositional gradients

Axis 1

The first DCA axes of the TWINSPAN 3+ and TWINSPAN 5+ ordinations have eigenvalues of 0.477 and 0.466, while the gradient lengths are 5.19 and 4.63 standard deviation (SD) units respectively (Table 24). The relatively high eigenvalues of the 1st as well as the other ordination axes indicate that a high percentage of total variance is accounted for by the axes which, however, does not guarantee ecological (phytogeographical) meaningful results (Gauch 1982).

The relatively high gradient lengths indicate total turnover of taxa along the 1st axis. In both cases the main compositional gradient is from low grid scores in the east and north-east of the study area, gradually increasing towards the south and west, to high scores along the west coast and adjacent interior (Figs. 41 & 45). Grids with low scores in the central and northern parts of the study area, e.g. 1723 C, 2723 A and 2527 B, should be regarded as outliers.

The species composition therefore changes from east to west in longitudinal bands more or less parallel to the coast line (Figs. 41 & 45).

Axis 2

The lower eigenvalues of 0.374 and 0.322 respectively (Table 24) show that axis 2 explains less of the variation in the data than axis 1 (Table 24). Although the relatively high gradient lengths of 4.84 and 4.54 SD (Table 24) indicate complete turnover of species there is less change in species composition along this axis. The TWINSPAN 3+ ordination results show that most grids have low scores and fall into the first two class intervals, thus many of the distribution ranges of taxa cover almost the whole gradient represented by this axis (Fig. 42). Complete turnover of species in the TWINSPAN 3+ data set is only achieved through grids 2732 D and 2632 D with extreme positive scores. These two grids are outliers already identified as such by the TWINSPAN classification of grid squares (see *TWINSPAN 3+ and TWINSPAN 5+ classifications*). The TWINSPAN 3+ grid scores change from low scores in the extreme northern inland regions of the study area to higher scores in the southern and southwestern coastal areas (Fig. 42).

Change in the TWINSPAN 5+ species composition along the 2nd axis is more gradual but in the opposite direction than the TWINSPAN 3+ results (Fig. 46). The gradient runs from low values in the southern and coastal parts of the study area gradually increasing towards the interior and extreme northern grid squares. The three eastern grids with extreme low scores (3229 A, 2632 D and 2731 D), although situated more or less on the coast, are probably outliers.

DCA axis 2 therefore represents a latitudinal north-south gradient in the floristic composition of the grids.

Axis 3

The lower eigenvalues of DCA axes 3 and 4 (Table 24) indicate that each captures only about half of the phytogeographic information accounted for by DCA axis 1. Complete turnover in TWINSPAN 3+ species composition (gradient length = 4.28 SD) is only achieved through the inclusion of three ouliers (3424 A, 3424 B, and 2931 A) with extreme low scores on the 2nd axis (Fig. 43). The rest of the grid scores gradually increase from the south-west to western and eastern coastal areas ranging into the northeastern lowveld and escarpment, to high altitude areas of the eastern and southern escarpments and central plateau.

There is less change in the TWINSPAN 5+ species composition along this axis and most grids fall into the first three divisional classes (Fig. 47). A gradient length of 3.74 SD is only achieved through the inclusion of a few grids with high scores in the arid Northern Cape Province and southern Namibia (3221 B, 2718 C, 2918 B, 2615 C and 2716 D). The gradient is different from that of the TWINSPAN 3+ ordination and contrasts grids in the central and northern bushveld parts of the study area with grids scattered over a large area in the southeastern part of southern Africa (Fig. 47).

Axis 4

The gradient lengths of 5.01 and 5.21 SD respectively give a false impression of the change in species composition along the 4th ordination axis. Many of the TWINSPAN 3+ grids have intermediate scores on the 4th axis and full species turnover is only achieved through grids 3222 D and 3024 A, the only grids in their divisional class of extreme low scores (Fig. 44). This axis contrasts some of the alpine and adjacent afromontane grids (low scores), on and around the high altitude central plateau, with high scoring grids scattered in the central and northern bushveld areas of South Africa. This gradient is more or less the same as, but in the opposite direction, of the TWINSPAN 5+ gradient along the 3rd DCA axis.

Most of the TWINSPAN 5+ grids belong to one divisional class of intermediate scores wich indicates little change in species composition along the 4th axis (Fig. 48). Full species turnover is only achieved through a few outliers with extreme low scores on the one end (3229 A, 2731 D, 2528 B) and extreme high scores on the other (2632 D and 1723 C). This axis contrasts 'bushveld' grids in central and northern south Africa with a few grids along the eastern escarpment. The low scoring grids along the Transkei coast (3030 A, 3129 C & D, 3128 D, 3228 B & C, and 3229 A) is probably the result of recent collecting and uneven taxonomic representation in the database. The grids with extreme low and high scores can be regarded as outliers.

It appears that the 3rd and 4th ordination axes represent the same floristic gradient that runs both altitudinally and latitudinally in southern Africa.

III. Correlation with environmental variables

Axis 1

The following environmental variables correlate in varying degrees with the main east-west gradient along the first DCA ordination axis:

1. **Solar radiation** (based on Clemence's Equation) for the **summer** months, roughly from November to March (Schulze 1997a). The values are low in the east and south, gradually increasing in more or less longitudinal bands to high values in the western interior.

2. **Mean annual precipitation** (Anon 1957, B.R. Schulze 1965, Schulze & McGee 1978; Schultze 1997, 1997a). Highest values in the east, gradually increasing towards the south and west in longitudinal bands.

3. **Coefficient of variation of annual precipitation** (Schulze 1997a) which measures the natural year to year variability of rainfall. The higher the mean annual precipitation the lower its inter-annual variability and vice versa. Therefore low percentages in the east and south, gradually increasing in longitudinal bands to high percentages (> 40%) in the Northern Cape and southern Namibia.

4. **Mean or median rainfall** for the **summer** months, roughly from October to March. Highest rainfall figures are generally recorded in the eastern and, to a lesser degree, the southern parts of the study area gradually decreasing in more or less longitudinal bands to very low figures in the west (Schulze 1997a).

5. **Daily mean (and minimum) relative humidity** in **spring** and **autumn**, particularly the month of March (Schulze 1997a). Lowest percentages occur in the western interior with a gradual increase towards the east. Low values are also recorded on the high plateau of Lesotho.

6. **Potential evaporation** (A-pan equivalent), and to a lesser degree **Reference Evapotranspiration** (FAO Penman-Monteith Method), over southern Africa in **December** (Schulze 1997a). The following climatic and physiographic variables were used by Schulze and Maharaj (Schulze 1997a) to estimate potential evaporation over South Africa.: 1) maximum daily temperature, 2) extraterrestrial radiation, 3) altitude, 4) median monthly rainfall and 5) evaporation regions. Low values occur in the east and south with a southeast-northwest increase towards high values in the western interior.

7. **Median annual simulated runoff** with high values in the east and south decreasing towards low values in the west (Schulze 1997a). Runoff patterns reflect a combination of rainfall and soil characteristics.

A number of environmental classifications and indices (usually including some moisture parameter) not mentioned here, also show an east-west gradient (see Schulze & McGee 1978; Schulze 1997, 1997a; Jury *et al.* 1997) , but these are mostly applicable to vascular plants.

Axis 2

The following environmental parameters correlate more or less with the latitudinal north-south gradient along the 2nd DCA ordination axis:

1. **Solar radiation** (based on Clemence's Equation) for the **winter** months, roughly from May to September (Schulze 1997a). The values are low in the south and east increasing in bands running more or less parallel to the coast line to high values in the northern interior.

2. **Temperature Range** (Diurnal) for the **winter** months of May - August (Schulze 1997, 1997a). Low values occur along the coast extending northwards into the lowveld, increasing in latitudinal bands to high values in the northern interior.

3. **Daily mean (and minimum) relative humidity** in the **winter** months, roughly from May to September (Schulze 1997a). Low values (%) are recorded in the northern interior of southern Africa, gradually increasing in latitudinal bands parallel to the coastline to high values along the south-western, southern and eastern coast, extending into the eastern lowveld.

4. **Potential evaporation** (A-pan equivalent), and to a lesser degree **Reference Evapotranspiration** (FAO Penman-Monteith Method), which includes temperature based information, over southern Africa in **spring**, and in particular the month of September (Schulze 1997a). Low values occur in the south-west and south, gradually increasing latitudinally to high values in the northern interior.

Axis 3

Although DCA ordination axes 3 & 4 are phytogeographically less important than the first two DCA axes, the gradients along these axes are nevertheless interpretable.

The following parameters are related to the gradient along the 3rd axis of the **TWINSPAN 3+** ordination (Fig. 43):

1. **Altitude** (Schulze 1997a), from low altitudes along the coastal plain (in particular the southwestern Cape and Maputaland where the coastal plain is at its widest) extending into the lowveld and the Limpopo River valley, to higher altitudes along the escarpment and interior plateau.

2. **Means of daily minimum temperature (°C)** for the **winter** months of May, June, July, and August (Schultze 1997a), with low axis scores corresponding to high daily minimum temperature and vice versa.

3. The gradient along the 3rd axis of the TWINSPAN 3+ grid ordination is also broadly related to most of the **frost**, and some of the **chill unit** parameters mapped in Schultze (1997a).

Two climatic parameters that might explain the floristic gradient along the 3rd axis of the **TWINSPAN 5+** ordination (Fig. 47) are:

1. **Means of daily maximum temperature (°C)** for **spring** with low means in the southern sector of the study area and high means (corresponding to low means on the ordination axis) in the northern and central interior (Schultze 1997a).

2. **Means of daily minimum temperature** (°C) in **summer** with low minimum temperatures along the southern escarpment and adjacent areas, and higher minimums in the northern parts, particularly the north-eastern sector of South Africa (Schulze 1997a).

Axis 4

The **TWINSPAN 3+** gradient along the 4th axis (Fig. 44) seems to be related to:

1. **Means of daily maximum temperature (°C)** for the months of **spring,** with low maximums along the southern escarpment and adjacent parts of southern

Africa, and high maximum temperatures in the northern and central parts (Schulze 1997a).

2. **Daily mean temperature (°C)** for the **summer** months, with low temperatures in the south, especially on the high plateau of Lesotho, increasing towards the central and northern parts of the study area.

3. **Mean annual temperature (°C)**, low means occur on the high plateau of Lesotho and the southern escarpment, gradually increasing towards the coast and interior, with high mean temperatures in the northern and central parts of South Africa (Schulze 1997a).

4. **Heat units (°days)** for the **summer** months of October to March, with 10 °C as base (Schulze 1997a). Low values occur on the high lying areas of the central plateau and alo`ng the escarpment with higher values in the northern and central parts of the study area.

The change in species composition along the 4th axis of the **TWINSPAN 5+** ordination (Fig. 48) might be explained by:

1. **Means of daily maximum temperature (°C)** in **spring** or, to a lesser degree, the **Means of daily minimum temperature (°C)** in **winter** with low temperatures more or less corresponding with high axis scores and vice versa.

2. **Mean annual temperature (°C)** with low degrees corresponding to high values on the ordination axis and vice versa.

3. **Heat units (°days)** for the **summer** months of October to March, with 10 °C as base (Schulze 1997a). Low axis scores correspond more or less to high degree days and vice versa.

Discussion

The DCA ordination supports the TWINSPAN classification of grid squares in that the bryogeographic Regions generally cluster together in ordination space. The distribution of grids along the first axis repeats the general pattern of the major TWINSPAN division: a gradient from sub-tropical Zambezi and Afromontane grids with low scores on the one side to temperate Karoo-Namib and Highlands grids with high scores on the other.

Over wide (broad) landscapes climatic gradients are generally considered to have greater influence on the distribution of plants, including bryophytes, than edaphic factors (Belland 1987, Woodward 1987, Mielke 1989, Pederson 1989, Hill & Dominguez Lozano 1994, McLaughlin 1994, Bates 1995, Akin in Schulze 1997, and references in O'Brien 1993). This hypothesis has also been proposed for southern Africa (Adamson 1938, Werger 1983), where the major climatic gradient runs from east to west, or from humid to hyper-arid (Schulze & McGee 1978; Partridge 1997; Schulze 1997,1997a). At a broad scale, Ellery *et al.* (1991) recently confirmed that there exists a high degree of correlation between climate and the distribution of biomes in southern Africa, in particular the grassland biome, and O'Brien (1993) found that climate accounts for a large percentage of the "...west -to-east pattern of increasing species richness." More examples are mentioned later on in the Discussion.

Most of the climatic factors that might be related to the main east-west change in floristic composition of mosses in southern Africa are associated with moisture. Of these the mean annual precipitation (MAP) gives the best fit. This is not surprising as it is well known that humidity can have a strong influence on the composition of bryophyte floras (Richards 1984a, Gradstein & Pocs 1989, Gradstein *et al.* 1989). Climatic and in particular rainfall variability over southern Africa can be explained by a number of factors including latitudinal displacements of major easterly and westerly wind belts, meridional displacements of the African tropical-temperate cloud band and convergence zone, and changes in sea-surface temperature fields (Tyson 1999). According to Schulze (1997a) physiography is one of the most important factors influencing the spatial distribution of MAP in southern Africa.

A water or moisture gradient, and in particular rainfall, has long been accepted as probably the most important climatic variable determining the diversity and distribution of (vascular) plants in southern Africa (Adamson 1938; Liversidge 1962; Shulze & McGee 1978; Tainton 1981; Werger 1983, Meadows 1985; Shulze 1997, 1997a). The following are examples of recent studies lending support to this hypothesis, not only for southern Africa but also for other parts of Africa:

1. Linder (1991) showed that rainfall is the best predictor of species richness in the south-western Cape.
2. O'Brien (1993) found that woody plant species richness increases with an increase in moisture.
3. Kornas (1993) and Dzonko & Kornas (1994) have shown that the humidity (rainfall) gradient is the main factor influencing the differentation of pteridophyte floras in tropical Africa.
4. Cawe (1994) found a high degree of correlation between rainfall and Acocks' veld types in the Transkei.
5. The most important environmental factors which determine the vegetation zonation on Mt. Kilimanjaro, Tanzania are the rainfall and the temperature (Pocs 1994).
6. In a quantitative analysis of the vegetation-environment relationships in the southern Langeberg Mountains, McDonald *et al.* (1996) found that rainfall is one of the major environmental gradients determining the distribution patterns of plant communities.
7. Cowling *et al.* (1997b) found that warm, moist and aseasonal environmental conditions are responsible for high plant diversity in the "...tropical-derived savanna and grassland flora,...".

The latitudinal north-south gradient along the 2nd DCA ordination axis is more difficult to interpret but appears to be related to temperature, and in particular the effect of temperature on the availability of moisture. Factors affecting temperature include latitude, altitude, continentality, seasonality, topography, and longitude in those regions with an east-west alignment (Schulze 1997a).

Axes 3 & 4 of the DCA ordination seem to represent the same floristic gradient, running both altitudinally and latitudinally, which is related to several temperature parameters and indices. Together with precipitation, temperature was singled out by Adamson (1938) as an important climatic factor influencing the distribution of southern African plants.

The species composition of the southern African moss flora can therefore be explained by two main climatic factors, precipitation (moisture) and temperature, acting independantly and in combination. This hypothesis should now be tested by 1) employing a direct gradient analysis as performed by Canonical Correspondence Analysis (CCA), a multivariate gradient analysis that relates species composition directly to measured environmental variables, and 2) by experimentation.

CHAPTER 5

FLORISTIC ELEMENTS IN THE MOSS FLORA OF SOUTHERN AFRICA

Chapter Outline

A. Historical Perspective

Since numerical programs generally perform classification or ordination on areas (grid squares or releves) and species simultaneously, the description and interpretation of floristic elements have become an integral part of phytogeographic investigations. Recent examples involving vascular plants and ferns include studies by Gill *et al.* (1985), Pederson (1990), Myklestad & Birks (1993), Dzwonko & Kornas (1994) and Heikkinen *et al.* (1998). Good examples of bryophyte distribution (floristic) elements are those described by Proctor (1967) and Belland (1987). More examples are listed in Chapter 2 under *Numerical Analysis*.

In southern Africa phytogeographic elements have received much less attention than phytogeographic regions (phytochoria), so much so that in recent reviews of southern African phytogeography by Werger (1978) and Cowling & Hilton-Taylor (1997) no mention is made of phytogeographic elements within the FSA area. Where phytogeographic elements have been described for southern Africa it has generally been for certain plant groups only (e.g. Nordenstam 1969, Acocks 1971, Kurzweil *et al.* 1991), for limited geographic areas (e.g. Weimarck 1941, Hilliard & Burtt 1987, Linder *et al.* 1992), or both (e.g. Geldenhuys 1994). An exception is the world distribution elements described for families and genera in the vascular plant flora of the entire FSA region by Goldblatt (1978). Some of the more recent studies describing biogeographic elements at the subcontinental scale or below are briefly discussed here:

I. Vascular plants

Weimarck (1941) recognised a number of world distribution (phytogeographic) elements in the Cape flora:

Cape element
Karoo element
Afromontane element
Subtropical–tropical African element
Mediterranean element
North-hemispherical temperate element
Antarctic element
Cosmopolitan element

He subdivided the Cape element, "...i.e. genera having their actual centre within the region.", into 17 'phytogeographical groups' defined as "...species with equivalent or nearly equivalent distribution areas." (Weimarck 1941). These species groups were divided into two main groups: 1) Species endemic to the Cape proper, and 2) Species also occuring outside the Cape proper. Weimarck's (1941) elements were therefore based on the distribution of vascular plant genera which occur in the Cape (the Cape flora) while his 'phytogeographical groups' were based on the distribution of species belonging to genera of the the Cape element.

Weimarck's (1941) subdivision of the Cape element into phytogeographical (species) groups

A. Species Endemic in the Cape Proper

1. The Cape Ubiquists
2. The Cape Ubiquists with a Knysna Interval
3. The Karoo-Mountain–Western Group
4. The Southern Group

5. The Southern Species with a Knysna Interval
6. The Western Group
7. The Lange Berg–South-Western Group
8. The South-Western Endems
9. The North-Western Endems
10. The Lange Berg Endems
11. The Karroo-Mountain Endems
12. The South-Eastern Endems

B. Species occurring (also) outside the Cape Proper

13. The Cape–Drakensberg Group
14. The Drakensberg Endems
15. The Drakensberg–Tropical African Mountain Group
16. The Montane Endems within Tropical Africa
17. The Madagascar Endems

Weimarck (1941) has further identified a number of distribution centres, some subdivided into subcentres: 1) within the Cape proper, and 2) outside the Cape proper. Distribution centres located within the Cape area are called 'endem-centres':

The Cape endem-centres and subcentres of Weimarck (1941)

1. The South-Western Centre
   a. The Cape Peninsula Subcentre
   b. The Frensch Hoek Subcentre
   c. The Bredasdorp Subcentre
   d. The Hottentotsholland Subcentre
2. The North-Western centre
   a. The Great Winterhoek Subcentre
   b. The Cedarberg Subcentre
   c. The Kamiesberg Subcentre

d. The Hantam–Roggeveld Subcentre

3. The Lange-Berg centre
4. The Karoo-Mountain centre
5. The South-Eastern centre
    a. The Zitzikamma Subcentre
    b. The Cockscomb Subcentre
    c. The Zuurberg Subcentre

Distribution centres and subcentres of the Cape element outside the Cape Proper

6. The Drakensberg Centre
7. The Tropical African Mountain Centre
    a. The Inyangani Subcentre
    b. The Mlanja Subcentre
    c. The Rungwe Subcentre
    d. The Katanga Subcentre
    e. The Kenya Subcentre
    f. The Kivu Subcentre
    g. The Abessinian Subcentre
    h. The Angolan Subcentre
    i. The Cameroon Subcentre
8. The Madagascar Centre

Weimarck (1941) has also classified the 17 phytogeographical groups (elements) in the Cape element according to the number and location of the distribution centres covered by each: 1) Species that occur in two or more Cape endem-centres (phytogeographical groups 1 to 7), 2) elements who's distributions coincide with one of the endem-centres (phytogeographic groups 8 to 12), and 3) species with distribution centres outside the Cape area (phytogeographical groups 13 to 17).

Gaps in the distributions of the Cape species are described as 13 'intervals' by Weimarck (1941). He distinguished between two kinds of intervals: 1) the intervals within the Cape proper (intervals 1-5) and 2) the intervals outside the Cape proper (intervals 6-13):

Intervals in the geographic distribution of the Cape element according to Weimarck (1941)

A. The Intervals within the Cape Proper

1. The North-Western Interval
2. The Doorn River Interval
3. The Tulbagh Interval
4. The Karoo Interval
5. The Knysna Interval

B. The Intervals outside the Cape Proper

6. The Kaffraria Interval
7. The Limpopo Interval
8. The Zambesi Interval
9. The Nyasa Interval
10. The East African Interval
11. The Rudolph Interval
12. The Upper-Zambesi–Kassai Interval
13. The Congo Basin Interval

In conclusion Weimarck (1941) compared the Cape element with other African elements, i.e. the Forest element, Karroo element, and the Afro-montane element. Within the latter he identified 5 'distribution-types'.

Distribution types within the Afromontane element of Weimarck (1941)

1. A ubiquistic group, distributed in west as well as east Africa
2. An eastern group, from Ethiopia to the Drakensberg
3. A southern group, limited to the southern mountains in Africa
4. A northern group, distributed in northern tropical Africa
5. A number of groups with species endemic in one or two adjacent subcentres

The criticisms of Weimarck's centres listed by Cowling *et al.* (1992) are largely unfounded. Weimarck (1941) clearly stated that his aim was to delimit species groups and endem-centres within the Cape element. It is also clear that his phytogeographic groups and centres are floristic elements and phytogeographic centres, and not biogeographic areas or "...phytogeographical regions..." as suggested by Cowling *et al.* (1992).

Levyns (1954) found that the genus *Muraltia* has a geographic distribution characteristic of the Cape Element. The magisterial divisions of Caledon, the Cape and Paarl-Stellenbosch were identified as the most species rich.

In 1962 **Stuckenberg** (1962) described the 'montane palaeogenic element' based on the distributions of palaeogenic invertebrates. He also recognised this element in other insect as well as plant groups and regarded it as an ancient distribution pattern (Stuckenberg 1962). This element was divided into two main centres of distribution: 1) the Cape Centre comprising the Cape Fold mountains, and 2) the Eastern Highlands Centre along the eastern escarpment. The Eastern Highlands Centre was subdivided into three subcentres: 1) The Basutoland–Drakensberg Highlands and Eastern Plateau Slopes, 2) The Amatola Range, and 3) The Eastern Transvaal Subcentre.

The montane palaeogenic element of Stuckenberg (1962)

- Cape Centre

- Eastern Highlands Centre
    1. Basutoland-Drakensberg Highlands and Eastern Plateau slopes
    2. Amatola Range
    3. Eastern Transvaal Subcentre

Liversidge (1962) identified nine 'generalised distribution patterns' of southern African birds and related these to the vascular plant vegetation.

Dahlgren (1963) identified *Aspalathus* as belonging to the Cape element of Weimarck (1941). He somewhat modified Weimarck's (1941) system to classify the species into floristic elements.

Croizat (1965) identified four main 'biogeographic centres', or "...centres of massing and form-making,..." in southern Africa. These were formally described as: 1) Barberton Centre, 2) Gariep Centre, 3) Caledon Centre, and 4) Albany Centre.

In his article *Die florengebiete von Südwestafrika* **Volk** (1966) recognised a number of elements and centres in the flora of Namibia but did not make a clear distinction between floristic regions and elements.

Although Zimbabwe falls outside the borders of the FSA region, many of the broad-scale phytogeographic elements described for that country by **Wild** (1968) range into the FSA area. However, from his statement " All elements above, except the montane and submontane elements (including the Cape element), are merely subdivisions of the Sudano-Zambesian phytogeographical region or Zambesian domain as defined by White (1965) and earlier authors." it is clear that Wild (1968) confused the distinction between floristic elements and floristic regions.

The principle phytogeographic elements of the Zimbabwe flora according to Wild (1968)

1. Cape element
2. Afro-montane element
3. High rainfall forest element
4. Forest or forest-savanna element
5. Medium altitude woodland or savanna-woodland elements
6. Low altitude savanna or savanna element on more basic soils
7. Kalahari Sand element

Nordenstam (1969) studied distribution patterns in the genus *Euryops* (Asteraceae), which has it's main distribution area in southern Africa. Five main 'phytogeographical groups' and 24 subdivisions are described in detail. Subdivision of the 'Cape Species' was largely based on the classification of Weimarck (1941).

Phytogeographical Groups in the genus Euryops *(Nordenstam 1969)*

A. Cape Species
   1. The Cape Ubiquists
   2. The Karoo Mountain–Western Group
   3. The Southern Group
   4. The Western Group
   5. The Langeberg–Southwestern Group
   6. The Southwestern Endemics
   7. The Northwestern Endemics
   8. The Langeberg Endemics
   9. T he Karroo Mountain Endemics
   10. The Southeastern Endemicss

B. South African (Extra-Cape) Species
   11. The Western Upper Karroo Endemics

12. The Roggeveld–Cape Karroo Group
13. The Upper Karroo Group
14. The Sneeuwbergen Endemics
15. The Sneeuwbergen–Drakensbergen Group
16. The Sneeuwbergen–Cape Group
17. The Drakensbergen Endemics
18. The Karroo Ubiquists
19. The Namaqualand–Cape Group
20. The Namaqua Group
21. The Vanrhynsdorp Karroo Endemics
22. The Gariep Endemics
23. The Highveld Group
24. The Kaffraria–Transkei Group

C. East Tropical African Species

D. Ethiopian Species

E. Somali–Arabian Species

Nordenstam (1969) also identified a number of 'phytogeographical centres' or centres of diversity and endemism in southern Africa, which are listed under *Historical Perspective*, Chapter 3. In conclusion Nordenstam (1969) identified three trends in the floristic plant geography of southern Africa: "(i) Increasing number of floristic units. (ii) Increasingly physionomic classification. (iii) Tendency to particularize the Cape Flora." which he correctly thought "...somewhat hampered the understanding of the floristic phytogeography of the South African Region."

Acocks (1971) described nine South African distribution patterns or 'types of distribution' in a selection of 44 ecologically important grasses:

Patterns of distribution in certain ecologically important grasses (Acocks 1971)

The North-eastern distribution of tropical and sub-tropical species
The south-eastern type of distribution
The Kalahari type of distribution
The north-western type of distribution
The Karoo type of distribution
The east-central type of distribution
The south-coastal and mountain type of distribution
The western type of distribution
The south-western type of distribution

Clayton (1975) used a clustering program to delimit floristic elements in the mountain grasses of Africa. The species groups were called "Chorological Regions" in one place and "chorological elements" in another. A mixture of categories (Sub-kingdom, element, Region and endemic centre) was used in the classification and some of the floristic elements were compared to floristic regions described by others. This confusion between floristic elements and regions continued in a paper on the "generalized distribution patterns of grass species in the Old World" by **Clayton & Cope** (1979). However, in an earlier paper Clayton (1974) drew a clear distinction between areas of the world with characteristic floras of grass genera (regions) and grass genera with similar distribution patterns (elements).

In *An analysis of the flora of southern Africa...* **Goldblatt** (1978) identified a number of distribution patterns in the 'phanerogamic families and genera' of the FSA area:

World distribution elements in the phanerogamic families and genera of southern Africa (Goldblatt 1978)

Cosmopolitan/Pantropic (22.8%)
Paleotropic (13.7%)

African-Madagascan (6.2%)

African (19.1%)

African-Eurasian (4.2%)

African-New World (2.5%)

African-Australian and South America (1.2%)

Endemic (30.2%)

Goldblatt (1978) recognised three main distribution patterns "...among the genera of southern and tropical Africa.": 1) tropical taxa, 2) arid elements of the Karoo-Namib and Kalahari, and 3) a Cape -Afromontane group of "...temperate southern African genera, mostly centered in the Cape, which extend outside southern Africa mainly in highland areas...".

Denys (1979) described a number of phytogeographic elements in tropical Africa, based on a factor analysis of distribution maps published in the *Distributiones Plantarum Africanarum* series. Some of these elements (which includes a few bryophytes) range into the northern provinces of South Africa.

Cowling (1983) has subjectively classified vascular plant species in the south-eastern Cape into 12 'phytochorological groups' based on the distribution of the species in the phytogeographic regions (phytochoria) of White (1982). These elements were classified as follows: 1) species endemic to a particular phytochorion (four groups), 2) species linking two usually adjacent phytochoria (six groups), 3) tropical wides (one group), and 4) widespread species (one group).

Linder (1983) delimited centres of endemism, overlap regions, and outliers within the distribution range of the Disinae (Orchidaceae). Two centres are recognised within the FSA area: the Cape centre and the Natal-Transvaal centre. The geographic distribution of this group shows that it belongs to the Afromontane element.

In a phytogeographic analysis of the flowering plants of the southern Drakensberg, **Hilliard & Burtt** (1987) described six 'classes of distribution' based on the world distributions of the genera, and 10 'species groups', some subdivided into subgroups, based on the geographic distributions of species.

Almborn (1988) identified the following distribution patterns in selected lichens of South Africa: 1) Ubiquitious species with a more or less worldwide distribution, 2) Steppe and desert species, 3) Montane species, 4) Oceanic species, 5) Tropic-oceanic species, 6) Maritime species, 7) Endemic species of South Africa.

The eight 'species groups' described in the vascular plant flora of the the Karoo Nature Reserve near Graaff-Reinet by **Palmer** (1990) are based on the distribution of differential species (of the plant communities) in the Biomes of Rutherford & Westfall (1986). These species groups can therefore be regarded as ecological rather than floristic elements.

Van Wyk (1990) classified the vascular plant flora of the Pondoland Centre into four floristic elements: Afromontane, Endemic sandstone, Cape, and Mixed tropical elements.

Hoffmann & Cowling (1991) described seven 'generalised tracks' in the vascular plant flora of the lower Sundays River Valley (Eastern Cape Province) based on the distribution of species relative to the phytochoria of White (1983).

The generalised tracks in a sample flora of the lower Sundays River valley, Eastern Cape (Hoffmann & Cowling 1991)

WID - widespread species
TRW - tropical widespread species
TZL - Tongaland-Pondoland – Zambezian linking species
TEN - Tongaland-Pondoland endemics

TKL - Tongaland-Pondoland – Karoo-Namib linking species
KEN - Karoo-Namib endemics
KZL - Karoo-Namib – Zambezian linking species

Species of the Coryciinae (Orchidaceae) were subjectively classified into a number of floristic groups or 'centres of endemism' by **Kurzweil** *et al.* (1991). These floristic elements were equated to the floristic regions delimited by a numerical classification of grid squares (see *Historical perspective*, Chapter 4), which is of course not possible. From the descriptions of the species groups, where they compared their groups with established phytochoria, it is evident that Kurzweil *et al.* (1991) confused the distinction between floristic elements and floristic regions. The Coryciinae is widespread in the more temperate parts of southern Africa and forms part of the Afrotemperate Track (Kurzweil *et al.* 1991).

Centres of endemism in the geographic distribution of the Coryciinae according to Kurzweil et al. *(1991)*

- Drakensberg
- Central African Centre
- Karoo-margins species
- Cape Floristic Centre
  - Ubiquitous
  - Southern group
  - Northern group
    - SW. Cape
    - W. Cape
    - SW.- and S. Cape

Lotononis of the Fabaceae is a southern African genus with a temperate distribution in Africa (**Van Wyk** 1991). The centres of diversity and endemism are listed under *Historical Perspective* in Chapter 3.

Linder *et al.* (1992) identified three world distribution elements or 'tracks' in the Cape flora: 1) the Gondwana track, 2) the African track, and 3) the boreal track. For phytogeographic patterns within the Cape flora they referred to the 'centres' of Weimarck (1941) and Cowling *et al.* (1992).

Geldenhuys (1994) summarized the geographical distribution of southern Cape forest species "...by means of 18 categories which describe the western and eastern distribution limits of the species". These categories were combined into "...five species groups which represent seperate geographical regions." or 'generalised tracks'. The phrase: "...which represent separate geographic regions". is confusing and should rather read: *with distinctive distribution patterns*. Geldenhuys (1994) also discussed the ecology of the groups and the origin and evolution of the southern Cape forest flora.

Generalized tracks in the southern Cape forest species (Geldenhuys 1994) with the percentage of the total flora represented by each

Western Cape group (15%)
Southern Cape group (4%)
Eastern Cape group (25%)
Afromontane group (21%)
Transgressor group (35%)

II. Bryophytes

The most recent attempt to identify distribution (floristic) elements in the bryophytes of the world is *Phytogeography of the Bryophyta* by **Schuster** (1983). He divided his world distribution elements into seven main groups, subdivided into a number of subelements.

The main distribution elements in the bryophytes of the world according to Schuster (1983)

Laurasian Patterns
Gondwanalandic Patterns
Tropical Distribution Patterns
Bipolar Ranges
'Cosmopolitan' Ranges
Anomalous Distribution Patterns
Man-Dispersed Taxa

In the publication series *East African bryophytes* (**Bizot & Pocs** 1974, 1982; **Ochyra & Pocs** 1985a; see the British Bryological Society Website: www.rbge.org.uk/bbs/eab.htm for a list of all 15 publications in the series) and *Results of a bryogeographical expedition to east Africa* (**Bizot** *et al.* 1979, 1985; **Ochyra & Sharp** 1988) mosses and liverworts of tropical and subtropical Africa were assigned to floristic elements, many of which are applicable to southern Africa mosses. These elements refer to the total or world distributions of African mosses.

Little work has been done on the phytogeography of southern African bryophytes. **Schelpe** (1953) studied the distribution of bryophytes in three vegetation zones (Montane Forest, Fynbos and Subalpine *Erica* Zones) of the KwaZulu-Natal Drakensberg. **Magill & Vitt** (1981) found that the moss genus *Macrocoma* (Orthotrichaceae) fits into an Afromontane distribution pattern.

In 1988 **Russell & Van Rooy** (1988) identified the following world distribution patterns in the bryoflora of Namibia:

Cosmopolitan (7% of the total bryoflora),
Widespread (15%),
Southern and Eastern Africa (14%),

Southern Africa (33%),

SWA/Namibia endemic (11%), and

Disjunct/anomalous (20%).

In the same year **Russell & Van Rooy** (1988a) referred to a few distribution patterns in the moss flora of the eastern Cape forests.

Dilg & Frahm (1997) identified three broad-scale phytogeographic elements in the epiphytic bryophytes of the southern KwaZulu-Natal Drakensberg. They are: 1) species distributed in temperate and subtropical Africa, 2) species distributed in tropical Africa, and 3) cosmopolitan taxa.

Hodgetts *et al.* (1999) briefly discussed the following 'phytogeographical patterns' or world distribution elements in the moss flora of Lesotho and adjacent Drakensberg Mountains:

1. The circum-subantarctic pattern of Seki (1974)
2. The South Africa distribution pattern of Seki (1974) or the tropical alpine element of a wider tropical Afro-American distribution after Gradstein *et al.* (1983)
3. Bipolar distributions
4. The East African or Afromontane element
5. African elements
6. Cosmopolitan elements
7. Endemics of the high Drakensberg

They found that a considerable number of Drakensberg species belongs to the East African or Afromontane element.

B. TWINSPAN 3+ Classification of Species

TWINSPAN 3+ classification of southern African moss species into floristic or phytogeographic elements (groups of species with similar spatial or geographic distributions within southern Africa).

The dendrogram resulting from the TWINSPAN 3+ classification of moss species is shown in Fig. 26.

1. **First level of division**

   The first and major TWINSPAN division splits the TWINSPAN 3+ data set into two large groups or elements (Fig. 49). Element 1/1 (first level of division, first group from the left in the TWINSPAN 3+ classification of species) is the smallest of the two main elements with 131 species; the larger element 1/2 consists of 370 species (Appendices III,1 & III,2). The differences in the taxonomic composition of these two main elements are striking.

   Element 1/1: Consists mostly of acrocarpous taxa in the Orders Dicranales, Pottiales, Funariales, Bryales and Orthotrichales (see Magill & Van Rooy, 1998 for a *Conspectus of classification*) of which the Pottiales is particularly well represented. The families Encalyptaceae, Bryobartramiaceae, Grimmiaceae and the endemic family Wardiaceae are restricted to this group. Most of the taxa in this element are xerophytic and therefore adapted to life in the semi-arid conditions of the main distribution area. Most of the ephemerals (see discussion under the *Karoo-Namib Region, Chapter 4*) such as six of the *Archidium* species, all four of the *Pleuridium* species, *Aloina bifrons*, *Acaulon recurvatum* and *A. leucochaete*, *Crossidium spiralifolium*, *Microcrossidium apiculatum*, *Pottia namaquensis*, *Bryobartramia novaevalesiae*, *Chamaebryum pottioides*, *Gigaspermum repens*, *Ephemerum namaquense* and *E. rehmannii*, *Cygnicollum immersum*, and *Goniomitrium africanum* (Appendix III,1) are part of this element. Pleurocarpous mosses of the Order

Hookeriales are absent from this element and the Orders Isobryales, Thuidiales and Hypnobryales are poorly represented.

Element 1/1 is mainly distributed in the south-western, winter-rainfall part of the study area as well as the high altitude, temperate areas of the interior plateau (Fig. 50). Two main centres of distribution are recognised within this element and Stuckenberg (1962) suggested that they be called the Cape Centre and the Eastern Highlands Centre:

- **Cape Centre:** The main distribution centre of this element is located in the south-western Cape Fold Mountains (Fig. 50), in particular Table mountain (grid 3318 C with 64 species), the mountains at Stellenbosch (3318 D with 54 species), the mountains of the Boland (3319 C with 51 species) and the Cedarberge at Clanwilliam (3218 B with 47 species).

- **Eastern Highlands Centre:** Consists of the high plateau of Lesotho, in particular grid 2828 D, the Mont Aux Sources – Oxbow area with 40 species (Fig. 50). Stuckenberg (1962) divided this centre into three subcentres: 1) The Basutoland–Drakensberg Highlands and Eastern Plateau Slopes, 2) The Amatola Range. and 3) The Eastern Transvaal Subcentre.

Other areas with relatively high species concentrations are (Fig. 50):

- the Bokkeveldberge at Niewoudtville (grid 3319 A),
- the mountains at Springbok (2917 D),
- the mountains of the Richtersveld, in particular grid 2927 A,
- the highlands at Windhoek in Namibia (2217 B),
- the Outeniqua Mountains between George and Oudsthoorn (3322 A & C),
- the high altitude Karoo mountains around Graaff Reinet (3224 A & B, 3124 D) and Middelburg (3024 B, 3025 C) and further north to Reddersburg in the southern Free state (2926 A),

- and the Witteberge in the Zastron–Lady Grey area (3027 A & C).

Element 1/2: The other main TWINSPAN division consists of 370 species (Appendix III,2). The pleurocarpous Orders Isobryales, Hookeriales, Thuidiales and Hypnobryales are restricted or largely restricted to this element in southern Africa. It is generally accepted that pleurocarpous mosses are much more abundant in stable, mesophytic (forest) habitats than acrocarps (Vitt 1979, 1984; Buck & Vitt 1986). In mesic environments (Buck & Vitt 1986) "...competitive interactions, broad niche overlap and long growing seasons...", as well as epiphytic habitats, give advantage to pleurocarpous mosses with their ability to form mats through continuous growth of the gametophyte (Vitt 1984, Buck & Vitt 1986).

Acrocarpous taxa adapted to subtropical forest/woodland environments, such as species of *Leucobryum*, *Calymperes*, *Syrrhopodon* and *Rhodobryum* are also restricted to this element. Many of the xerophytic Orthotrichaceae, adapted to habitats on trees and rocks within the Afromontane forest areas (e.g. *Macrocoma*, *Macromitrium* and *Schlotheimia* species) form part of this element. The following families, mostly pleurocarpous, have all their southern African representatives confined to the subtropical element:

Families retsricted to the main subtropical, mesophytic element (Element 1/2)

Seligeriaceae	Cryphaeaceae
Splachnaceae	Leucodontaceae
Mniaceae	Prionodontaceae
Eustichiaceae	Trachypodaceae
Erpodiaceae	Pterobryaceae
Rhachitheciaceae	Meteoriaceae
Rhabdoweisiaceae	Leptodontaceae
Racopilaceae	Neckeraceae
Fontinalaceae	Thamnobryaceae

Hookeriaceae	Brachytheciaceae
Stereophyllaceae	Entodontaceae
Leskeaceae	Plagopytheciaceae
Thuidiaceae	Catagoniaceae
Rigodiaceae	Sematophyllaceae
Amblystegiaceae	

Element 1/2 is widely distributed in the northern, eastern and southern subtropical (mesic) or Afromontane areas of southern Africa (Fig. 51). The main centres of distribution are:

- **Mpumalanga Centre**. The 'eastern Transvaal' or Mpumalanga escarpment in the Graskop – Blyderivierspoort area (grid 2430 D with 163 species) and the Nelspruit – Sabie area (2530 B with 104 species). Croizat (1965) formally named this centre the Barberton Centre.

- **KwaZulu-Natal Centre**. Situated in the KwaZulu-Natal Drakensberg and Midlands area, in particular the montane forests in the Pietermaritzburg – Karkloof area (grids 2930 C with 150 species and 2930 A with 106 species) and the 'High Berg' from Mont Aux Sources in the north to Sehlabathebe in the south (grids 2828 D with126, 2829 C with 102, 2929 A with 124, and 2929 C with 121 species). This centre might therefore be subdivided into two subcentres (Fig. 51): 1) the Drakensberg Subcentre and 2) the Midlands Subcentre.

Other areas of relatively high species concentrations include:

- The entire escarpment of the northern provinces, from the Soutpansberg in the north (grid 2230 C with 68 species) to Swaziland in the south (grid 2631 A with 76 species).

- The Magaliesberg, from Pretoria in the east (grid 2528 C with 67 species) to Rustenburg in the west (grid 2527 C with 56 species).
- Montane forests in the Eshowe – Empangeni grids (2831 C with 93 species and 2831 D with 63 species).
- The montane forests in the King William's Town area (grid 3227 C with 84 species), the southern Cape or 'Knysna' forests (Van der Merwe 1998), especially in the Outeniqua Mountains at George (grid 3322 C with 80 species).
- The montane forest on the eastern slopes of Table Mountain (, grid 3318 C with 122 species, which is the main secondary centre of distribution.

2. **Second level of division**

At the second level of the TWINSPAN 3+ division the two main centres (Cape and Eastern Highlands) in the south-western, xerophytic element (element 1/1) are neatly seperated as species groups or elements 2/1 and 2/2 (Fig. 49). Element 2/1 consist of 47 species, centred on the high interior plateau of Lesotho (Fig. 52). Element 2/2 consist of 84 species, mainly distributed in the south-western corner of the study area (Fig. 53).

The other dichotomy splits the widespread, subtropical group of species (element 1/2) into element 2/3 of 63 species, centred on the Mpumalanga escarpment, KwaZulu-Natal Drakensberg and Midlands, and the mountains of the Cape Peninsula and Boland (Fig. 54), and element 2/4, by far the largest of the 4 elements, with 307 species, widely distributed along the escarpment of the northern provinces, KwaZulu-Natal, and down to the southern Cape (Fig. 55). The group has it's highest species diversity on the Mpumalanga escarpment, the northern part of the KwaZulu-Natal Drakensberg and Natal Midlands, and Table Mountain in the south-western Cape.

3. **Third level of division**

The four elements delimited at the 2nd level of division are here subdivided into eight groups (Fig. 49):

1) Element 2/1 is split into element 3/1, a group of 35 species with restricted distributions, and a smaller element 3/2 consisting of 12 species with wide geographic distributions (Figs. 56 & 57).
2) Element 2/2 with its south-western Cape distribution is subdivided into element 3/3 consisting of 57 species with a 'west coast' distribution, and element 3/4 with 27 species restricted to the southern part of the distribution range (Figs. 58 & 59).
3) Element 2/3 is split into a small group of 11 species (element 3/5), largely absent from the KwaZulu-Natal Drakensberg, and a larger group of 52 species (element 3/6), centred in this area (Figs. 60 & 61).
4) Element 2/4 is divided into a widespread group of 49 species (element 3/7) and a large group of 258 species (element 3/8) whos distributions are largely centred in the KwaZulu-Natal Midlands and the Mpumalanga escarpment (Figs. 62 & 63).

TWINSPAN goes on to subdivide the species groups into 16 elements at the 4th level of division, 30 elements at the 5th level, and 50 elements at the 6th and last level of division (Fig. 49). Although at least some of the elements delimited at the 4th ,5th and 6th levels are ecologically meaningful, they are not treated here as this study is concerned with broad-scale patterns only. The species groups delimited at the second and third levels of division are formally described as phytogeographic Elements and Subelements, analogous to the Regions and Domains described from the TWINSPAN classifications of grid squares (see Chapter 4).

Discussion

The TWINSPAN classification has successfully distinguished between a group of xerophytic mosses, mainly distributed in the arid and semi-arid, temperate south-western and central parts of the study area (element 1/1 of the TWINSPAN 3+ classification), and a mesophytic group distributed in more stable, subtropical habitats in the northern, eastern and southern parts of southern Africa (element 1/2 of the TWINSPAN 3+

classification). The species classification therefore follows the same pattern as the grid classification where the study area was divided into a semi-arid temperate south-western region (region1/1 of the TWINSPAN 3+ and 5+ classifications) with a xerophytic moss flora, and a subtropical region in the northern and eastern parts, extending southward along the coast (region 1/2 of the TWINSPAN 3+ and 5+ classifications) with a mesophytic moss flora.

The distribution area of the south-western element (element 1/1) coincides with that of the montane palaeogenic element of Stuckenberg (1962) and the Cape-Afromontane group (of genera) of Goldblatt (1978). The distribution area also coincides with the high altitude areas of an Afrotemperate Track mentioned by Kurzweil *et al.* (1991). It is difficult to compare the bryofloristic elements of southern Africa with the floristic elements of Weimarck (1941) since his elements refer to distribution patterns within the Cape flora only. However, Weimarck's (1941) Cape element is more or less comparable to the south-western element or element 1/1 of the moss classification.

The subtropical element (element 1/2 of the species classification) is probably part of an East African or Afromontane element (Weimarck 1941, Hodgetts *et al.* 1999), also called the African track (Linder *et al.* 1992), distributed throughout the Afromontane areas of Africa. Most phytogeographers do not make a clear distinction between this element and the Afrotemperate element, just as they do not regard the Afroalpine region in southern Africa as distinct from the Afromontane region. The southern part of the Afromontane element, from Malawi down to the Cape, has been described as the South African element by Clayton (1975). Weimarck (1941) distinguished five distribution types in the Afromontane element but none of these is recognisable in the TWINSPAN classification.

The distribution area of element 1/2 more or less coincides with the 'North-eastern distribution of tropical and subtropical (grass) species' plotted by Acocks (1971) and the distribution area of mixed evergreen forests in southern Africa (Geldenhuys 1994: 972).

The main distribution areas of element 1/1 and element 1/2 overlap at several points along the eastern escarpment of southern Africa. Element 1/1, is more or less evenly distributed in the two main floristic regions (regions 1/1 and 1/2) of the TWINSPAN 3+ classification of grid squares while the widespread, Afromontane element (element 1/2) is mainly distributed in the subtropical region or region 1/2 of the TWINSPAN 3+ grid classification (Fig. 65).

C. Classification of the Bryofloristic Elements of Southern Africa

I. Introduction

The classification of bryogeographic elements within the FSA region is based exclusively on the results of the TWINSPAN 3+ analysis. The classification is hierarchical (see *Classification of the Bryogeographic Regions of Southern Africa*, Chapter 4) and restricted to the 2nd and 3rd levels of division of the TWINSPAN 3+ species classification (Fig. 64). Endemism in the bryofloristic Elements and Subelements is summarised in Table 37.

The names assigned to the Elements and Subelements are provisional because of the regional nature of this study.

Hierarchical classification of the bryogeographic elements of southern Africa

1. **Eastern Highlands Element**
   - 1.1 Mont Aux Sources Subelement
   - 1.2 Widespread Subelement
2. **Cape Element**
   - 2.1 West Coast Subelement
   - 2.2 Boland Subelement
3. **Afromontane Grassland Element**
   - 3.1 Disjunct Cape Peninsula Subelement
   - 3.2 Drakensberg Subelement

4. **Afromontane Forest Element**
    4.1 Widespread Afromontane Subelement
    4.2 Tropical Afromontane Subelement

II. Descriptions of Elements and Subelements

1. Eastern Highlands Element

Taxa

The Eastern Highlands Element consists of 47 species in 29 genera and 13 families (Appendix III,3). Most are from the acrocarpous Orders of Dicranales (three families), Pottiales (three families), Funariales (two families), Bryales (two families), as well as the Orthotrichales (two families), and Thuidiales with a single species. Only 13 families are represented in this element of which Pottiaceae is the largest with 13 species, followed by Funariaceae with seven and Bryaceae with six species.

A total of 10 species/infraspecific taxa is southern African endemics. This constitutes 21% of species in this element or 9% of all southern African endemics. None of the genera restricted to this element is a southern African endemic but *Quathlamba* of the Afromontane Forest Element (see note there) may actually belong here. One species of the southern African endemic genus *Ptychomitriopsis* (*P. aloinoides*) is a part of this element.

Geographic distribution

This element is mainly distributed on the high altitude plateau of Lesotho and adjacent areas (Fig. 52), extending as far south as the Sneeuberge near Graaff Reinet (grid 3224 B). The distribution ranges of up to 13 species extend eastwards into the KwaZulu-Natal Midlands. This element is centred in the Drakensberg and Maloti mountains of northern Lesotho and more precisely in the Mont Aux Sources-Oxbow area (grid 2828 D) where 29 of the 47 species occur. Other areas where up to 12 species occur are the Mpumalanga escarpment, the Magaliesberg, the Amathole Mountains near King William's Town and the Cape Fold mountains of the south-western Cape.

The distribution ranges of the species vary from those that are nearly restricted to the centre (e.g. *Anomobryum drakensbergense, Ptychomitrium diexaratum, Orthotrichum oreophilum*) to more widespread species reaching the northern provinces and the Cape (e.g. *Funaria rottleri, Bartramia hampeana, Ptychomitrium cucullatifolium*). The wide distribution of this element is only achieved through the inclusion of a few very widespread species, viz. *Funaria hygrometrica, Bryum argenteum, B. pycnophyllum* and *Trichostomum brachydontium*.

Discussion

This element is named after the Eastern Highlands Centre of Stuckenberg (1962). It has also been described as the Drakensberg endemic centre by Kurzweil *et al.* (1991). Most of the species favour microhabitats in, or the harsh climate of the high altitude, summer rainfall grassland areas, while the few widespread species of this element have wide ecological amplitudes.

The Eastern Highlands Element is mainly distributed in the Highlands and Afromontane Regions (Fig. 65) although the Afromontane distribution is probably exaggerated as a result of grid squares spanning the Lesotho/KwaZulu-Natal escarpment.

The numbers of Eastern Highlands species occurring in each of the Biomes (Rutherford & Westfall (1986) are listed in Table 25. Given the distribution of this element it is not surprising to find that:

- Most species (92%) occur in the Grassland Biome (Table 25).

- A large percentage of Eastern Highlands species (72%) are found in the Nama-Karoo Biome, especially the north-eastern Lesotho 'island' which coincides with the centre of distribution.
- Relatively few species (30%) are found in forest areas.

1.1 Mont Aux Sources Subelement

Taxa

This group is the largest of the Eastern Highlands divisions and contains 35 species in 23 genera and 12 families (Appendix III,7). *Funaria* (Funariaceae) with five species, and *Didymodon* (Pottiaceae) and *Bryum* (Bryaceae) with four species each, are the largest genera in this group.

The southern African species of Encalyptaceae (a family of montane and arctic mosses fide Horton, 1982), are restricted to the Mont Aux Sources Subelement. *Funaria*, a large and widespread genus, and *Didymodon*, which is known as "...a cosmopolitan genus widely diversified in temperate and montane regions" (Zander 1993), are largely restricted to this subelement in southern Africa.

There are nine southern African endemics in this subelement: *Anomobryum drakensbergense Didymodon jackvancei, Funaria bergiana, Microbryum davallianum* var. *conicum, Orthotrichum oreophilum, Physcomitrium spathulatum* var *sessile, Ptychomitriopsis aloinoides, Ptychomitrium diexaratum* and *Weissia dieterleniae*. This constitutes 26% of the element.

Geographic distribution

This element is largely restricted to the mountains of north-eastern Lesotho and is named after Mont Aux Sources, one of the the highest mountain peaks in grid 2828 D and the centre of distribution (Fig. 56). The number of species per grid drops rapidly outside the main distribution area and the relatively wide distribution is only achieved through species such as *Fissidens curvatus, Didymodon ceratodonteus, Funaria rottleri, Bryum alpinum* and *Bartramia hampeana*. The endemics *Didymodon jackvancei, Weissia dieterleniae, Anomobryum drakensbergense, Ptychomitrium diexaratum* and *Orthotrichum oreophilum* are largely restricted to the main distribution area of the subelement.

Discussion

The Mont Aux Sources Subelement is congruent with the Basutoland–Drakensberg Highlands and Eastern Plateau Slopes subcentre of Stuckenberg (1962). It is mainly distributed in the Drakensberg Alpine Domain with a secondary peak in the Cape Domain (Fig. 65). As in the Eastern Highlands Element, most of the species in this subelement occur in the Grassland (89%) and Nama-Karoo (71%) Biomes (Table 29).

1.2 Widespread Subelement

Taxa

The Widespread Subelement is a group of 12 species (Appendix III,8) in the families Fissidentaceae (2), Archidiaceae (1), Dicranaceae (1), Pottiaceae (2), Grimmiaceae (1), Funariaceae (2) and Bryaceae (3). Some of the most frequently collected and widespread species, in southern Africa as well as the world, have been classified here. They are: *Trichostomum brachydontium* (Pottiaceae), *Schistidium apocarpum* (Grimmiaceae), *Funaria hygrometrica* (Funariaceae) *and Bryum argenteum* (Bryaceae), all with (sub)cosmopolitan distributions, and *Bryum cellulare* which is pantropical in distribution.

Funaria rhomboidea (Funariaceae) is the only endemic in this group.

Geographic distribution

This element is more or less evenly distributed throughout the study area as a result of the widespread species *Trichostomum brachydontium, Schistidium apocarpum, Funaria hygrometrica, Bryum argenteum, B. cellulare and B. pycnophyllum* (Fig. 57). The main area of distribution seems to be the KwaZulu-Natal Midlands and Drakensberg foothills, and the mountains of the eastern Free State. The group has it's highest diversity around the eastern Free State town of Fickburg (grid 2827 D) where nine species occur.

Other areas of relatively high species diversity are (Fig. 57):

1. The Port St. Johns area on the Eastern Cape Wild Coast (grid 3129D).
2. The Ngome forest area near Vryheid in KwaZulu-Natal (grid 2731 C).
3. The Magaliesberg range between Pretoria and Rustenburg (grids 2527 D & 2528 C).
4. The Sabie/Graskop/Blyderivierspoort area (grids 2430 D & 2530 B) as well as the adjacent Sekhukuneland (grid 2430 C).
5. The Malolotja Nature Resereve in northern Swaziland (grid 2631 A).
6) The Houtbosch and other forests east of Pietersburg in the Northern Province (grid 2329 D).

Discussion

The areas of high species diversity within the Widespread Subelement (Fig. 57) include historical and recent collection sites. A few examples are:

- Port St. Johns (3129 D), the largest town on the Wild Coast, has been visited by many plant collectors, including bryologists such as T.R. Sim and H.A. Wager.
- Bryophytes were collected in the Fouriesburg-Lady Brand (grids 2827 D, 2828 C, 2927 A & B) and Zastron-Lady Grey (grids 3027 A & C)

areas of the eastern Free State by J. van Rooy in 1980 and 1986 respectively.

- The Free State city of Bloemfontein is situated in grid square 2926 A, the site of one of the earliest settlements north of the Orange River. Mosses were colleted here by botanists passing through and residents such as G. Potts, Professor of Botany, University College of the Orange Free State (Gunn & Codd 1981).
- Grid 2928 D in Lesotho stands out as a result of R.E. Magill's collecting there in 1977.
- The relatively high number of species in grid 2430 C is the result of a collecting trip to Sekhukuneland by R.E. Magill in 1977.
- The Malolotja Nature Reserve in north-western Swaziland (grid 2631 A) was the focus of attention of K. Braun, L. Smook and others who worked or visited there in the early nineties.

The concentration of Widespread taxa along the Mpumalanga escarpment has been described as the Eastern Transvaal Subcentre by Stuckenberg (1962).

The Widespread subelement has it's main centre of distribution in the Drakensberg Alpine Domain but it is well represented in most Domains (Fig. 65). The lowest numbers of species occur in the Caprivi and Namaqua Domains.

All 12 species occur in the Grassland as well as the adjacent Savanna Biome, nine (75%) are found in the Nama-Karoo Biome, eight (67%) in the Fynbos Biome, 7seven(58%) in the Forest Biome, four (33%) in the Succulent Karoo Biome, and only one (8%) in the Desert Biome (Table 30).

2. Cape Element

Taxa

The Cape Element consists of 84 species in 52 genera and 25 families (Appendix III,4). Most moss taxa are xerophytic and adapted to the dry, hot summers of the mediterranean-type climate, as in the case of the vascular plant flora of this region (Goldblatt 1978). For discussions and a list of ephemerals see the *Karoo-Namib Region, Chapter 4*, and element 1/1 under the first TWINSPAN 3+ division (this Chapter). The acrocarpous family Pottiaceae, with 24 species, is the best represented in this element followed by Funariaceae with seven, and Dicranaceae, Grimmiaceae and Bryaceae six species/infraspecific taxa each.

The endemic, monotypic family Wardiaceae has been classified here. *Wardia hygrometrica* is a semi-aquatic moss restricted to streams of the south-western Cape (Fig. 13). Three or 50% of genera endemic to southern Africa form a part of this element. They are: *Microcrossidium* (Pottiaceae), *Cygnicollum* (Funariaceae) and *Wardia* (Wardiaceae). This represents 6% of genera in the Cape Element or 2% of genera in southern Africa. All three are monotypic and restricted to the main distribution area which may indicate a possible origin in the Pliocene as a result of the inception of a mediterranean type climate in the Cape (Deacon *et al.* 1992). However, Frey (1990) is of the opinion that a mediterranean-type distribution pattern, which he described as the Xerothermic Pangaean genoelement, is an ancient one, supposedly of pre-angiosperm origin. A total of 30 species (36% of species in this element) are FSA endemics.

Geographic distribution

The main distrubution is in the winter rainfall area of the western Cape and more specific along the north-south axis of the western zone of the Cape Fold Mountains, from the Cape Peninsula right up to Namaqualand and northwards to the Richtersveld (Fig. 53). The number of species per grid drops rapidly outside the main distribution area and very few species reach the eastern Cape coast, KwaZulu-Natal, Swaziland, and the northern provinces.

The main centre of distribution is in the mountains of the south-western Cape, in particular Table mountain (grid 3318 C) with 64 species, the mountains at Stellenbosch (3318 D) with 54 species, and the mountains of the Boland (3319 C) with 51 species (Fig. 53). A secondary centre, which probably is an extension of the main centre, is situated in the Clanwilliam – Vanrhynsdorp area, in particular the Clanwilliam grid (3218 B) with 47 species. Other areas showing concentrations of species are the western escarpment around Springbok (2917 D), the mountains of the Richtersveld, in particular grid 2927 A, the Outeniqua Mountains between George and Oudsthoorn (3322 A & C), and the southern KwaZulu-Natal drakensberg (grids 2929 A & C).

Some species such as *Bruchia brevipes, Tetrapterum tetragonum, Ptychomitrium crassinervium, Zygodon runcinatus* and *Orthotrichum incurvomarginatum* are restricted to the main distribution area while others like *Fissidens rufescens, Tortula atrovirens, Pseudocrossidium crinitum, Syntrichia ruralis, Grimmia pulvinata* and *Bryum canariense* give this element it's wide distribution. Weimarck (1941) classified species of the Cape Element with a wide distribution in the Cape area asThe Cape Ubiquists.

Discussion

This element is named after the Cape Centre of Stuckenberg (1962). The Cape Element is distributed in more or less the same area as Weimarck's (1941) 'Species endemic in the Cape Proper', the 'Cape Species' of Nordenstam (1969), the 'western type of distribution' of Acocks (1971), and the combined Karoo-margin species and Cape Floristic Centre of Kurzweil *et al.* (1991). It must be remembered, however, that those elements were subjectively determined, with reference to the Cape flora in the case of Weimarck (1941) and specific vascular plant taxa in the case of Nordenstam (1969), Acocks (1971) and Kurzweil *et al.*

(1991). Unlike the vascular plant elements, up to 15 species or 18% of the mosses in the Cape Element occur to the east of the Cape area. The main distribution area of the Cape Element might also be compared to that of Weimarck's (1941) Cape Ubiquists with a Knysna Interval.

The Cape Element has it's main distribution in the southern part of the Afromontane Region or the Cape Domain but this may be exaggerated as a result of the grid resolution (the coarse grain) and the phytogeographic heterogeneity of the area. As expected the Cape Element is well represented in the Karoo-Namib Region (Fig. 65).

The main distribution area of the Cape Element coincides with the western part of the Fynbos Biome (83% of species) while more than half of the species (55%) ranges northwards into the Succulent Karoo Biome (Table 26). The main distribution area of this element doesn't include many forest areas and this is reflected in the low percentage of Cape species found in the Forest Biome (19%).

2.1 West Coast Subelement

Taxa

The xerophytic West Coast Subelement is the largest of the two Cape subelements and consists of 57 species in 25 genera and 17 families (Appendix III,9). By far the largest family is the Pottiaceae with 23 species. Most of the ephemerals in the study area (see *element 1/1* under *1. First level of division*, this Chapter) are found in this group.

A large percentage (40%) of taxa in this subelement are southern African endemics. Two of the six endemic genera (*Cygnicollum* and *Microcrossidium*), or 33% of genera endemic to southern Africa belong to this subelement.

The monotypic *Bryobartramia* (Bryobartramiaceae) is shared with western and southern Australia where mediterranean type climates similar to that of the western Cape are found. In fact, a great number of non-endemics (40%) occurs in other mediterranean and temperate to hot, semi-arid to arid areas of the world (see map in Gess, 1992). Together with endemics in the West Coast Subelement, these taxa represent 80% of the element. Frey (1990) described this mediterranean-type distribution pattern as the Xerothermic Pangaean genoelement, supposedly of pre-angiosperm origin. He found that many mosses with the Xeropottioid life syndrome display this kind of distribution pattern (see *Floristic composition* of the *Karoo-Namib Region*, *Chapter 4*).

Species of the West Coast Subelement which are also found in other mediterranean and temperate to hot, semi-arid to arid areas of the world

Acaulon leucochaete
Aloina bifrons
Bartramia compacta *var.* compacta
Bruchia brevipes
Bruchia queenslandica
Bryobartramia novaevalesiae
Bryum canariense
Bryum radiculosum
Bryum torquescens
Didymodon australasiae
Fissidens pygmaeus
Fissidens rufescens
Gigaspermum repens
Grimmia laevigata
Grimmia pulvinata
Ischyrodon lepturus
Orthotrichum diaphanum
Pleuridium nervosum
Pseudocrossidium hornschuchianum
Syntrichia chisosa
Syntrichia princeps
Syntrichia ruralis
Tortula atrovirens

Some of these species are restricted to areas with mediterranean type climates, e.g. *Fissidens pygmaeus, Acaulon leucochaete, Bruchia brevipes,* *Bryobartramia novaevalesiae, Gigaspermum repens, Bartramia compacta* var. *compacta and Ischyrodon lepturus* while others are widespread and also occur in other climatic regions e.g. *Didymodon australasiae, Pseudocrossidium crinitum, Syntrichia princeps, Tortula atrovirens, Bryum canariense, Bryum radiculosum, Bryum torquescens* and *Orthotrichum diaphanum.*

Geographic distribution

The geographic distribution of the West Coast Subelement is more or less the same as that of the Cape Element. The main distribution area runs parallel to the West Coast, from the Cape Peninsula in the south to the Richtersveld in the north (Fig. 58). The highest numbers of species are found in the Clanwilliam (3218 B) and Cape Town (3318 C) areas with pockets of relatively high species diversity in the Kamiesberge (3018 A) and the northern part of the Richtersveld (2817 A). A number of species also ranges eastward to the Langeberg mountains near Montagu (3320 C) and the Outeniekwa Mountains near George (3322 C). The distribution ranges of some species include the high altitude interior plateau but few occur to the north and east of Lesotho.

Discussion

Both subdevisions of the Cape Element have main centres of distribution in the Cape Peninsula and therefore overlap in the south-western Cape area. The West Coast Subelement is comparable to the 'Western' phytogeographic groups of Weimarck (1941), Dahlgren (1963) and Nordenstam (1969), and the 'Nearly (Cape) ubiquitous species Concentrated in the West' of Dahlgren (1963).

One of the main centres of distribution, The Cape Town or Table Mountain centre (Fig. 58), coincides with the Cape Peninsula Subcentre (South Western Centre) of Weimarck (1941) while the Clanwilliam centre more or less coincides with the Cedarberg Subcentre (North -Western Centre). The distribution centre in Namakwaland overlaps with the Kamiesberg Subcentre (North -Western Centre) of Weimarck (1941). The concentration of species in the Richtersveld has been described as the Gariep Centre by Croizat (1965) and Nordenstam (1969). It should be noted, however, that the name 'Gariep Centre' has more recently been applied to a chorological subdevision of the Western Cape Domain or the Succulent Karoo (Hilton-Taylor 1987, 1994, 1996; Cowling *et al.* 1999) and to a centre of plant endemism (Van Wyk & Van Wyk 1997).

The West Coast Subelement has it's main distribution in the Cape and Western Cape Domains (Fig. 65) with a minor peak in the Drakensberg Alpine Domain. It is completely absent from the Caprivi Domain.

The two main centres of distribution fall into the Fynbos Biome (75% of species) but the main distribution area extends into the Succulent Karoo Biome (72% of species). More or less the same numbers of species occur in the Grassland (42%), Nama-Karoo (40%) and Savanna (42%) Biomes (Table 31).

2.2 Boland Subelement

Taxa

The Boland Subelement consists of 27 species in 19 genera and 16 families (Appendix III,10). The families Aulacomniaceae and Wardiaceae are restricted to this subelement in southern Africa. The only representative of the Aulacomniaceae, *Leptotheca gaudichaudii*, is also distributed in the southern temperate areas of southern South America, the Falkland Islands, Juan Fernandez, South Georgia, the Auckland and Campbell islands, southern and eastern Australia, Tasmania, and New

Zealand. The genera *Archidium* (Archidiaceae) and *Racomitrium* (Grimmiaceae) with three species each are the best represented in this group.

Seven of the 27 species (26%) are FSA endemics. This includes the monotypic family Wardiaceae.

Geographic distribution

This element is largely restricted to the south-western corner of the study area (Fig. 59). The centre of distribution is Table Mountain (grid 3318 C with 21 species) and the Cape Fold mountains of the Boland (grids 3318 D with 18 species and 3319 C with 19 species). The number of species per grid drops rapidly outside the main distribution area and very few make it to the northern provinces of South Africa. Up to eight species range as far as the Cedarberge near Clanwilliam, the Groot Swartberge and Outeniekwaberge mountain ranges of the Klein Karoo, and the Sani Pass–Sehlabathebe area in the KwaZulu-Natal Drakensberg.

Species more or less restricted to the centre of distribution include *Andreaea subulata, Archidium rehmannii, Racomitrium lanuginosum, Pyrrhobryum vallisgratiae, Leptotheca gaudichaudii, Zygodon runcinatus* and *Wardia hygrometrica*, all restricted to Gondwana fragments except *Racomitrium lanuginosum* with a widespread bipolar distribution. This subelement is only present in the northern provinces through the inclusion of *Archidium ohioense, Fissidens fasciculatus, Leucoloma sprengelianum* and *Rhacocarpus purpurascens*.

Discussion

The main distribution area of the Boland Subelement coincides with that of Weimark's (1941) Western Group or the South-Western Centre. The centre of distribution (Table Mountain) coincides with Weimarck's (1941)

Cape Peninsula Subcentre. The concentrations of species in grids 3318 D and 3319 C have been described as the Hottentotsholland and French Hoek Subcentres by Weimarck's (1941).

The Boland Subelement is largely confined to the Cape Domain (Fig. 65) and all of the species occur in the Fynbos Biome (Table 32).

3. Afromontane Grassland Element

Taxa

The smallest of the widespread, subtropical elements, the Afromontane Grassland Element consists of 63 species in 40 genera and 21 families (Appendix III,5). The family Pottiaceae is the best represented with 15 species, followed by the Bryaceae with nine and the Dicranaceae with eight species/infraspecific taxa. The pleurocarpous orders of Isobryales, Hookeriales, Thuidiales and Hypnobryales are poorly represented, and the Andreales and Polytrichales completely absent from the Afromontane Grassland Element.

There are 10 southern African endemics (16% of species in this element or 9% of all southern African endemics) in this element of which three belong to the family Pottiaceae.

Geographic distribution

The Afromontane Grassland Element is characterised by three widespread centres of distribution which include Table Mountain (grid 3318 C) in the Western Cape (Fig. 54). The other two centres are situated in the KwaZulu-Natal Midlands (2930 C) and Drakensberg (2828 D, 2929 A & C) area, and the Graskop – Blyderivierspoort area (grid 2430 D) in Mpumalanga. Other areas of relatively high species concentrations include the grids adjacent to the main centres of distribution, the King William's Town area (3227 C), the Lady Grey area in the Eastern Cape (3027 C), the north-eastern Free State including the Maseru grid

(2927 B), and the Magaliesberg Mountains between Pretoria and Rustenburg (grids 2527 C &D, 2528 C). Compared to the Afromontane Forest Element, the number of Afromontane Grassland elements in the George – Knysna area of the southern Cape, the Eshowe – Empangeni area in KwaZulu-Natal, and the northern and southern parts of the 'eastern Transvaal' escarpment, is relatively low.

Some species are more or less restricted to the Cape centre of distribution (*Trematodon pillansii, Sphagnum pycnocladulum, Calyptrochaeta asplenioides*), others only occur in the KwaZulu-Natal centre (*Distichium capillaceum, Aongstroemia julacea, Barbula microcalycina, Bryum caespiticium, Pohlia cruda*), but none is restricted to the northern or Mpumalanga centre. A number of species occurs in all three centres, of which *Fissidens bryoides, Syntrichia fragilis, Mielichhoferia bryoides, Philonotis dregeana, Ptychomitrium crispatum, Fabronia pilifera, Pseudoleskeopsis claviramea, Leptodon smithii,* and *Hypnum cupressiforme* are the most widespread.

Discussion

The Afromontane Grassland Element is mainly distributed in the Afromontane Region with minor peaks in the Zambezian and Highlands Regions (Fig. 65).

Great numbers of species occur in the Grassland Biome (94%) and it's southern Afromontane replacement, the Fynbos Biome (64%), as well as the Savanna Biome (76%). This element is further characterised by the relatively great numbers of species present in the semi-arid Succulent Karoo (22%) and Nama-Karoo (56%) Biomes compared to only 0.16% and 11% of the Afromontane Forest Element. The southern centre of distribution is evident in the relatively high percentage of species (64%) present in the Fynbos Biome compared to the 45% of the Afromontane Forest Element (Table 27).

3.1 Disjunct Cape Peninsula Subelement

Taxa

The Disjunct Cape Peninsula Subelement is the smallest of all the subelements with only 11 species in 11 genera and eight families (Appendix III,11).

Of the 11 species in this subelement three or 27% are southern African endemics (*Trematodon pillansii, Plagiothecium membranosulum and Isopterygium punctulatum*), five are distributed in the African–Arabian–Madagascan region (*Sphagnum truncatum, Fissidens plumosus,Pseudocrossidium porphyreoneurum, Weissia latiuscula, Fabronia pilifera*) and three are widespread or subcosmopolitan (*Syntrichia pagorum, Bryum capillare, Pohlia elongata*).

Geographic distribution

This subelement (Fig. 60) is centred in the Cape Peninsula (grids 3318 C and 3418 A) with disjunct occurrences in the KwaZulu-Natal Midlands at Pietermaritzburg (grid 2930 C), the Graskop–Blyderivierspoort area on the Mpumalanga escarpment (2430 D), and the Magaliesberg mountains between Pretoria and Rustenburg (grids 2527 C & D, 2528 C). It is largely absent from the high altitude plateau and mountains of the Free State and Lesotho as well as large parts of the southern and Eastern Cape and KwaZulu-Natal (Fig. 60).

The Cape endemic *Trematodon pillansii* (Dicranaceae) is the only species more or less restricted to the main centre of distribution while *Weissia latiuscula* (Pottiaceae) and *Bryum capillare* (Bryaceae) are only found in the northern regions. The wide geographic distribution of this subelement is attained through species such as *Sphagnum truncatum,* *Pseudocrossidium porphyreoneurum, Syntrichia pagorum Bryum capillare,* and *Fabronia pilifera.*

Discussion

The Disjunct Cape Peninsula Subelement is most abundant in the Cape Domain with secondary occurrences in the Drakensberg, Bushveld and Caprivi Domains (Fig. 65).

Eighty two percent of species occur in each of the Grassland, Savanna and Fynbos Biomes where the disjunct centres of distribution are located (Table 33). Although Afromontane forests are present in all three centres, only 27% of species in this elemenet were recorded from this Biome.

3.2 Drakensberg Subelement

Taxa

The 52 species in this element are mostly acrocarpous, distributed in the drier areas of the Afromontane region and beyond. They belong to 35 genera and 20 families (Appendix III,12). The Pottiaceae is the best represented with 11 species followed by the Dicranaceae and Bryaceae with seven species each. *Bryum* is the largest genus in this subelement with four species, followed by *Campylopus, Philonotis and Ptychomitrium* with three species each. Seven (14%) of the species are FSA endemics.

Geographic distribution

The main distribution area is in the Midlands and Drakensberg region of Kwazulu-Natal, and the eastern Free State down to the Zastron-Lady Grey area (Fig. 61). Significant numbers of species are also present along the escarpment in northern Swaziland and Mpumalanga, the Magaliesberg mountains west of Pretoria, and the mountains of the Cape Peninsula and Boland. The main centre of distribution is situated in the KwaZulu-Natal

Drakensberg (grids 2828 D, 2929 A & C) with secondary centres in the Graskop-Blyderivierspoort area of Mpumalanga (grid 2430 D) and Table Mountain in the Western Cape (grid 3318 C).

Species more or less restricted to the main Drakensberg centre of distribution are: *Distichium capillaceum, Aongstroemia julacea, Barbula microcalycina, Bryum caespiticium* and *Pohlia cruda*. Widespread species include:, *Fissidens bryoides, Hypodontium dregei, Syntrichia fragilis, Campylopus introflexus, Brachymenium acuminatum, Philonotis dregeana, Philonotis falcata, Ptychomitrium crispatum* and *Hypnum cupressiforme*.

Discussion

The subelement is most abundant in the Cape and Drakensberg Domains and a significant number of species is present in the Drakensberg Alpine Domain (Fig. 65).

Almost all of the species (96%) occur in the Grassland Biome and great numbers are also present in the Savanna (75%), Forest (62%), Nama-Karoo (62%), and Fynbos (60%) Biomes (Table 34). The relatively great number of species distributed in the Nama-Karoo Biome (62%) is only as a result of this biome's presence in the north-eastern part of Lesotho (Fig. 2).

4. Afromontane Forest Element

Taxa

By far the largest of the bryogeographic elements, the Afromontane Forest Element consists of 307 species (61% of all the mosses in southern Africa) in 157 genera and 46 families (Appendix III,6). Most species belong to the Dicranaceae (33), Orthotrichaceae (23), Bryaceae (20) and Pottiaceae (18) while *Fissidens*

(Fissidentaceae) with 19 species, *Campylopus* (Dicranaceae) with 15 species, and *Fabronia* (Fabroniaceae), *Brachythecium* (Brachytheciaceae) and *Sematophyllum* (Sematophyllaceae) with seven species each, are the largest genera.

In southern Africa most of the (sub)tropical forest species, many who belong to the pleurocarpous Orders of Isobryales, Hookeriales, Thuidiales, and Hypnobryales, figure in this element. However, a number of xerophytic taxa such as species of *Archidium* (Archidiaceae) and *Ephemerum* (Ephemeraceae) shares a similar distribution pattern.

Of the 307 species in this element 62 (or 20%) are southern African endemics. This represents 54% of all FSA endemics, the highest figure for all the elements. Two of the six, or 33% of genera endemic to southern Africa, are restricted to this element. They are: *Physcomitrellopsis* (Funariaceae) and *Quathlamba* (Bartramiaceae). The monotypic *Quathlamba* grows high up on the Drakensberg escarpment at Sani Pass (Magill 1987) and may actually belong to the Eastern Highlands Element, but as a result of the predominantly Afromontane grid square (2929 C) in which it occurs, it has been classified here. *Physcomitrellopsis*, the other southern Africam endemic, grows on the endge of a forest area in the Eastern Cape Province. One species of the southern African endemic genus *Ptychomitriopsis* (*P. africana*) belongs to this element, the other (*P. aloinoides*) is part of the Eastern Highlands Element.

Geographic distribution

The Afromontane Forest Element is mainly distributed in the KwaZulu-Natal Midlands and Drakensberg area, and along the escarpment of the northern provinces (Fig. 55). The two main centres of distribution are Pietermaritzburg (grid 2930 C) with 117 species and Blyderivierspoort (grid 2430 D) with 129 species.

Other areas of relatively high species diversity are (Fig. 55):

- Table Mountain in the Western Cape (grid 3318 C) with 86 species.
- The southern Cape forests in the George (grid 3322 C with 64 species) and Knysna (grid 3423 A with 53 species) area.
- Forests in the Amathole Mountains near King William's Town (grid 3227 C with 66 species).
- The Zululand forests in the Empangeni (grid 2831 D with 54 species) – Eshowe (grid 2831 C with 77 species) area.
- The forests on the slopes of the Soutpansberg in the Northern Province (grid 2230 C) with 54 species.

Compared to the Afromontane Grassland Element, the numbers of species distributed in the mountains of the Cape Peninsula and Boland, Lady Grey and eastern Free State, and the Magaliesberg, are relatively low in this element. The numbers of species distributed in the semi-arid and arid central and western parts of the study area are very low (Fig. 55).

The distribution ranges of the species vary from those restricted to one of the main distribution centres, to species present in both main centres, to widespread species found throughout the distribution area of the element.

The following species are restricted to the northern centre of distribution situated in the Graskop-Blyderivierspoort region:

Campylopus fragilis
Campylopus jamesonii
Platyhypnidium macowanianum
Rhacopilopsis transvaaliensis
Rigodium toxarion
Syrrhopodon asper

Trachypodopsis serrulata

Species more or less restricted to the KwaZulu-Natal centre of distribution include:

Drepanocladus aduncus
Fissidens enervis
Oligotrichum afrolaevigatum
Plagiobryum Zierii
Pterobryopsis rehmannii
Stoneobryum mirum

The following species are widespread and occur in forest areas from Table Mountain in the Cape to the Soutpansberg in the Northern Province:

Aerobryopsis capensis
Brachymenium pulchrum
Fissidens glaucescens
Hypopterygium laricinum
Macrocoma tenue subsp tenue
Neckera valentiniana
Polytrichum commune
Porotrichum madagassum
Pyrrhobryum spiniforme
Sematophyllum dregei

Discussion

The distribution area of the Afromontane Forest Element overlaps with that of the Afromontane Grassland Element except in Namakwaland and southern Namibia where it is absent. The Afromontane Forest Element is largely restricted to the Afromontane Region (Fig. 65).

As with the Afromontane Grassland Element, the greatest numbers of species occur in the Grassland (76%) and Savanna (59%) Biomes (Table 28). However, the numbers of species found in the semi-arid Succulent Karoo (0,16%) and Nama-Karoo (11%) Biomes are much lower than in the Afromontane Grassland Element and only 45% of species occur in the Fynbos Biome compared to 64% of the Afromontane Grassland Element.

4.1 Widespread Afromontane Subelement

Taxa

This subelement consists of 49 species in 38 genera and 21 families (Appendix III,13). The genus *Campylopus* (Dicranaceae) with four species is the best represented followed by *Fissidens* (Fissidentaceae) and *Sematophyllum* (Sematophyllaceae) with three species each.

The family Catagoniaceae with it's single, endemic representative *Catagonium nitens* ssp. *maritimum* is restricted to this subelement. Six or 12% of species in the Widespread Afromontane Subelement are southern African endemics.

Geographic distribution

Species in this group are widespread throughout the southern African part of the Afromontane Region (see *Chapter 4*) or the Drakensberg regional mountain system (Domain) of White (1978) and Denys (1980). The main distribution areas are (Fig. 62):

- The escarpment forests of the northern provinces, from the Soutpansberg in the north to Swaziland in the south.
- The Magaliesberg kloof forests between Pretoria and Rustenburg.
- Forests of the KwaZulu-Natal Midlands and Drakensberg.

- Forests of the Eastern Cape Province (represented by grids 3129 B and 3227 C), still very much under-collected.
- The southern Cape forests in the George-Knysna region.
- Forest patches on Table Mountain and the Somerset West-Betty's Bay area of the Western Cape.

The main centres of distribution are (Fig. 62):

- The Graskop-Blyderivierspoort area (grid 2430D) on the Mpumalanga escarpment.
- The forests around Pietermaritzburg (grid 2930 C) in the KwaZulu-Natal Midlands.

Only a few species are more or less restricted to the northern centres of distribution (*Archidium acanthophyllum, Campylopus perpusillus, Leptodictyum riparium*) or reach their southern limit in the Eastern Cape (*Anomobryum filiforme, Hedwigia ciliata, Lindbergia viridis, Thuidium matarumense*). Most species in this subelement occur in the south as well as the north of the distribution area and the following are among the most widespread: *Spagnum capense, Fissidens glaucescens, Campylopus pyriformis, Campylopus robillardei, Macrocoma tenue* subsp. *tenue, Brachythecium implicatum, Sematophyllum brachycarpum, Sematophyllum dregei* and *Polytrichum commune*. Species which range into the arid western parts of the study area include: *Erpodiumcoronatum* subsp. *transvaaliense, Philonotis hastata* and *Physcomitrium spathulatum* var. *spathulatum*.

Discussion

Surprisingly this subelement is most abundant in the Cape Domain and not the Drakensberg Domain where the main centres of distribution are situated (Fig. 65). It is absent from the arid Namaqua Domain.

The species are abundant in each of the Biomes found along the Afromontane region, i.e. the Grassland (94%), Savanna (92%), Forest (76%) and Fynbos (80%) Biomes (Table 35). The widespread nature of this subelement is evident in the relatively high percentage (63%) of species that occur in all of these Biomes (Grassland, Forest, Savanna as well as the Fynbos Biome) compared to only 16% of species in the Tropical Afromontane Subelement.

4.2 Tropical Afromontane Subelement

Taxa

By far the largest of the bryogeographic subelements, the Tropical Afromotane Subelement consists of 258 species in 140 genera and 44 families (Appendix III,14). Particularly well represented are the largely pleurocarpous orders Orthotrichales, Isobryales, Hookeriales, Thuidiales and Hypnobryales. Dicranaceae (26 species) is the largest family as far as the number of species is concerned, followed by Orthotrichaceae (19), Bryaceae (17) and Fissidentaceae (16). *Fissidens* (Fissidentaceae) is by far the largest of the genera with 16 species, followed by *Campylopus* (Dicranaceae) with 11 and *Brachythecium* (Brachytheciaceae) with six species.

Two (33%) of the six genera endemic to the FSA region, *Physcomitrellopsis* (Funariaceae) and *Quathlamba* (Bartramiaceae), both monotypic, belong to this subelement. One species of the southern African endemic genus *Ptychomitriopsis* (*P. africana)* is part of this subelement, the other species (*P. aloinoides*) belongs to the Mont Aux Sources Subelement. FSA endemics constitute 22% of species in this subelement, most of which are found in the Orthotrichaceae (9), Brachytheciaceae (7), Fabroniaceae (5) and Polytrichaceae (5).

Geographic distribution

Although widely distributed in the eastern and southern parts of the study area, the Tropical Afromontane Subelement is concentrated in a few areas of the Afromontane region (Fig. 63). The two main distribution areas are:

- The KwaZulu-Natal Midlands and Drakensberg.
- The Mpumalanga Drakensberg escarpment.

The group has it's highest diversity in the Graskop-Blyderivierspoort area (grid 2430 D), where 91 of the species are found, and around Pietermaritzburg (grid 2930 C) where 81 species occur (Fig. 63). Other areas of relatively high species concentrations are:

- The montane forests in the Tzaneen-Haenertzburg area of the Northern Province.
- The Zululand forests around Empangeni and Eshowe.
- The forests of the Amathole Mountains north of King William's Town in the Eastern Cape Province.
- The Outeniekwa Mountains near George in the Western Cape Province.
- The Afromotane forest on the slopes of Table Mountain, Cape Town.

The following species are more or less restricted to the two main distribution areas in the north-east of the study area: *Brachymenium leptophyllum, Brachymenium nepalense, Calymperes rabenhorstii, Campylopus fragilis, Campylopus jamesonii, Floribundaria floribunda, Leptodontium longicaule, Leucoloma chrysobasilare, Levierella perserrata, Pogonatum oligodus, Porotrichum elongatum* and *Rhabdoweisia fugax.*

Mosses restricted to the Mpumalanga centre of distribution include: *Platyhypnidium macowanianum, Rhacopilopsis transvaaliensis, Rigodium toxarion*, *Syrrhopodon asper* and *Trachypodopsis serrulata*.

The following are examples of mosses more or less restricted to the KwaZulu-Natal centre of distribution: *Drepanocladus aduncus, Fissidens enervis, Oligotrichum afrolaevigatum, Plagiobryum zierii, Stoneobryum mirum*. Taxa restricted to the top of the Lesotho escarpment, (e.g. *Quathlamba debilicostata* and *Orthotrichum armatum*) might also be included in this group but, as explained earlier under the *Afromontane Forest Element*, it is most likely that they have been classified here as a result of the grid resolution and probably belong to the Mont Aux Sources Subelement of the Eastern Highlands element.

Widespread species include: *Aerobryopsis capensis,* Atrichum androgynum, *Brachymenium pulchrum, Ditrichum brachypodum, Hypopterygium laricinum, Neckera valentiniana, Porothamnium stipitatum, Porotrichum madagassum, Pyrrhobryum spiniforme, Racopilum capense* and *Sematophyllum subpinnatum*. Species responsible for this subelement's distribution in the semi-arid central and northern parts are : *Brachymenium systylium, Erpodium beccarii, Erpodium grossirete, Fissidens capriviensis, Fissidens erosulus, Fissidens submarginatus, Fissidens subobtusatus, Hyophila baginsensis* and *Vesicularia galerulata*.

Discussion

This subelement has strong (sub)tropical affinities. The majority of species (38%) display a tropical African-Madagascan distribution pattern, 23% has wider tropical distribution patterns (pantropical, palaeotropical etc.), 9% of species is widespread or bipolar in distribution, 5% is southern temperate species, and 3% belongs to other distribution patterns.

Together with the southern African endemics, which constitute 22% of species in this subelement, 83% of species has (sub)tropical distribution patterns.

The Tropical Afromontane Subelement is most abundant in the Drakensberg and Cape Domains and absent from the Namaqua Domain (Fig. 65).

This subelement is most abundant in the Grassland Biome (73%) while only about half of the species occur in each of the Forest (51%) and Savanna (52%) Biomes (Table 36). The northern bias of this group is illustrated by the relatively low percentage of species (39%) present in the Fynbos Biome compared to 80% in the Widespread Afromontane Subelement. The restricted nature of this subelement is evident in the relatively low percentage (16%) of species that occur in the Grassland, Forest, Savanna as well as the Fynbos Biomes compared to the 63% of species in the Widespread Afromontane Subelement.

D. World Distribution Elements

It is beyond the scope of this study to present a detailed analysis of the total or world distribution ranges of southern African mosses. However, the distribution data in the MOSS database (see Table 2) makes it possible to present a preliminary, broad-scale classification of world distribution elements in the moss flora of southern Africa. The classification is subjective and heavily influenced by other schemes.

The basic area used to plot the distributions is the political country, or occasionally a region within a country. The group or element with the most restricted geographic distribution is therefore the mosses endemic to the FSA area or the endemic element.

World distribution elements in the moss flora of southern Africa

Cosmopolitan/widespread/bipolar element 86 (17%)
Tropical element 241 (48%)
- African subelement 168 (33%)
- Pantropical subelement 37 (7%)
- Palaeotropical subelement 15 (3%)
- African–neotropical subelement 21 (4%)

Mediterranean/semi-arid element 24 (5%)
Southern Hemisphere element 35 (7%)
Endemic element 114 (23%)
Other elements 3 (1%)

The largest world distributional element in the moss flora is the Tropical element which consists of 241 species or 48% of all the mosses in southern Africa. This element can be divided into a number of subelements of which the African subelement with 168 species (33% of the total) is the largest. This subelement consists of mosses largely restricted to the African region of Hollis & Brummitt (1992) which includes Macaronesia and the west Indian Ocean islands. I therefore agree with Schofield (1992) that the "Affinities of the South African flora are predominantly with continental Africa....".

E. DCA Ordination of Species

The eigenvalues of the first four DCA ordination axes, which are relative measures of the variation accounted for by each axis, are listed in Table 24. The positions of TWINSPAN 3+ species on DCA ordination axes 1 and 2, the two axes with the highest eigenvalues, are shown in Fig. 66. In this scattergram each species is also classified according to the TWINSPAN Element it belongs to.

1. TWINSPAN Elements

Although there is considerable overlap among the Elements, especially towards the centre of the DCA scattergram (Fig. 66), the species are roughly grouped into TWINSPAN 3+ floristic elements. Afromontane Forest species form a large group on the left hand side of the scattergram while Cape Element species are grouped towards the right. The Afromontane Grassland and Eastern Highlands species do not form coherent groups but are more or less grouped to the left and to the right of centre respectively.

2. Distributional gradients

Axis 1

There is a clear gradient along axis 1 from Afromontane Forest species with negative or low values at the one end, to Eastern Highlands and Afromontane Grassland species with higher values along the middle of the axis, to Cape species with the highest values at the other end (Fig. 66). Therefore a gradient from species distributed in the northern and eastern part of the study area, to species with an 'eastern highlands' distribution, to species distributed throughout the drier, inland regions of the Afromontane region, to species with a south-western distribution pattern. The distributional gradient therefore runs from the north-east, more or less longitudinally, to the south-west.

The species with extreme negative values along axis 1 (*Fissidens capriviensis, Erpodium grossirete, Orthostichopsis pinnatella, Ptychomitrium exaratifolium, Physcomitrellopsis africanum, Rhynchostegiella sublaevipes, Leskeella zuluensis)* are distributed in the north-eastern corner of the study area (Okavango swamps in Botswana, Northern Province of South Africa, eastern Mpumalanga, and northern KwaZulu-Natal). Species at the extreme positive end of the axis (*Crossidium spiralifolium, Leucoperichaetium eremophilum, Pterygoneurum macleanum, Pottia namaquensis, Acaulon leucochaete, Tortula splachnoides, Cygnicollum immersum*) are distributed in the arid west (Richtersveld, Namaqualand) and interior of the Northern Province (Fig. 67). These two species groups represent the poles of the axis, a wet eastern pole and a dry western pole, with the rest of the species distributed in between.

Axis 2

Along the second axis most species fall into a narrow range of species scores (mostly between 50 and 150 SD units) indicating little change in geographic distribution (Fig. 66). However, this axis does separate a few species with extreme north-eastern distributions in northern KwaZulu-Natal and eastern Mpumalanga (*Calymperes tenerum* , *C. rabenhorstii, Leptodictyum riparium, Bryum erythrocaulon, B. canariense*), most which belong to the Afromontane Forest Element, from species with extreme northern and western distributions in the Caprivi (*Fissidens capriviensis, Erpodium grossirete)* and Namibia (*Bruchia queenslandica, Archidium dinteri, A. microthecium, Ptychomitriopsis aloinoides, Funaria rhomboidea*).

The species with extreme negative values along axis 2, i.e. those with northern and western distributions, are clearly separated along axis 1 (Fig. 66). From Afromontane Forest species with negative values (*Fissidens capriviensis, Erpodium grossirete*), distributed in the north of South Africa and north-eastern Namibia (Caprivi), to Eastern Highlands species mainly distributed in central Namibia (*Funaria rhomboidea, Ptychomitriopsis aloinoides*), to Cape species restricted to Namibia (*Archidium dinteri, Bruchia queenslandica*).

Axis 3

There is a more gradual change in species scores along the 3rd and 4th DCA axes which indicates a better distributional gradient. However, the lower eigenvalues (Table 24) indicate that each axis only captures about half of the distributional information accounted for by DCA axis 1.

Axis 3 contrasts species distributed in the Highlands of Lesotho and other high altitude areas on the interior plateau (Fig. 68), i.e. those species with extreme positive values (*Didymodon trivialis, D. jackvancei, Syntrichia austroafricana, Weissia* a wet eastern pole and a dry western pole, with the rest of the species distributed in between.

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The species with extreme negative values along axis 2, i.e. those with northern and western distributions, are clearly separated along axis 1 (Fig. 66). From Afromontane Forest species with negative values (*Fissidens capriviensis, Erpodium grossirete*), distributed in the north of South Africa and north-eastern Namibia (Caprivi), to Eastern Highlands species mainly distributed in central Namibia (*Funaria rhomboidea, Ptychomitriopsis aloinoides*), to Cape species restricted to Namibia (*Archidium dinteri, Bruchia queenslandica*).

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The gradient along DCA axis 3 supports the TWINSPAN classification gradient, with eastern Highlands species at the one end and Afromontane species at the other. The DCA gradient runs from low altitudes in the south and south-west to high altitudes on the central plateau, geographically exactly the same as the compositional gradient along axis 3 of the TWINSPAN 3+ grid ordination (see Fig. 43).

Axis 4

Species with extreme positive scores along axis 4 (*Crossidium spiralifolium, Leucoperichaetium eremophilum, Weissia latiuscula, Barbula eubryum, Erpodium coronatum* subsp. *transvaaliense, Campylopus catarractilis, C. perpusillus, Didymodon tophaceopsis, Ptychomitrium exaratifolium, Archidium acanthophyllum, Bryum capillare*) are distributed throughout the bushveld or savanna vegetation types of the Savanna Biome (Low & Rebelo 1996) in the northern and central parts of southern Africa (Fig. 69). Most of these species belong to the Afromontane Forest element. Species with extreme negative scores (*Pterygoneurum macleanum, Tortula splachnoides, Bruchia queenslandica, Archidium dinteri, Physcomitrium spathulatum* var. *sessile, Microbryum davallianum* var. *conicum, Acaulon leucochaete, Pottia* *namaquensis, Rhabdoweisia crispata, Quathlamba debilicostata, Leptoterigynandrum austro-alpinum*) are distributed in the arid and semi-arid Succulent and Nama Karoo Biomes (Low & Rebelo 1996). Most of these species belong to the West Coast Subelement of the Cape Element.

Geographically this gradient is more or less the same as the DCA gradient of TWINSPAN 3+ grids (see Fig. 44), contrasting southern temperate areas, and other high altitude areas along the Great Escarpment, with bushveld areas in the central and northern parts of southern Africa.

Discussion

The first and most important DCA axis of the species ordination represents an east -west distributional gradient in South Africa, similar to the east-west compositional gradient described by the 1st axis of the grid ordination. Through indirect analysis of the compositional gradient (see *D. Indirect Gradient Analysis*, Chapter 4) it has been established that this gradient can be related to moisture parameters, in particular the mean annual precipitation (see map in Schultze 1997a).

The east-west distributional gradient displayed by species with extreme northern and north-western distributions in southern Africa coincides with the east-west climatic gradient in these parts (Barnard 1998). Moisture parameters, in particular the mean annual precipitation and mean water deficit (Barnard 1998), seem to describe this gradient the best. This confirms the importance of moisture (rainfall) in determining the distribution of floristic elements, also in the undercollected, (semi-) arid parts of the study area.

The distributional gradients along axes 3 & 4 are geographically the same as the compositional gradients along axes 3 & 4 of the TWINSPAN 3+ grid ordination. I have suggested (see *Correlation with environmental variables*, Chapter 4) that these gradients, running altitudinally as well as latitudinally, are related to several temperature parameters and indices.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSIONS

Chapter Outline

A. Diversity and Endemism

Southern Africa has a diverse moss flora with strong tropical African affinities. Moss species are not uniformly distributed throughout the region but are concentrated in the shape of a horseshoe along and below the Great Escarpment. Diversity is greatest in the mountains of the south-western Cape, KwaZulu-Natal, and Mpumalanga/Northern Province. In the FSA area moss species richness increases with altitude to peak between 500 m and 1000 m, above which species numbers gradually decrease. Along the eastern escarpment of southern Africa species numbers peak in the montane forest belt (1001 m – 1500 m).

As a result of this study the numbers of species and endemics in each southern African moss family and genus, the largest families and genera, the most frequently collected mosses, and the most widely distributed species, could be identified. Lists of endemics, aquatics, and mosses with recent range expansions are provided for the first time.

Moss endemism is most pronounced in the south-western Cape, and in particular on Table Mountain. In keeping with results from other parts of the world, endemism is significantly lower in the mosses than the vascular plants of the region at all taxonomic levels.

The main centres of moss diversity and endemism overlap in southern Africa to form 'hot-spots', which largely coincide with the 'hot-spots' described for vascular plants. Although collecting bias is responsible for concentrations of species and endemics in many areas, moss diversity and endemism were found to be strongly correlated with habitat heterogeneity and mean annual rainfall. The more diverse the habitat and the higher the rainfall, the more species as well as endemics are present. This is in agreement with existing hypotheses of a broad-scale correlation between environmental heterogeneity and climate on the one side, and vascular plant diversity and distributions on the other.

B. Numerical Analysis

Attempts to analyse bryophyte distributions using large data sets have been limited and this is the first such study in Africa. It also is the first broad-scale, numerical analysis of plant distributions in the Flora of Southern Africa area.

Although the data sets used in the analyses are rather 'noisy', intended for mapping species distributions rather than numerical analysis of distribution patterns, the results of the TWINSPAN classification and DECORANA ordination show that the numerical methods used in this study have been remarkably successful in delimiting broad-scale phytogeographic patterns in the moss flora of southern Africa.

After deleting species poor grid squares from the complete data set, TWINSPAN successfully divided the grid squares, as well as the moss species, into two major groups. The main groups were subdivided into two groups each (2nd level of division), which in turn were subdivided to give eight groups at the 3rd level of division. Most of the groups delimited by the TWINSPAN classifications are coherent and ecologically interpretable.

The DECORANA ordination programme has successfully revealed broad-scale compositional as well as distributional gradients in the moss flora which could be related to major climatic gradients in the study area.

C. Bryogeographic Regions

The numerical classification of grid squares divided the study area into two main regions: 1) a temperate or austral region in the central and western parts of southern Africa, and 2) a subtropical or palaeotropical region in the northern, eastern and southern parts of southern Africa. The temperate region has a xerophytic moss flora while the flora of the subtropical region is mesophytic. Pleurocarpous mosses make up an increasingly larger proportion of the moss flora as one moves from temperate areas in the west to subtropical areas in the east and south of the study area. Results of the numerical analysis indicate that the boundary between the two main floristic regions in southern Africa is located much further to the north than generally accepted.

The temperate region is subdivided into the Karoo-Namib and Highlands Regions, and the subtropical region into the Zambezian and Afromontane (including the former 'Cape') Regions. The four Regions are further subdivided into eight Domains. The Afromontane Region is not only the largest bryofloristic region in southern Africa, it also boasts the largest moss flora, and most of the centres of moss diversity and endmism are located in this phytochorion.

Although there is a high degree of congruence between the bryofloristic regions and the floristic regions recognised in contemporary vascular plant classifications (Werger 1978, White 1983, Goldblatt 1978, Cowling & Hilton-Taylor 1997), I would like to point out a number of important differences between the two:

- The Afromontane Region is not part of the temperate, but the palaeotropical regions of Africa.
- A separate 'Cape' phytochorion is here only recognised at the level of domain, and then as a subdivision of the Afromontane Region. This supports the hypothesis by Linder (1990) that the 'Cape' phytochorion forms part of the Afromontane Region, but not in a combined 'Afrotemperate Region' as suggested by him. The combined Afromontane Region is formally described for the first time in this study.
- A separate Tongaland-Pondoland Region is not recognised in the bryogeographic scheme.
- Although it is generally accepted that the Karoo-Namib Region is of palaeotropic affinity (Werger 1978, Hilton-Taylor 1994), this study clearly shows that it is part of the temperate region of southern Africa.
- The bryofloristic Highlands Region is restricted to high altitude areas of southern Africa and does not occupy the sandy Kalahari basin.
- The Afro-alpine flora of Lesotho is not part of, or closely related to the Afromontane flora. The bryogeographic classification shows that it belongs to the temperate flora of the Highlands Region.

Rutherford & Westfall (1986) argue that if phytochoria were classified objectively (according to rigorous phytosociological methology), based on adequate sampling, then correspondence to biomes would be better. Hilton-Taylor (1987) supported this argument based on "Preliminary indications from my analysis of floristic data...". However, Rutherford (1997) has recently stressed that due to different criteria used in the determination of biomes and phytochoria, they do not necessarily coincide. In a comparison of floristic and structural vegetation classifications of the same island, Lux & Bemmerlein-Lux (1998) recently found that "...structural vegetation units reflect a short-term development." while "...the floristic units reflect the sum of the effective environmental factors over the course of time,...". Although there is considerable congruence between the numerically determined bryofloristic Regions of this study and the Biomes of Rutherford & Westfall (1986), there is no obvious improvement from conventional phytogeographic schemes, which indicates that there might indeed be significant differences between structural and floristic classifications in the flora of southern Africa area.

D. Bryogeographic Elements

The mosses of southern Africa are divided into two main floristic elements: 1) a xerophytic element mainly distributed in the winter rainfall and semi-arid, temperate areas of southern Africa, and 2) a mesophytic element distributed in more stable, subtropical habitats of the northern, eastern and southern parts of southern Africa. The xerophytic element is dominated by acrocarpous mosses (inluding the ephemerals) while the mesophytic element contains most of the pleurocarpous mosses.

The xerophytic element is subdivided into the Eastern Highlands and Cape Elements while the mesophytic element consists of the Afromontane Grassland and Afromontane Forest Elements. The Elements are subdivided into eight Subelements. The Afromontane Forest Element is by far the largest of the elements and contains the most FSA endemics. Many of the distribution centres in the bryogeographic elements are known phytogeographic centres of the vascular plants.

The majority of bryogeographic Elements are distributed in the Afromontane Region while the greatest number of Subelements displays a Cape bias. This stresses the phytogeographic importance of the Afromontane islands in the south-western Cape, especially the Table Mountain locality.

E. Indirect Gradient Analyses

The DCA ordination revealed a main longitudinal (east–west), and secondary latitudinal (north south) and altitudinal gradients in the floristic composition of the grid squares as well as the geographic distribution of the species. The main east–west gradient in the moss data coincides with the main east–west climatic gradient in southern Africa, best explained by moisture parameters, in particular mean annual rainfall. The secondary gradient in the data, running latitudinallly as well as altitudinallly, appears to be related to temperature, and in particular the effect of temperature on the availability of moisture.

The fact that the DCA ordination revealed broad-scale compositional and distributional gradients in the data indicates that fine-scale heterogeneity in the study area has been averaged out by the coarseness of the grain (the grid size) as well as the deletion of species-poor grids from the complete data set. The variation may therefore be explained satisfactory at the hand of a few major climatic variables, in this case rainfall and temperature, which is in line with hypotheses proposed for vascular plants in southern Africa.

F. Needs and Prospects for Future Research

In my opinion the following paradigms retarded progress in southern African phytogeography in the latter part of the Twentieth Century:

1. The pre-occupation with the Cape flora (Cape Floristic Kingdom), or as Nordenstam (1969) put it, the "Tendency to particularize the Cape Flora.".

2. The introduction and indiscriminant application of non-hierarchical categories, in particular the 'centres of endemism', in the classification of geographic areas (floristic regions).

3. Confusion between, and the misapplication of the two main concepts in floristic plant geography, i.e. phytogeographic (floristic) regions and phytogeographic (floristic) elements.

4. The lack of clear and precise definitions of phytogeographic terms currently used in southern African studies.

5. The use of endemic or 'ecologically important' taxa only in the delimitation of floristic regions.

6. The currently recognised centres of vascular plant diversity and endemism (hot-spots) in southern Africa as a mixture of floristic regions, biomes, geological formations, and distribution centres of high diversity and endemism.

7. The lack of a broad-scale, subcontinental classification of floristic elements based on the distribution of all the plants in southern Africa.

I would now like to propose the following guide-lines for future phytogeographic studies in southern Africa:

Guide-lines for future phytogeographic studies in southern Africa

1. Phytogeographic analyses should in future be based on distribution data of as many taxa as possible, preferably all plants present in the study area. At the regional or subcontinental scale such a database already exists in the form of PRECIS (Magill *et al.* 1983), which contains the distributions of all southern African flowering plants, ferns, and bryophytes represented in the National Herbarium, Pretoria.

2. A clear distinction should be drawn, right from the start, between the the two main concepts in floristic plant geography, i.e. floristic regions and floristic elements.

3. Repeatable (more or less objective), numerical techniques should be employed to identify patterns in the distribution data, and to relate these patterns to environmental variables.

4. The term 'centre' should rather be used to describe concentrations of species (or higher taxa) within the distribution areas of floristic elements or floras, and not to describe floristic regions.

5. It is confusing to group different categories of species and endemic-rich areas together as centres of species diversity and endemism without explaining how they differ and how they came about. The challenge is now to identify and describe centres of plant diversity and endemism in southern Africa in a uniform and objective way.

6. Although centres of diversity and endemism generally overlap in southern Africa to form 'hot-spots' (Cowling & Hilton-Taylor 1997), this is not necessarily always the case. The two kinds of centres should therefore be determined separately and then compared.

7. The grain of the study (the area of recording, e.g. the degree grid square system) should be set as fine as possible in order to lay down boundaries with some accuracy. This in turn will enable ecologists, environmentalists, conservationists etc. to make more use of phytogeographic maps in regional studies.

Visual comparison between maps is a rather unsatisfactory, although not necessarily an ineffective method of interpreting the ordination results. A more objective, direct gradient analysis approach, as performed by canonical correspondence analysis (CCA), should prove to be a most worthwile and pertinent next step in the bryogeographic analysis of the distribution data. However, a limiting factor in such an analysis is the lack of detailed environmental (climatic) data for large parts of South Africa and neighbouring states (O'Brien 1993, Schulze & Kunz 1995).

The all important first steps of identifying and describing bryogeographic regions and elements in southern Africa have now been taken. The patterns identified here are not only due to similarities among areas in their environmental parameters, or similarities among species in their ecological tolerances, but also to the evolutionary histories of areas and species. Historical reasons for the observed bryogeographic patterns might now be sought within the broad climatic parameters laid down in this study. Such explanations should, however, not overstep the ecological requirements of the taxa. As Cowling *et al*. (1997b) aptly put it: "A new synthesis is emerging where ecological and historical explanations are not seen as contending assertions, but as integrated parts of realistic and general explanations of ecological diversity."

SUMMARY

Diversity and phytogeography of the moss flora of southern Africa

by

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Philosophiae Doctor

According to the revised checklist prepared for this study, the moss flora of southern Africa consists of 503 species/infraspecific taxa in 204 genera and 54 families. The largest families and genera, and the most frequently collected and widely distributed taxa have been identified for the first time. This study also provides lists of (semi-) aquatic mosses and mosses endemic to the Flora of Southern Africa area. In keeping with results from other parts of the world, endemism is significantly lower in the mosses than the flowering plants of the region.

Mosses are concentrated in a zone the shape of a horseshoe along and below the Great Escarpment of southern Africa. The centres of moss diversity and endemism, formally described here for the first time, overlap in this zone to form 'hot-spots', which largely coincide with the 'hot-spots' described for vascular plants. Diversity and endemism is greatest along the eastern and southern parts of the escarpment, including the Cape Fold Mountains in the south-west. In southern Africa moss diversity and endemism are strongly correlated with habitat heterogeneity and

mean annual rainfall. The more heterogeneous the habitat and the higher the rainfall, the greater the diversity and higher the endemism.

The main objective of the present study was to delimit and formally describe bryogeographic regions and elements in the Flora of Southern Africa area. To achieve this goal three moss data sets, consisting of presence /absence data, were subjected to 1) classification using TWINSPAN to detect patterns in the data, followed by 2) DCA ordination using DECORANA to compliment the TWINSPAN classification and to describe gradients in the data. These gradients were then subjectively related to a range of environmental variables.

The numerical analyses of moss distributions resulted in the formal classification of grid squares into four bryogeographic or floristic Regions, the Zambezian, Afromontane, Karoo-Namib and Highlands regions, subdivided into eight Domains. The mosses were classified into four bryofloristic Elements, the Eastern Highlands, Cape, Afromontane Grassland and Afromontane Forest Elements, subdivided into eight Subelements. The Afromontane Region is the largest bryofloristic region in southern Africa and, as is shown for the first time, includes a large part of the former 'Cape Region'. The majority of southern African mosses (61%) belong to the Afromontane Forest Element. Compositional and distributional gradients in the moss flora of southern Africa are determined by the same set of environmental factors, identified in this study as precipitation (moisture) and temperature, acting independently and in combination.

The study is concluded with the suggestion that phytogeographic studies in southern Africa should be conducted more objectively than in the past and based on data sets that include the geographic distribution of all plants in the region.

OPSOMMING

Diversiteit en fitogeografie van die mosflora van Suider-Afrika

deur

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Volgens die hersiene kontrolelys wat opgestel is vir hierdie ondersoek, bestaan die mosflora van Suider-Afrika uit 503 spesies in 204 genusse en 54 families. Die grootste families en genusse, sowel as die taksons wat die meeste versamel word en die wydste versprei is, is vir die eerste keer uitgewys. Mosse wat endemies is tot die *Flora of Southern Africa* (FSA) gebied en (semi-) akwatiese mosse word vir die eerste keer gelys in hierdie ondersoek. In ooreenstemming met resultate vanuit ander wêrelddele is endemisme aansienlik laer in die mosse as in die vaatplante van die streek.

Mosse is gekonsentreer in die vorm van 'n hoefyster langs en benede die platorand van Suider-Afrika. Die sentrums van mosdiversiteit en endemisme, wat hier vir die eerste keer formeel beskryf word, oorvleuel in hierdie sone om *'hot-spots'* te vorm wat grootliks ooreenstem met die *'hot-spots'* wat beskryf is vir die vaatplante. Diversiteit is die hoogste langs die oostelike en suidelike dele van die platorand, insluitend die Kaapse plooiberge in die suidweste. Mosdiversiteit en endemisme is sterk gekorreleer met habitat-heterogeniteit en gemiddelde jaarlikse reënval. Hoe

meer heterogeen die habitat en hoe hoër die reënval, hoe meer spesies asook endemiese spesies is teenwoordig.

Die hoofdoelstelling van die huidige ondersoek was om briogeografiese streke en elemente in die FSA-gebied af te baken en formeel te beskryf. Om hierdie doelwit te bereik is die drie mosdata-stelle, bestaande uit teenwoordigheid/afwesigheid-data, onderwerp aan 1) 'n TWINSPAN-klassifikasie om patrone in die data op te spoor, en 2) 'n DECORANA-ordinasie om die TWINSPAN-klassifikasie te komplimenteer en om gradiente in die data te beskryf. Hierdie gradiente is toe subjektief in verband gebring met 'n reeks van omgewingsveranderlikes.

Die sukses wat behaal is met die numeriese analise van mosverspreidings het gelei tot die formele klassifikasie van ruite in vier briogeografiese streke, die *Zambezian*, *Afromontane*, *Karoo-Namib* en *Highlands*-streke, onderverdeel in agt domeine. Die mosse is geklassifiseer in vier briofloristiese elemente, die *Eastern Highlands*, *Cape*, *Afromontane Grassland* en *Afromontane Forest*-elemente, onderverdeel in agt subelemente. Die *Afromontane*-streek is die grootste briofloristiese streek in Suider-Afrika en sluit vir die eerste keer 'n groot gedeelte van die gewese *Cape*-streek in. Die meeste Suider-Afrikaanse mosse (61%) behoort tot die *Afromontane Forest*-element. Samestellings- en verspreidingsgradiente in die mosflora van Suider-Afrika word bepaal deur dieselfde stel omgewingsfaktore, in hierdie ondersoek geïdentifiseer as reënval (vog) en temperatuur, wat onafhanklik en in kombinasie optree.

Die ondersoek word afgesluit met die voorstel dat fitogeografiese ontledings in Suider-Afrika meer objektief moet geskied as in die verlede en gebaseer moet wees op data-stelle wat die geografiese verspreiding van alle plante in die streek insluit.

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CURRICULUM VITAE

Jacques van Rooy was born in the city of Bloemfontein, Free State, South Africa on 11 October 1953. He attended the President Brandskool in Bloemfontein (Jan. 1960 – July 1965), the Laerskool Menlopark in Pretoria (July 1965 – Dec.1966), and matriculated from Die Hoërskool Menlopark in 1971.

In 1982 he received a B.Sc. degree from the University of South Africa, majoring in Botany and Zoology. This was followed by a B.Sc. (Hons.) degree in 1989 and a M.Sc. degree in botanical taxonomy (awarded cum laude) in 1991, both at the University of Pretoria. His M.Sc. thesis, entitled *A Taxonomic Revision of the Macromitrioideae (Orthotrichaceae: Musci) in Southern Africa,* won him the South African Association for the Advancement of Science (S_2A_3)-GENCOR Bronze Medal for the best Magister thesis at the University of Pretoria in 1992.

Jacques started his career in botany in 1978 when he joined the National Herbarium of the Botanical Research Institute (now National Botanical Institute) in Pretoria. He was assistant to Dr R.E. Magill of the Missouri Botanical Garden (then on contract to the Botanical Research Institute to initiate research for the moss *Flora of Southern Africa* project) from 1978 to 1981. During this period he gained valuable experience in taxonomic research, herbarium management, and the running of a Scanning Electron Microscope unit. He currently holds the position of Senior Researcher responsible for the Cryptogamic collections of the National Herbarium where he conducts taxonomic and phytogeographic research on the mosses of Africa.

His collecting activities (more than 4000 specimens) has led to the description of several new records and new species of southern African bryophytes. He is the author or co-author of 40 scientific and popular scientific publications in national as well as international journals. Jacques contributed to the first 2, and is co-author of the 3rd fascicle of the moss *Flora of Southern Africa*. He is currently a member of the International Association of Bryologists, the Mountain Forum, and the Lesotho Mountain Research Group.

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Diversity and phytogeography of the moss flora of southern Africa

Part 2 Tables, Figures and Appendices

by

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Submitted in partial fulfilment of the requirements for the degree

Philosophiae Doctor

in the Faculty of Natural, Agricultural and Information Sciences

(Department of Botany)

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Promotor: Prof. Dr. A.E. van Wyk

March 2000

Brief Table of Contents

PART 2 TABLES, FIGURES, AND APPENDICES

Table 1. Selected literature references to several aspects of the study area (see *Literature References* at the end of Part 1).

Aspect of study area	Literature reference
Geographic limits	Goldblatt (1978).
Fragmentation of Gondwana	Dietz & Holden (1970, 1970a), Schopf (1970), Smith & Hallam (1970), Tarling & Tarling (1971), Raven & Axelrod (1974), Axelrod & Raven (1978), Cooper (1980), Audley-Charles *et al.* (1981), Dingle *et al.* (1983), Schuster (1983), Partridge & Maud (1987), De Wit (1990), Pitman III *et al.* (1993), Reader's Digest (1994), White (1994).
Geology	Truswell (1977), Kent (1980), Dingle *et al.* (1983), Tankard *et al.* (1982), White (1983), Visser (1984), Hammerbeck & Allcock (1985), Reader's Digest (1994).
Geomorphology	Wellington (1955), King (1963, 1978), Kruger (1983), White (1983), Partridge & Maud (1987), Moon & Dardis (1988), Reader's Digest (1994), Partridge (1997), Barnard (1998)
Soils	Van der Merwe (1941), MacVicar (1973), Von M. Harmse (1978), Schulze (1997a), Barnard (1998).
Climate	Schulze, B.R. (1965), Schulze & McGee (1978), Reader's Digest (1994), Schulze (1997, 1997a)
Climatic change and variability	Tyson (1986), Preston-Whyte & Tyson (1988), Livingstone (1993).
Vascular plant flora	Goldblatt (1978), Gibbs Russell (1985), Cowling *et al.* (1989), Cowling & Hilton-Taylor (1994, 1997).

Aspect of study area	Literature reference
Vascular plant vegetation	Giess (1971), Acocks (1975); Werger (1978c), White (1983); Rutherford & Westfall (1986), Irish (1994), Low & Rebelo (1996), Rutherford (1997), Cowling *et al.* (1997a), Barnard (1998).
Vegetation history	Axelrod & Raven (1978), Van Zinderen Bakker (1978, 1983), Coetzee (1993), Scott *et al.* (1997), DeBusk (1998)
Origin and evolution of the vascular plant flora.	Raven & Axelrod (1974), Goldblatt (1978), Raven (1983).

Table 2. Some of the most important and most recent checklists and related publications consulted for the world distributions of southern African mosses in the MOSS database. The regions in this table are those of Hollis & Brummitt (1992) with the following changes to the boundaries: 1) the boundary between Northern and Southern America follows the political boundary between Mexico and Guatemala, and 2) the Auckland and Campbell Islands south of New Zealand are included in the Antarctic region. The references are numerically arranged. The full references are given in *Literature References* of Part I.

Region	Source of distribution data
Europe	Koponen *et al.* (1977, 1995), Corley *et al.* (1981), Duell (1984, 1985, 1992, 1995), Presten (1984), Townsend (1986), Hallingback & Soderstrom (1987), Dirkse *et al.* (1988), Casas (1991), Corley & Crundwell (1991), Cortini Pedrotti (1992), Sergio & Schumacker (1992), Greven (1995).
Africa	Cufodontis (1951), Richards & Argent (1968), Bizot & Pocs (1974, 1979, 1982), Schultze-Motel (1975, 1979), Bizot *et al.* (1976, 1978, 1979, 1985), Egunyomi & Olarinmoye (1979), Egunyomi (1980), Long *et al.* (1981), Eggers (1982), Ochyra & Pocs (1982, 1985, 1985a, 1986, 1992a, 1994), Duell (1984, 1985), Frahm (1978, 1984, 1988),

Region	Source of distribution data
	Prendergast (1984), Kis (1985), Phiri & Ochyra (1985), Bizot & Tixier (1986-1987), Losada Lima. & Beltran Tejera (1987), Townsend (1984, 1987), Gauthier (1987), Ochyra & Sharp (1988), Tixier (1989, 1995), Best (1990), Kürschner & Onraedt (1990), Gonzalez-Mancebo *et al.* (1992), Born *et al.* (1993), Dirkse *et al.* (1993), O'Shea (1993, 1995), Chuah-Petiot (1994, 1994a, 1995, 1996, 1997), Crundwell *et al.* (1994), Al-Gifri *et al.* (1995), Frahm *et al.*. (1996), O'Shea *et al.* (1996), Enroth (1996), Muller (1996), Perez & Sanchez (1996), Een (1997).
Asia Temperate	Iwatsuki & Noguchi (1973, 1979), Agnew & Vondracek (1975), Frey. & Kürschner (1983), 1988, 1991a),Gao & Chang (1983), El-Oqlah & Lahham (1985), Redfearn & Wu (1986), Hu & Wang (1987), Cetin (1988), El-Oqlah *et al.* (1988), Vitt & Cao (1989), Redfearn (1990), Herrnstadt & Heyn (1991), Iwatsuki (1991), Townsend (1991), Herrnstadt (1992), Ignatov & Afonina (1992), Koponen & Luo (1992), Koponen & Li (1992), Lin *et al.* (1992), Wu (1992), Afonina & Czernyadjeva (1995), Tan *et al.* (1994, 1995), Ignatov (1994), Manakyan (1995), So (1995), So & So (1995), So & Yip (1995, 1995a), So & Zhu (1996), Redfearn *et al.* (1996), Zhang (1996).
Asia Tropical	Townsend (1978, 1993, 1994a, 1996), Onraedt (1986), Tan (1987, 1989, 1993), Gangulee (1980), Mohamed & Tan (1988), Hegewald & Van Zanten (1986), Hyvonen (1989), Tan & Koponen (1989), Menzel & Passow-Schindhelm (1990), Tan & Iwatsuki (1991, 1993), Long (1992, 1994), Touw (1992), Ninh (1993), Nishimura & Higuchi (1993, 1994), Akiyama (1996).
Australasia	Streimann & Touw (1981), Stone (1982, 1984, 1985, 1990, 1994), Fife (1984, 1995), Ochi & Streimann (1987), Catcheside (1988), Streimann & Curnow (1989), Beever *et al.* (1992), Stoneburner *et al.* (1993).
Pacific	Hoe (1974, 1979), Schultze-Motel (1974), Whittier & Whittier (1974), Pursell & Reese (1982), Higuchi (1996).

Region	Source of distribution data
Northern America	Delgadillo M. (1971, 1979, 1992), Persson & Viereck (1983), Brassard (1984), Ireland *et al.* (1987), Anderson *et al.* (1990), Delgadillo & Cardenas (1989), Mcintosh (1989), Spence (1987), Vitt *et al.* (1987), Bourell (1992), Murray (1992), Sharp *et al.* (1994, 1994a), Belland (1995), Delgadillo *et al.* (1995).
Southern America	Herzog (1940), Bowers (1974), Hegewald & Hegewald (1975, 1977, 1985), Robinson (1975), Seki (1974), Ochi (1980), Yano (1981, 1989, 1995, 1996), Hassel De Menendez *et al.*. (1984), Wiersma (1984), Buck (1985), Greene (1986), Churchill (1989 1991), Schafer-Verwimp & Vital (1989), Cornelissen & Gradstein (1990), Porto (1990), Florschutz-De Waard (1990), Churchill *et al.* (1991-1992), Schafer-Verwimp (1991, 1992), Reese (1991), Arrocha (1992), Menzel (1992), Sipman (1992), Vital & Pursell (1992), Townsend (1994), Delgadillo *et al.* (1995), Germano & Porto (1996).
Antarctic	Clifford (1953), Van Zanten (1971), Vitt (1979), Seppelt (1981), Gremmen (1982), Greene (1986), Kanda (1987), Smith (1988), Bergstrom & Seppelt (1988-1989), Ochyra & Hertel (1990), Seppelt *et al.* (1995), Bergstrom & Selkirk (1997).

Table 3. Number of genera and species/infraspecific taxa, and the largest genera and their number of species/infraspecific taxa, in the 54 families of southern African mosses. Families are in alphabetical order.

Families	Genera	Species	Largest genus	Species
Amblystegiaceae	7	9	*Drepanocladus*	2
			Platyhypnidium	2
Andreaeaceae	1	4	*Andreaea*	4
Archidiaceae	1	11	*Archidium*	11
Aulacomniaceae	1	1	*Leptotheca*	1
Bartramiaceae	7	22	*Philonotis*	8
Brachytheciaceae	5	17	*Brachythecium*	8
Bryaceae	9	40	*Bryum*	19
Bryobartramiaceae	1	1	*Bryobartramia*	1
Calymperaceae	4	8	*Calymperes*	3
Catagoniaceae	1	1	*Catagonium*	1
Cryphaeaceae	1	1	*Cryphaea*	1
Dicranaceae	15	49	*Campylopus*	19
Ditrichaceae	9	15	*Ditrichum*	4
			Pleuridium	4
Encalyptaceae	1	2	*Encalypta*	2
Entodontaceae	4	7	*Entodon*	4
Ephemeraceae	1	4	*Ephemerum*	4
Erpodiaceae	2	5	*Erpodium*	4
Eustichiaceae	1	1	*Eustichia*	1
Fabroniaceae	5	14	*Fabronia*	10
Fissidentaceae	1	29	*Fissidens*	29
Fontinalaceae	1	2	*Fontinales*	2
Funariaceae	6	16	*Funaria*	10
Gigaspermaceae	3	3	*Chamaebryum*	1
			Gigaspermum	1
			Oedipodiella	1

Families	Genera	Species	Largest genus	Species
Grimmiaceae	4	8	*Grimmia*	1
			Racomitrium	1
Hedwigiaceae	4	4	*Braunia*	1
			Hedwigia	1
			Hedwigidium	1
			Rhacocarpus	1
Hookeriaceae	8	9	*Distichophyllum*	2
Hypnaceae	6	18	*Isopterygium*	6
Leptodontaceae	2	2	*Forsstroemia*	1
			Leptodon	1
Leskeaceae	7	13	*Lindbergia*	4
Leucodontaceae	2	2	*Leucodon*	1
			Pterogonium	1
Meteoriaceae	5	5	*Aerobryopsis*	1
			Floribundaria	1
			Papillaria	1
			Pilotrichella	1
			Squamidium	1
Mniaceae	1	1	*Plagiomnium*	1
Neckeraceae	1	1	*Neckera*	1
Orthotrichaceae	9	30	*Orthotrichum*	8
Plagiotheciaceae	1	2	*Plagiothecium*	2
Polytrichaceae	5	13	*Oligotrichum*	4
			Polytrichum	4
Pottiaceae	30	69	*Syntrichia*	8
Prionodontaceae	1	1	*Prionodon*	1
Pterobryaceae	3	6	*Pterobryopsis*	3
Ptychomitriaceae	2	10	*Ptychomitrium*	8
Racopilaceae	1	1	*Racopilum*	1
Rhabdoweisiaceae	1	2	*Rhabdoweisia*	2
Rhachitheciaceae	1	1	*Rhachithecium*	1

Families	Genera	Species	Largest genus	Species
Rhizogoniaceae	1	2	*Pyrrhobryum*	2
Rigodiaceae	1	1	*Rigodium*	1
Seligeriaceae	1	1	*Blindia*	1
Sematophyllaceae	5	12	*Sematophyllum*	7
Sphagnaceae	1	7	*Sphagnum*	7
Splachnaceae	1	2	*Tayloria*	2
Stereophyllaceae	2	3	*Stereophyllum*	2
Thamnobryaceae	3	5	*Porotrichum*	3
Thuidiaceae	5	7	*Cyrtohypnum*	3
Trachypodaceae	2	2	*Trachypodopsis*	1
			Trachypus	1
Wardiaceae	1	1	*Wardia*	1
Total	204	503		

Table 4. Numbers and percentages of southern African mosses in the African regions of Hollis & Brummit (1992).

Geographic region	No. of taxa (% of FSA mosses)
Northern Africa	76 (15%)
Macaronesia	85 (17%)
West Tropical Africa	63 (13%)
Northeast Tropical Africa	84 (17%)
West-Central Tropical Africa	165 (33%)
East Tropical Africa	252 (50%)
Western Indian Ocean	166 (33%)
South Tropical Africa	261 (52%)
Middle Atlantic Ocean	11 (2%)

Table 5. The 10 (11) largest moss families in southern Africa according to the number of genera in each. The number of species in each family as well as the largest genus, with it's number of species, are also listed.

Family	No. of genera	No. of species	Largest genus	No. of species
Pottiaceae	30	69	*Syntrichia*	8
Dicranaceae	15	49	*Campylopus*	19
Bryaceae	9	40	*Bryum*	19
Ditrichaceae	9	15	*Ditrichum*	4
			Pleuridium	4
Orthotrichaceae	9	30	*Orthotrichum*	8
Hookeriaceae	8	9	*Distichophyllum*	2
Amblystegiaceae	7	9	*Drepanocladus*	2
			Platyhypnidium	2
Bartramiaceae	7	22	*Philonotis*	8
Leskeaceae	7	13	*Lindbergia*	4
Funariaceae	6	16	*Funaria*	10
Hypnaceae	6	18	*Isopterygium*	6

Table 6. The 10 largest moss families in southern Africa according to the number of species in each.

Family	No. of species	No. of genera	Largest genus	No. of species
Pottiaceae	69	30	*Syntrichia*	8
Dicranaceae	49	15	*Campylopus*	19
Bryaceae	40	9	*Bryum*	19
Orthotrichaceae	30	9	*Orthotrichum*	8
Fissidentaceae	29	1	*Fissidens*	29
Bartramiaceae	22	7	*Philonotis*	8
Hypnaceae	18	6	*Isopterygium*	6
Brachytheciaceae	17	5	*Brachythecium*	8
Funariaceae	16	6	*Funaria*	10
Ditrichaceae	15	9	*Ditrichum* *Pleuridium*	4 4

Table 7. The 10 largest moss genera in southern Africa.

Genera	No. of species
Fissidens	29
Bryum	19
Campylopus	19
Archidium	11
Fabronia	10
Funaria	10
Brachythecium	8
Orthotrichum	8
Philonotis	8
Ptychomitrium	8

Table 8. The 10 most frequently collected mosses in southern Africa according to the number of specimens in PRECIS.

Taxon	**No. of specimens**
Trichostomum brachydontium	829
Bryum argenteum	586
Fissidens glaucescens	531
Pseudocrossidium crinitum	514
Macrocoma tenue *subsp.* tenue	423
Papillaria africana	370
Campylopus pilifer	345
Tortula atrovirens	328
Polytrichum commune	324
Hypnum cupressiforme	318

Table 9. The 10 moss species in PRECIS which occur in the greatest number of grid squares.

Taxon	**No. of grid squares**
Trichostomum brachydontium	331
Bryum argenteum	262
Pseudocrossidium crinitum	211
Fissidens glaucescens	163
Tortula atrovirens	136
Bryum pycnophyllum	131
Campylopus pilifer	129
Grimmia pulvinata	127
Funaria hygrometrica	118
Fissidens rufescens	117

Table 10. List of aquatic/semi-aquatic mosses in Glen *et al.* (1999) - see key on next page.

TAXON	COMMON NAME	HABITAT	GROWTH FORM	STATUS	ORIGIN
SPHAGNACEAE					
Sphagnum capense	Peat-moss	5,7	D	nt	In
Sphagnum fimbriatum	Peat-moss	5	D	nt	Al?
Sphagnum perichaetiale	Peat-moss	5,7	D	nt	In
Sphagnum pycnocladulum	Peat-moss	5,7	D	nt	In
Sphagnum strictum subsp. pappeanum	Peat-moss	5,7,8	D	nt	In
Sphagnum truncatum	Peat-moss	5,7,8	D	nt	In
Sphagnum violascens	Peat-moss	5	D	nt	In
FISSIDENTACEAE					
Fissidens fasciculatus	Fork-moss	4,5,7	D	nt	En
Fissidens palmifolius	Fork-moss	4,5	C	nt	In
Fissidens glaucescens	Fork-moss	4,5,7	D	nt	In
Fissidens porrectus	Fork-moss	5	D	nt	In
POTTIACEAE					
Barbula ehrenbergii	Little beard-moss	5,7	D	nt	In
Timmiella pelindaba	Timmiella	4,7	D	nt	En
BRYACEAE					
Bryum apiculatum	Pointed thread-moss	4,5,7	D	nt	In
Bryum cellulare	Thread-moss	5,7	D	nt	In
FONTINALACEAE					
Fontinalis antipyretica var. gracilis	Greater water-moss	5	C	nt	Al

TAXON	COMMON NAME	HABITAT	GROWTH FORM	STATUS	ORIGIN
Fontinalis squamosa	Alpine water-moss	5	C	nt	Al
WARDIACEAE					
Wardia hygrometrica	Ward`s moss	4,5	C,D	nt	En
LESKEACEAE					
Pseudoleskea chilensis	Pseudoleskea	7	D	nt	In
AMBLYSTEGIACEAE					
Campyliadelphus polygamus	Curved moss	8	D	nt	In
Cratoneuron filicinum	Strongly nerved moss	7	D	nt	Cos
Drepanocladus aduncus	Sickle-moss	6,7,8	C,D	nt	Cos
Leptodictyum riparium	Short-beaked water-moss	3,5,7	C,D	nt	Cos
Platyhypnidium aquaticum	Platyhypnidium	4	C	nt	In
Vittia pachyloma	Vitt`s moss	4	C,D	nt	In
PLAGIOTHECIACEAE					
Plagiothecium rhynchostegioides	Oblique-capsuled moss	4,7	D	nt	In
HYPNACEAE)					
Isopterygium strangulatum	Equal-winged moss	4,5	D	R	En

Key

Habitats:

1. Sea
2. Estuaries,brackish lagoons, saltmarshes, coastal seepage areas

3. Mangroves, coastal swamps
4. Rivers/streams: rapids/waterfalls, wet vertical rockfaces
5. Rivers/streams: slow-flowing, pools
6. Open waters: lakes, pans, dams, permanent pools
7. Seepage areas
8. Swamps, marshes, vleis (standing water)
9. Seasonal pans and streams (arid areas)
10. High altitude bogs, mountain rock pools

Growth form:

A Floating unattached plants (Riemer, 1993)

B Floating attached plants (Riemer, 1993)

C Submerged plants (Riemer, 1993)

D Emergent plants (Riemer, 1993)

E Sudd plants

H Haptophyte: a specialised group of plants that are attached to but not penetrate the substrate, usually rocks in fast flowing rivers or the face of a waterfall. (Cook,1990).

Status:

E Endangered (according to Hilton-Taylor 1996)

V Vulnerable (according to Hilton-Taylor 1996)

R Rare (according to Hilton-Taylor 1996)

nt Not threatened or natural

? Insufficient information available

I Invader: introduced plant which is a problem plant, destroying the natural aquatic life

O Opportunistic, occurring naturally but in biologically disturbed aquatic environments, tend to become the dominant plant to the detriment of the other aquatic taxa.

Origin: Al - Introduced alien; In - Indigenous; En - Endemic; Cos - Cosmopolitan.

Table 11. Endemism in the moss families of southern Africa.

Families	endemic species	% endemism	endemic genera	% endemism
Amblystegiaceae	0	0	0	0
Andreaeaceae	1	25	0	0
Archidiaceae	6	55	0	0
Aulacomniaceae	0	0	0	0
Bartramiaceae	7	32	1	14
Brachytheciaceae	8	47	0	0
Bryaceae	2	5	0	0
Bryobartramiaceae	0	0	0	0
Calymperaceae	0	0	0	0
Catagoniaceae	1	100	0	0
Cryphaeaceae	0	0	0	0
Dicranaceae	5	10	0	0
Ditrichaceae	1	7	0	0
Encalyptaceae	0	0	0	0
Entodontaceae	1	14	0	0
Ephemeraceae	2	50	0	0
Erpodiaceae	1	20	0	0
Eustichiaceae	0	0	0	0
Fabroniaceae	6	43	0	0
Fissidentaceae	4	14	0	0
Fontinalaceae	0	0	0	0
Funariaceae	7	44	2	33
Gigaspermaceae	1	33	0	0
Grimmiaceae	1	13	0	0
Hedwigiaceae	0	0	0	0
Hookeriaceae	1	11	0	0
Hypnaceae	5	28	0	0
Leptodontaceae	0	0	0	0

Families	endemic species	% endemism	endemic genera	% endemism
Leskeaceae	3	23	0	0
Leucodontaceae	0	0	0	0
Meteoriaceae	0	0	0	0
Mniaceae	0	0	0	0
Neckeraceae	0	0	0	0
Orthotrichaceae	14	47	0	0
Plagiotheciaceae	1	50	0	0
Polytrichaceae	5	39	0	0
Pottiaceae	21	30	1	3
Prionodontaceae	0	0	0	0
Pterobryaceae	1	17	0	0
Ptychomitriaceae	5	50	1	50
Racopilaceae	0	0	0	0
Rhabdoweisiaceae	0	0	0	0
Rhachitheciaceae	0	0	0	0
Rhizogoniaceae	1	50	0	0
Rigodiaceae	0	0	0	0
Seligeriaceae	0	0	0	0
Sematophyllaceae	2	17	0	0
Sphagnaceae	0	0	0	0
Splachnaceae	0	0	0	0
Stereophyllaceae	0	0	0	0
Thamnobryaceae	0	0	0	0
Thuidiaceae	0	0	0	0
Trachypodaceae	0	0	0	0
Wardiaceae	1	100	1	100
Totals	114		6	

Table 12. Species/infraspecific endemism in the moss genera of southern Africa.

Genera	No. of species	Endemics	Percentage endemism
Abietinella	1	0	0
Acaulon	2	1	50
Aerobryopsis	1	0	0
Aloina	1	0	0
Amphidium	2	0	0
Anacolia	1	0	0
Andreaea	4	1	25
Anoectangium	1	1	100
Anomobryum	2	1	50
Aongstroemia	2	0	0
Aongstroemiopsis	1	0	0
Archidium	11	6	55
Astomiopsis	1	0	0
Atrichum	1	0	0
Aulacopilum	1	0	0
Barbula	5	1	20
Bartramia	5	2	40
Blindia	1	0	0
Brachymenium	6	0	0
Brachythecium	8	4	50
Braunia	1	0	0
Breutelia	5	3	60
Bruchia	3	0	0
Bryobartramia	1	0	0
Bryoerythrophyllum	2	0	0
Bryum	19	0	0
Callicostella	1	0	0
Calymperes	3	0	0
Calyptrochaeta	1	0	0

Genera	No. of species	Endemics	Percentage endemism
Campyliadelphus	1	0	0
Campylopus	19	0	0
Cardotiella	1	1	100
Catagonium	1	1	100
Ceratodon	1	0	0
Chamaebryum	1	1	100
Cheilothela	1	0	0
Chenia	1	0	0
Chorisodontium	1	0	0
Chrysohypnum	1	0	0
Cladophascum	1	0	0
Conostomum	1	0	0
Cratoneuron	1	0	0
Crossidium	1	1	100
Cryphaea	1	0	0
Cyclodictyon	1	0	0
Cygnicollum	1	1	100
Cyrtohypnum	3	0	0
Dicranella	3	1	33
Dicranoloma	2	1	50
Didymodon	6	2	33
Dimerodontium	1	1	100
Distichium	1	0	0
Distichophyllum	2	1	50
Ditrichum	4	0	0
Drepanocladus	2	0	0
Eccremidium	1	0	0
Ectropothecium	3	0	0
Encalypta	2	0	0
Entodon	4	1	25
Entodontopsis	1	0	0

Genera	No. of species	Endemics	Percentage endemism
Ephemerum	4	2	50
Erpodium	4	1	25
Erythrodontium	1	0	0
Eustichia	1	0	0
Fabronia	10	4	40
Fissidens	29	4	14
Floribundaria	1	0	0
Fontinalis	2	0	0
Forsstroemia	1	0	0
Funaria	10	3	30
Gigaspermum	1	0	0
Goniomitrium	1	1	100
Grimmia	3	0	0
Gymnostomum	3	2	67
Haplocladium	1	0	0
Haplohymenium	1	0	0
Hedwigia	1	0	0
Hedwigidium	1	0	0
Helicodontium	1	1	100
Hennediella	1	0	0
Herpetineuron	1	0	0
Holomitrium	1	0	0
Hookeriopsis	1	0	0
Hymenostylium	1	0	0
Hyophila	2	0	0
Hypnum	2	0	0
Hypodontium	2	0	0
Hypopterygium	1	0	0
Ischyrodon	1	0	0
Isopterygium	6	5	83
Jaegerina	1	0	0

Genera	No. of species	Endemics	Percentage endemism
Lepidopilidium	1	0	0
Leptobryum	1	0	0
Leptodictyum	1	0	0
Leptodon	1	0	0
Leptodontium	3	0	0
Leptoischyrodon	1	0	0
Leptoterigynandrum	1	0	0
Leptotheca	1	0	0
Leskeella	1	1	100
Leucobryum	3	1	33
Leucodon	1	0	0
Leucoloma	4	1	25
Leucoperichaetium	1	1	100
Levierella	1	0	0
Lindbergia	4	1	25
Lopidium	1	0	0
Macrocoma	3	2	67
Macromitrium	5	2	40
Meiothecium	1	1	100
Microbryum	3	3	100
Microcrossidium	1	1	100
Microdus	1	0	0
Micropoma	1	0	0
Mielichhoferia	2	1	50
Mittenothamnium	5	0	0
Neckera	1	0	0
Octoblepharum	1	0	0
Oedipodiella	1	0	0
Oligotrichum	4	4	100
Oreoweisia	1	0	0
Orthodontium	1	0	0

Genera	No. of species	Endemics	Percentage endemism
Orthostichopsis	2	0	0
Orthotrichum	8	4	50
Oxyrrhynchium	2	2	100
Palamocladium	1	0	0
Papillaria	1	0	0
Phascum	1	0	0
Philonotis	8	1	13
Physcomitrellopsis	1	1	100
Physcomitrium	2	1	50
Pilotrichella	1	0	0
Pinnatella	1	0	0
Plagiobryum	1	0	0
Plagiomnium	1	0	0
Plagiopus	1	0	0
Plagiothecium	2	1	50
Platyhypnidium	2	0	0
Plaubelia	1	1	100
Pleuridium	4	1	25
Pogonatum	3	1	33
Pohlia	4	0	0
Polytrichastrum	1	0	0
Polytrichum	4	0	0
Porothamnium	1	0	0
Porotrichum	3	0	0
Pottia	1	1	100
Prionodon	1	0	0
Pseudocrossidium	4	0	0
Pseudoleskea	2	0	0
Pseudoleskeopsis	3	1	33
Pterobryopsis	3	1	33
Pterogonium	1	0	0

Genera	No. of species	Endemics	Percentage endemism
Pterygoneurum	1	0	0
Ptychomitriopsis	2	2	100
Ptychomitrium	8	3	38
Pyrrhobryum	2	1	50
Quathlamba	1	1	100
Racomitrium	3	0	0
Racopilum	1	0	0
Rauiella	1	0	0
Rhabdoweisia	2	0	0
Rhachithecium	1	0	0
Rhacocarpus	1	0	0
Rhacopilopsis	2	0	0
Rhodobryum	4	0	0
Rhynchostegiella	3	1	33
Rhynchostegium	3	1	33
Rigodium	1	0	0
Saelania	1	0	0
Sanionia	1	0	0
Schistidium	1	0	0
Schlotheimia	3	1	33
Sematophyllum	7	1	14
Sphaerothecium	1	0	0
Sphagnum	7	0	0
Squamidium	1	0	0
Stereophyllum	2	0	0
Stoneobryum	1	1	100
Streptocalypta	1	1	100
Syntrichia	8	1	13
Syrrhopodon	2	0	0
Tayloria	2	0	0
Tetrapterum	1	1	100

Genera	No. of species	Endemics	Percentage endemism
Thuidium	1	0	0
Timmiella	1	0	0
Tortella	3	0	0
Tortula	4	1	25
Trachyphyllum	1	0	0
Trachypodopsis	1	0	0
Trachypus	1	0	0
Trematodon	6	1	17
Trichosteleum	1	0	0
Trichostomum	3	0	0
Triquetrella	1	0	0
Tristichium	1	0	0
Ulota	1	1	100
Vesicularia	1	0	0
Vittia	1	0	0
Wardia	1	1	100
Weisiopsis	1	0	0
Weissia	5	3	60
Wijkia	1	0	0
Zygodon	6	2	33
Totals	503	114	

Table 13. Comparison between moss and vascular plant diversity and endemism in the Flora of Southern Africa area. Moss figures from this study, vascular plant figures from various sources quoted in Cowling & Hilton-Taylor (1997).

Taxonomic level	Mosses	Vascular plants
Families		
Total no.	54	226
endemics/% endemism	1/2%	10/23%
Genera		
Total no.	204	1930
Endemics/% endemism	6/3%	560/29%
Species/infraspecific taxa		
Total no.	503	23352
Endemics/% endemism	114/23%	c. 80%

Table 14. Floristic diversity and endemism in the four bryogeographic Regions of southern Africa. **Diagnostic** = species/infraspecific taxa restricted to this Region in southern Africa but not necessarily endemic, may occur in other parts of the world; **endemic** = species/infraspecific taxa that only occur in this Region and nowhere else in the world. Totals for the FSA area: 503 species, 204 genera and 54 families.

Flora	**Zambezian**	**Afromontane**	**Karoo-Namib**	**Highlands**
Families				
No./% of total	31/57%	54/100%	37/69%	29/54%
Diagnostic/%	0	11/20%	0	0
Endemic/%	0	0	0	0
Largest fam. - no. genera /species	Bryaceae 7/21 Pottiaceae 10/17 Dicranaceae 5/15	Pottiaceae 24/61 Dicranaceae 14/48 Bryaceae 9/40	Pottiaceae 19/38 Dicranaceae 10/19 Bryaceae 5/16	Pottiaceae 16/37 Bryaceae 5/21 Dicranaceae 5/11
Genera				
No./% of total	74/36%	197/97%	93/46%	71/35%
Diagnostic/%	0	70/36%	6/7%	0
Endemic/%	0	2/1%	2/2%	0
Largest genera - no. species.	*Fissidens* -13 *Bryum* -12 *Campylopus* -11	*Fissidens* -28 *Bryum* -19 *Campylopus* -19 *Funaria* -10	*Fissidens* -11 *Bryum* - 10 *Campylopus* -7 *Funaria* -7	*Bryum* -15 *Fissidens* -9 *Syntrichia* -8
Species				
No./% of total	136/27%	481/96%	196/39%	152/30%
Diagnostic/%	3/2%	188/39%	14/7%	3/2%
Endemic/%	1/1%	47/10%	11/6%	2/1%

Table 15. Floristic diversity and endemism in the eight bryogeographic Domains of southern Africa. **W Cape** = Western Cape Domain, **Alpine** = Drakensberg Alpine Domain, **Karoo** = Upper Karoo Domain. **Diagnostic** = species/infraspecific taxa restricted to this Domain in southern Africa but not necessarily endemic, may occur in other parts of the world; **endemic** = taxa that only occur in this Domain and nowhere else in the world. **%** = percentage of the total number of taxa in that particular phytochorion. Totals for the FSA area: 503 species, 204 genera and 54 families.

Flora	Caprivi	Bushveld	Drakensberg	Cape	W Cape	Namaqua	Alpine	Karoo
Families								
No./% of total	12/22%	30/56%	50/93%	44/82%	37/69%	10/19%	27/50%	15/28%
Diagnostic no./%	0	0	8/16%	1/2%	0	0	0	0
Endemic no./%	0	0	0	0	0	0	0	0
Largest family (no. of genera/species)	Dicranaceae 1/3 Pottiaceae 2/3 Bartramiaceae 1/3	Bryaceae 7/20 pottiaceae 10/17 Dicranaceae 5/14	Pottiaceae 21/53 Dicranaceae 13/40 Bryaceae 8/36	Pottiaceae 17/33 Dicranaceae 11/29 Bryaceae 7/23	Pottiaceae 19/37 Dicranaceae 10/19 Bryaceae 5/14	Pottiaceae 5/6 Bryaceae 2/4 Funariaceae 1/3	Pottiaceae 16/36 Bryaceae 5/20 Dicranaceae 5/11	Pottiaceae 11/18 Bryaceae 2/12 Funariaceae 3/8
Genera								
No./% of total	15/7%	73/36%	179/88%	127/62%	93/46%	15/7%	67/33%	32/16%
Diagnostic no./%	0	0	45/25%	6/5%	6/7%	0	0	0
Endemic no./%	0	0	1/1%	0	2/2%	0	0	0

Flora	**Caprivi**	**Bushveld**	**Drakensberg**	**Cape**	**W Cape**	**Namaqua**	**Alpine**	**Karoo**
Largest genus -no. of species	*Campylopus* -3 *Philonotis* -3 *Erpodium* -2	*Fissidens* -12 *Bryum* -12 *Campylopus* -10	*Fissidens* -24 *Bryum* -18 *Campylopus* -17	*Fissidens* -14 *Bryum* -13 *Campylopus* -13	*Fissidens* -10 *Bryum* -8 *Campylopus* -7	*Bryum* -3 *Funaria* -3 *Pseudocrossidium* -2	*Bryum* -14 *Fissidens* -8 *Syntrichia* -7 *Funaria* -7	*Bryum* -11 *Funaria* -6 *Fissidens* -5
Species								
No./% of total	22/4%	130/26%	409/81%	284/57%	190/38%	20/4%	142/28%	63/13%
Diagnostic no./%	2/9%	1/1%	153/37%	35/12%	14/7%	0	2/1%	0
Endemic no./%	1/5%	0	28/7%	19/7%	11/6%	0	1/1%	0

Table 16. Comparison between the moss flora (this study) and vascular plant flora (Goldblatt 1978 and White 1983, as summarised by Beentje *et al.* 1994) of the Zambezian Region (regional centre of endemism). Where available, the number of endemic taxa and it's percentage of the total number of taxa present in the phytochorion is given.

Flora of the Zambezian Region	Mosses	Vascular plants - (Goldblatt 1978)	Vascular plants - (White 1983)
Number of species	137		c. 8500
% of total flora	27%		c. 36%
Species endemism	1/1%	Few	54%
Endemic genera	None	2	Few
Endemic families	None	None	None

Table 17. Comparison between the moss flora of the Afromontane Region (this study) and the vascular plant floras of the (whole) Afromontane archipelago-like regional centre of endemism (Region) of White (1983), and the Maputaland-Pondoland Region of Van Wyk (1994) as summarised by Beentje *et al.* (1994).

Flora	Afromontane Mosses	Afromontane (White 1993)	Maputaland - Pondoland (Van Wyk 1994)
number of species	481	c. 4000	6000–7000
% of total	96%	c. 10%	25%–29%
% Species endemism	10%	75%	c. 20%
Endemic genera	2	c. 200	c. 58
Endemic families	none	1–2	2

Table 18. Comparison between the moss flora of the Drakensberg Domain and the flora of the Maputaland-Pondoland Region of Van Wyk (1994) as summarised by Beentje *et al.* (1994).

Drakensberg Flora	Mosses of the Drakensberg Domain	Maputaland-Pondoland flora (Van Wyk 1994)
number of species	409	6000–7000
% of total	81%	25%–29%
% Species endemism	7%	c.20%
Endemic families (%)	0	2
Endemic genera (%)	1/1%	c.58

Table 19. Comparison between the moss flora of the Cape Domain and the vascular plant flora of the Cape Region (Bond & Goldblatt 1984).

Flora of the Cape region	Mosses	Vascular plants
number of species	284	8600
% of total	57%	36%
% species endemism	12%	68%
Endemic families	0	6
Endemic genera	0	193/20%

Table 20. Comparison between the moss flora (this study) and vascular plant flora (White 1983, Hilton-Taylor 1987) of the Karoo-Namib Region.

Karoo-Namib Flora	Mosses	Vascular plants
number of species	196	c.7000
% of total	39%	c.29%
% Species endemism	6%	35–50%
Endemic families	0	1
Endemic genera	2/2%	c.160

Table 21. Comparison between the moss flora (this study) and vascular plant flora (Hilton-Taylor 1996) of the Western Cape Domain.

Karoo-Namib Flora	Mosses	Vascular plants
number of species	19	4849
% of total	38%	20%
% Species endemism	6%	40%
Endemic families	0	1
Endemic genera	2/2%	58/8%

Table 22. Comparison between the moss flora of the Highlands Region (this study) and the vascular plant flora of the Kalahari-Highveld transition zone (White 1983).

Highlands Flora	Mosses	Vascular plants
number of species	153	c.3000
% of total	30%	c.13%
% Species endemism	1%	few
Endemic families	0	?
Endemic genera	0	few

Table 23. Comparison between the moss flora (this study) and vascular plant flora (Killick 1994, Beentje *et al.* 1994) of the Drakensberg Alpine Domain (Region).

Flora	Mosses	Vascular plants
number of species	142	›2000
% of total	28%	c.8%
% Species endemism	1%	c.30%
Endemic families	0	?
Endemic genera	0	?

Table 24. Eigenvalues and gradient lengths (in SD units) for the four principal axes of the TWINSPAN 3+ and TWINSPAN 5+ DCA ordinations. TW = TWINSPAN.

Database/DCA axis	Eigenvalues		Gradient lengths	
Database	TW 3+	TW 5+	TW 3+	TW 5+
axis 1	0.477	0.466	5.19	4.63
axis 2	0.374	0.322	4.84	4.54
axis 3	0.281	0.240	4.28	3.74
axis 4	0.234	0.201	5.01	5.21

Table 25. Abundance of the **Eastern Highlands Element** in the Biomes of southern Africa.

Biome	**No. of species**	**Percentage**
Desert	1	2
Grassland	43	92
Succulent Karoo	15	32
Forest (sensu lato)	14	30
Nama-Karoo	34	72
Savanna	23	49
Fynbos	22	47

Table 26. Abundance of the **Cape Element** in the Biomes of southern Africa.

Biome	**No. of species**	**Percentage**
Desert	0	0
Grassland	38	45
Succulent Karoo	46	55
Forest (sensu lato)	16	19
Nama-Karoo	29	35
Savanna	31	37
Fynbos	70	83

Table 27. Abundance of the **Afromontane Grassland Element** in the Biomes of southern Africa.

Biome	**No. of species**	**Percentage**
Desert	1	2
Grassland	59	94
Succulent Karoo	14	22
Forest (sensu lato)	35	56
Nama-Karoo	35	56
Savanna	48	76
Fynbos	40	64

Table 28. Abundance of the **Afromontane Forest Element** in the Biomes of southern Africa.

Biome	**No. of species**	**Percentage**
Desert	0	0
Grassland	234	76
Succulent Karoo	2	0.16
Forest (sensu lato)	168	55
Nama-Karoo	35	11
Savanna	180	59
Fynbos	139	45

Table 29. Abundance of the **Mont Aux Sources Subelement** in the Biomes of southern Africa.

Biome	**No. of species**	**Percentage**
Desert	0	0
Grassland	31	89
Succulent Karoo	11	31
Forest (sensu lato)	5	14
Nama-Karoo	25	71
Savanna	11	31
Fynbos	14	40

Table 30. Abundance of the **Widespread Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	1	8
Grassland	12	100
Succulent Karoo	4	33
Forest (sensu lato)	7	58
Nama-Karoo	9	75
Savanna	12	100
Fynbos	8	67

Table 31. Abundance of the **West Coast Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	0	0
Grassland	24	42
Succulent Karoo	41	72
Forest (sensu lato)	9	16
Nama-Karoo	23	40
Savanna	24	42
Fynbos	43	75

Table 32. Abundance of the **Boland Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	0	0
Grassland	14	52
Succulent Karoo	5	19
Forest (sensu lato)	7	26
Nama-Karoo	6	22
Savanna	7	26
Fynbos	27	100

Table 33. Abundance of the **Disjunct Cape Peninsula Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	0	0
Grassland	9	82
Succulent Karoo	3	27
Forest (sensu lato)	3	27
Nama-Karoo	3	27
Savanna	9	82
Fynbos	9	82

Table 34. Abundance of the **Drakensberg Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	1	2
Grassland	50	96
Succulent Karoo	11	21
Forest (sensu lato)	32	62
Nama-Karoo	32	62
Savanna	39	75
Fynbos	31	60

Table 35. Abundance of the **Widespread Afromontane Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	0	0
Grassland	46	94
Succulent Karoo	1	2
Forest (sensu lato)	37	76
Nama-Karoo	8	16
Savanna	45	92
Fynbos	39	80

Table 36. Abundance of the **Tropical Afromontane Subelement** in the Biomes of southern Africa.

Biome	No. of species	Percentage
Desert	0	0
Grassland	188	73
Succulent Karoo	1	0,4
Forest (sensu lato)	131	51
Nama-Karoo	27	11
Savanna	135	52
Fynbos	100	39

Table 37. Percentages of FSA endemics in the Elements and Subelements of southern African mosses. The numbers represent: % of element/% of FSA endemics.

Elements and Subelements	Endemic Families	Endemic Genera	Endemic Species
Eastern Highlands Element	0	0	21/9
Mont Aux Sources Subelement	0	0	26/8
Widespread Subelement	0	0	8/1
Cape Element	4/2	6/50	36/26
West Coast Subelement	0	8/33	40/35
Boland Subelement	4/2	0	26/6
Afromontane Grassland Element	0	0	16/9
Disjunct Cape Peninsula Subelement	0	0	27/3
Drakensberg Subelement	0	0	14/6
Afromontane Forest Element	0	1/33	20/54
Widespread Afromontane Subelement	0	0	12/5
Tropical Afromontane Subelement	0	1/33	22/49

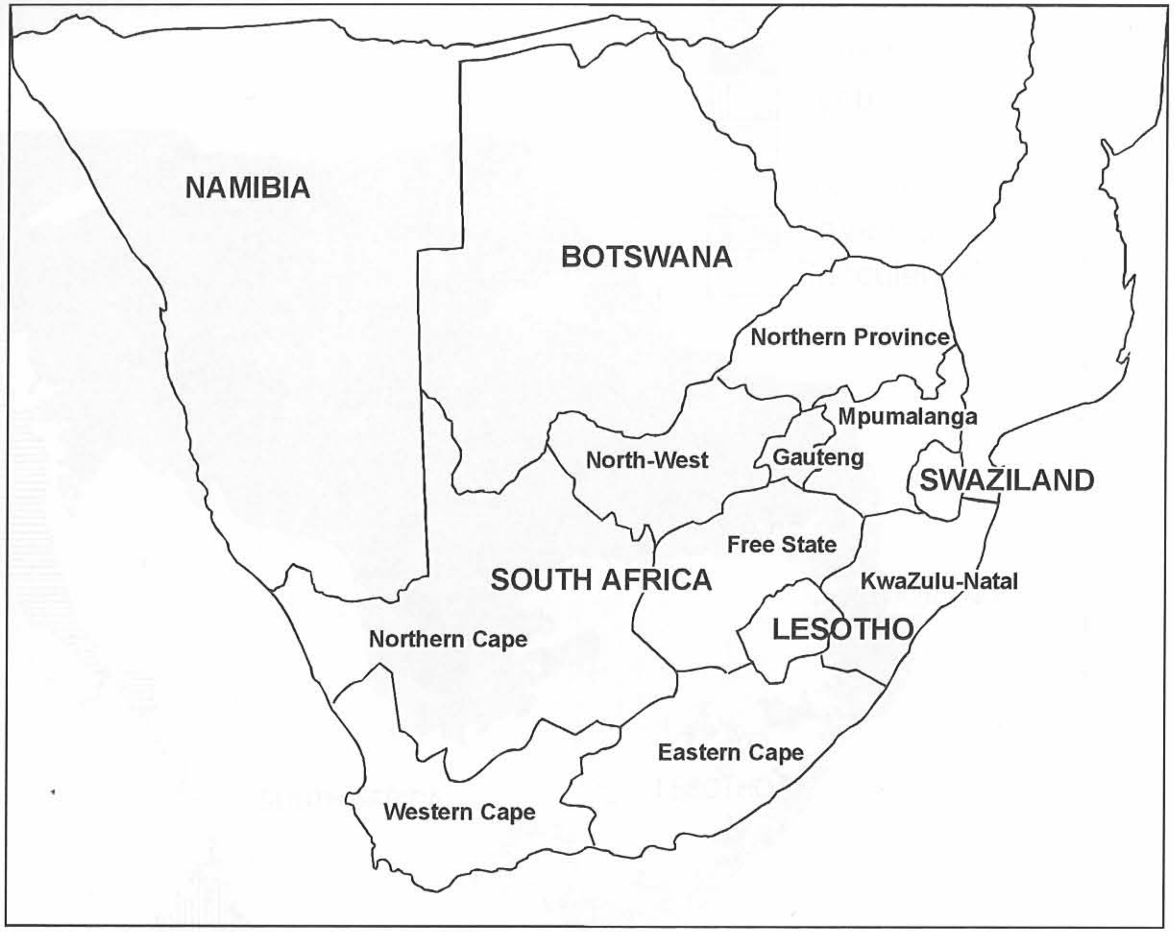


Figure 1. The Flora of Southern Africa (study) area.

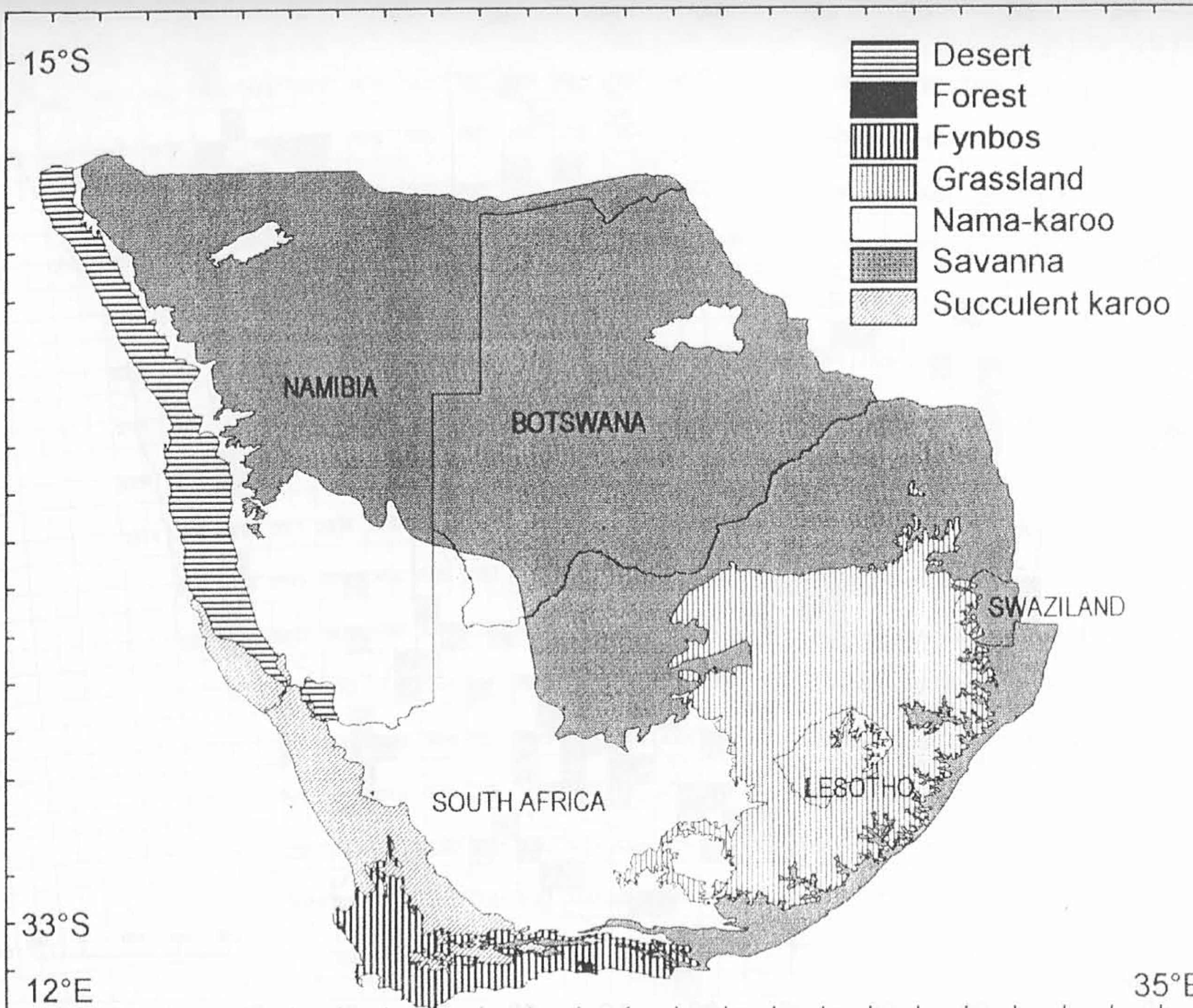


Figure 2. The Biomes of southern Africa according to Rutherford & Westfall (1986) and Rutherford (1997).

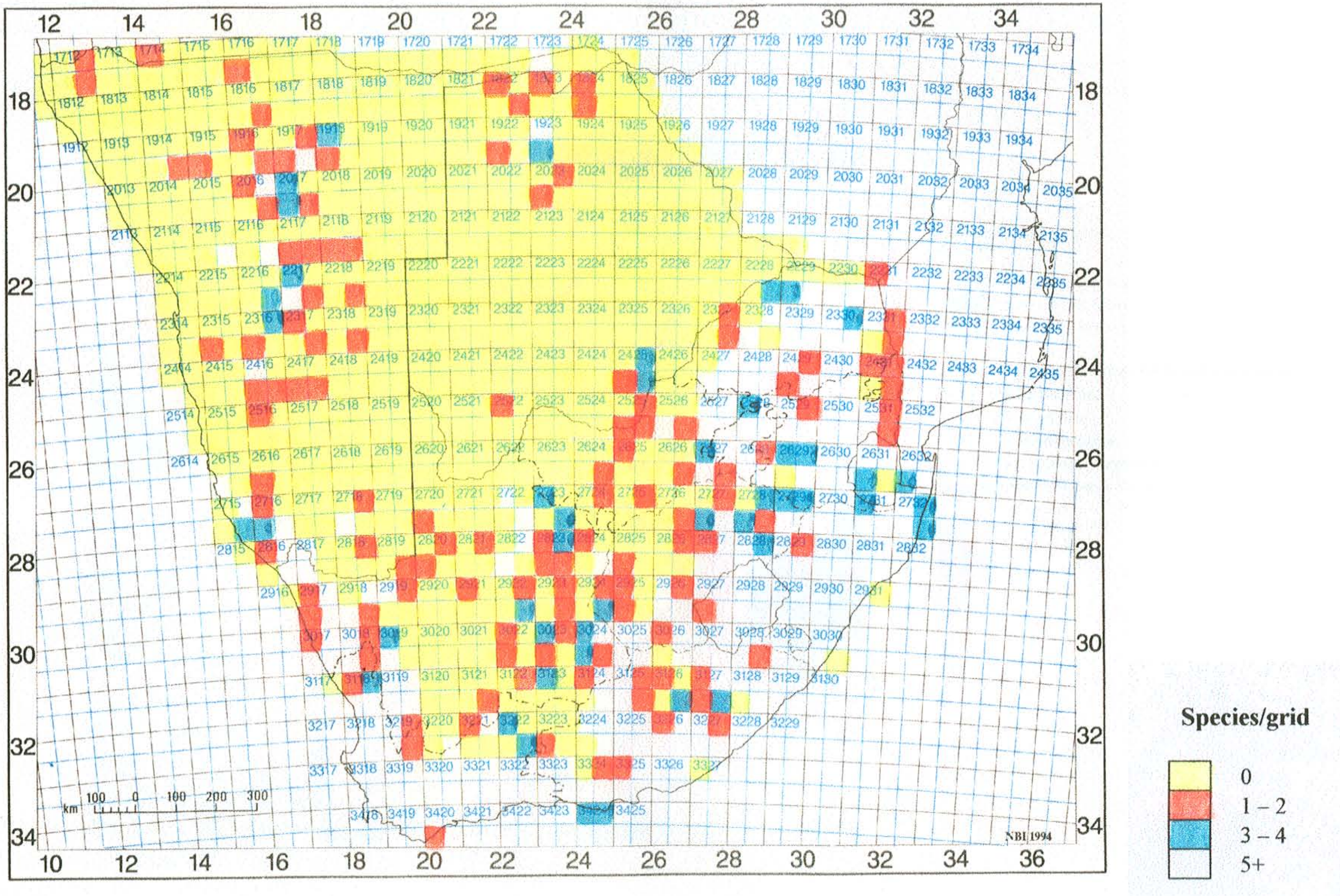


Figure 3. The geographic area in southern Africa from which less than five species\infraspecific taxa has been recorded. This figure also shows the grid squares omitted for the TWINSPAN 3+ (1 - 2) and TWINSPAN 5+ (1 - 2 plus 3 - 4) data sets.

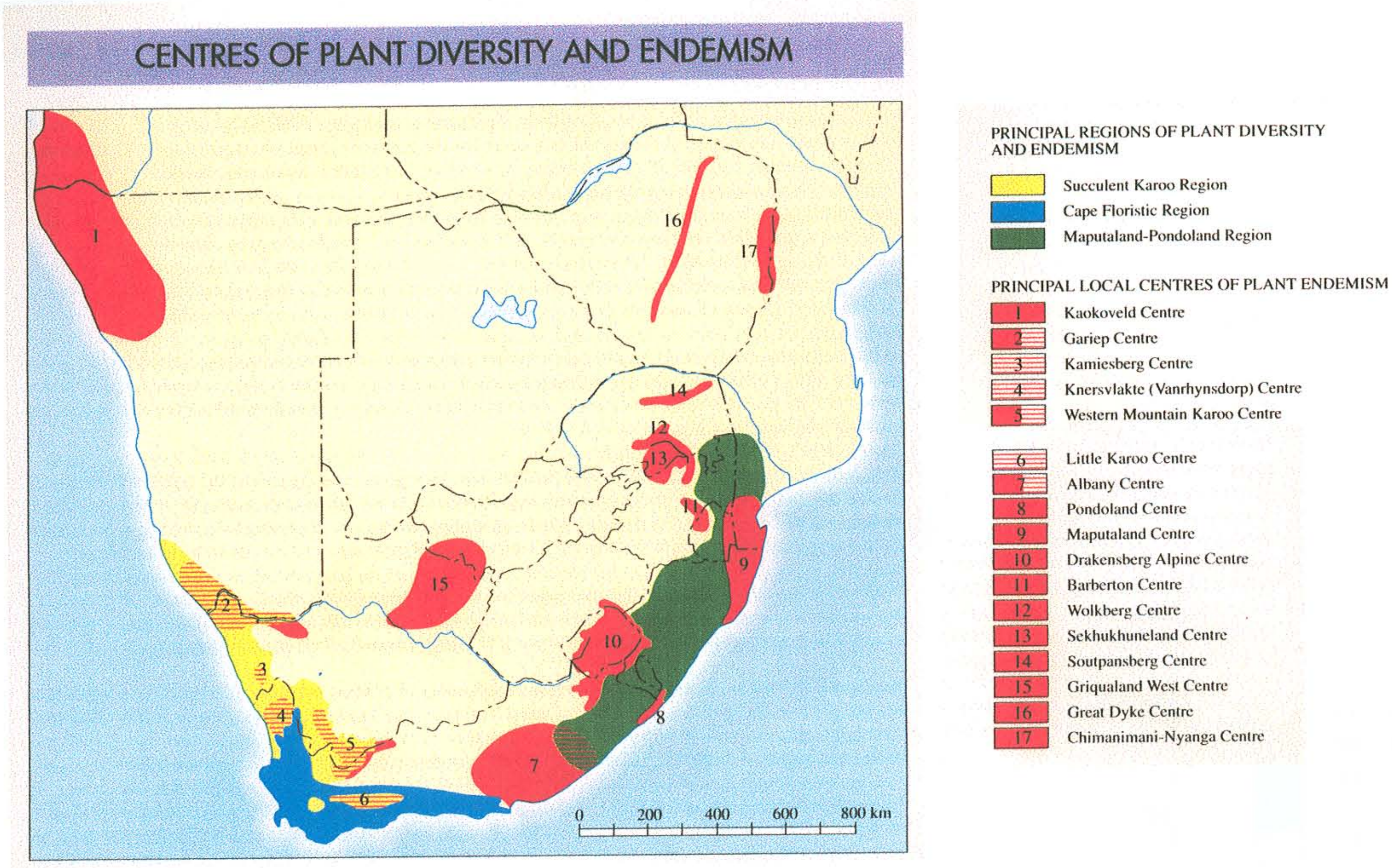


Figure 4. Centres of vascular plant diversity and endemism in southern Africa, from Van Wyk & Van Wyk (1997).

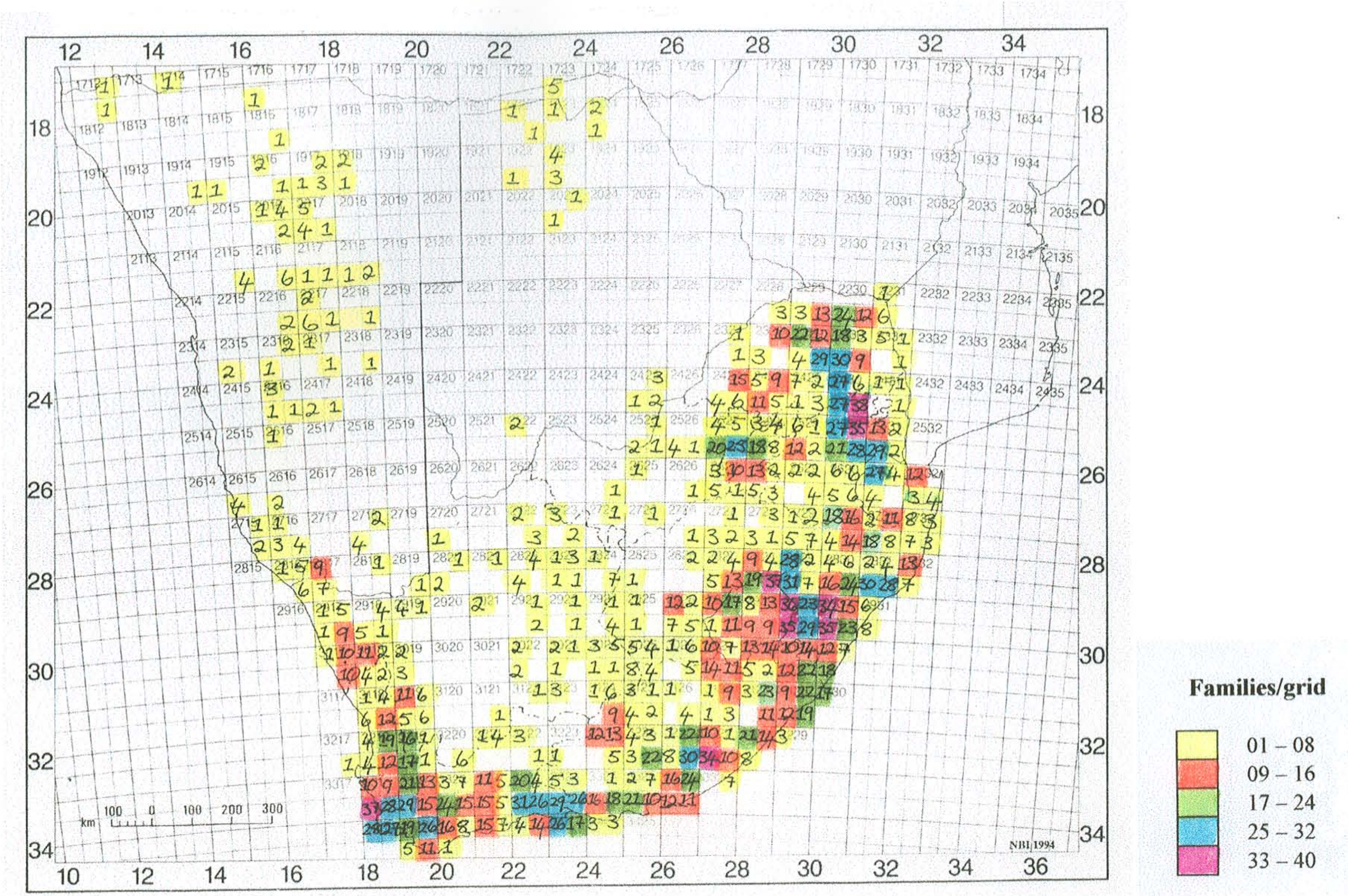


Figure 5. The geographic distribution of southern African moss families showing the number of families per ½° grid square.

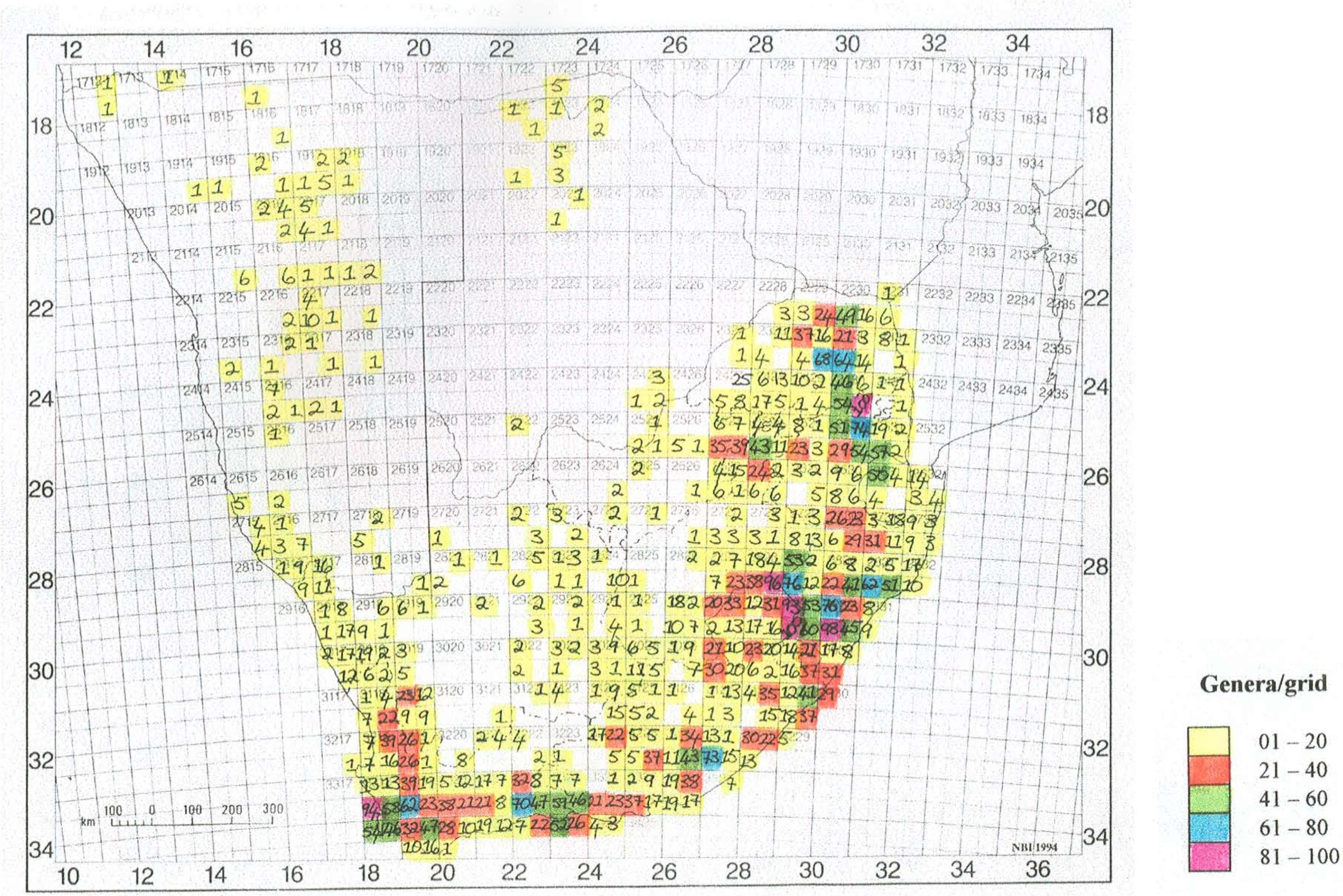


Figure 6. The geographic distribution of southern African moss genera showing the number of genera per ½° grid square.

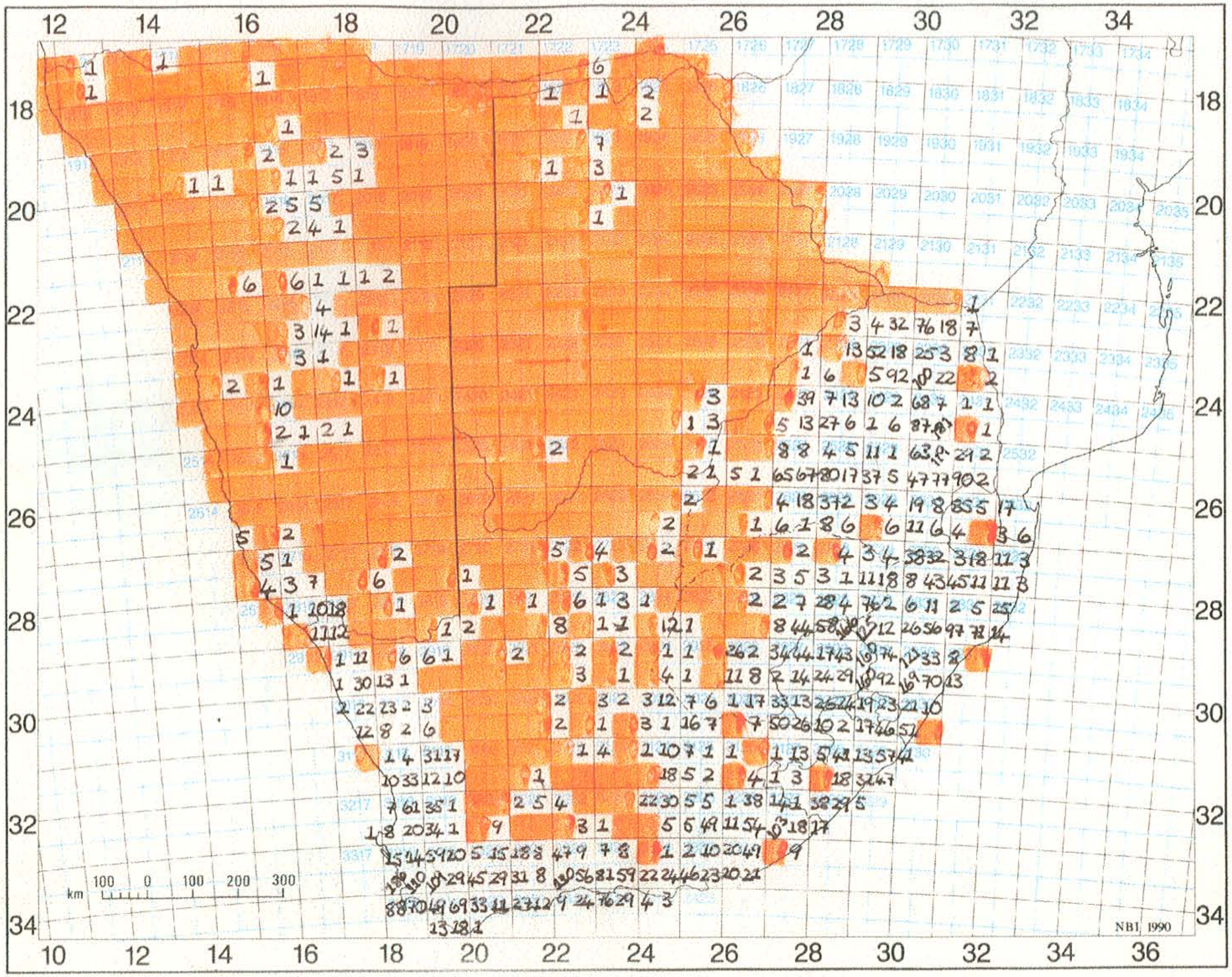


Figure 7. The joint geographic distribution of southern African mosses showing the number of moss species/infraspecific taxa per ½° grid square.

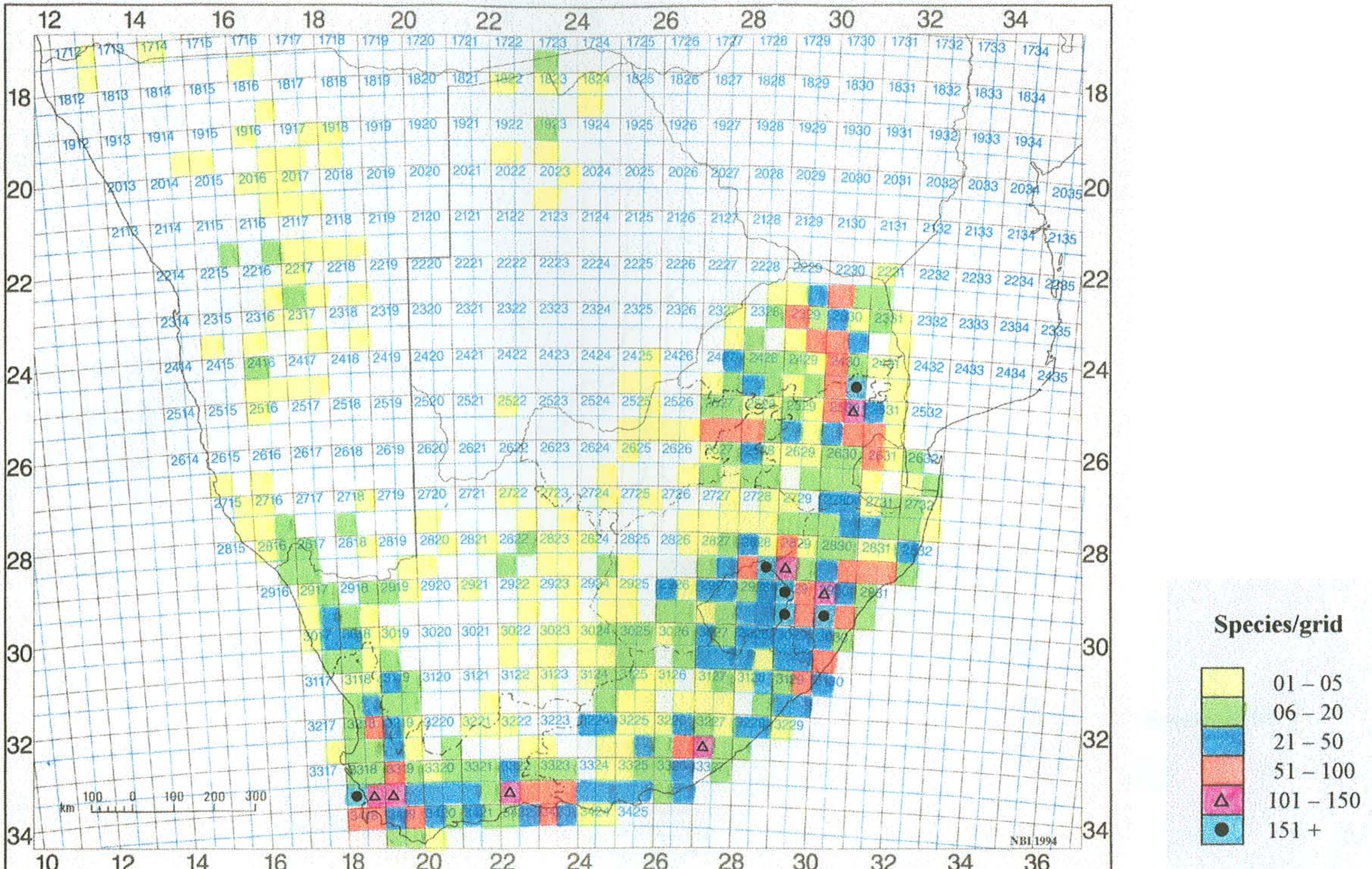


Figure 8. The joint geographic distribution of southern African mosses. The number of moss species/infraspecific taxa per ½° grid square is shown in six intervals.

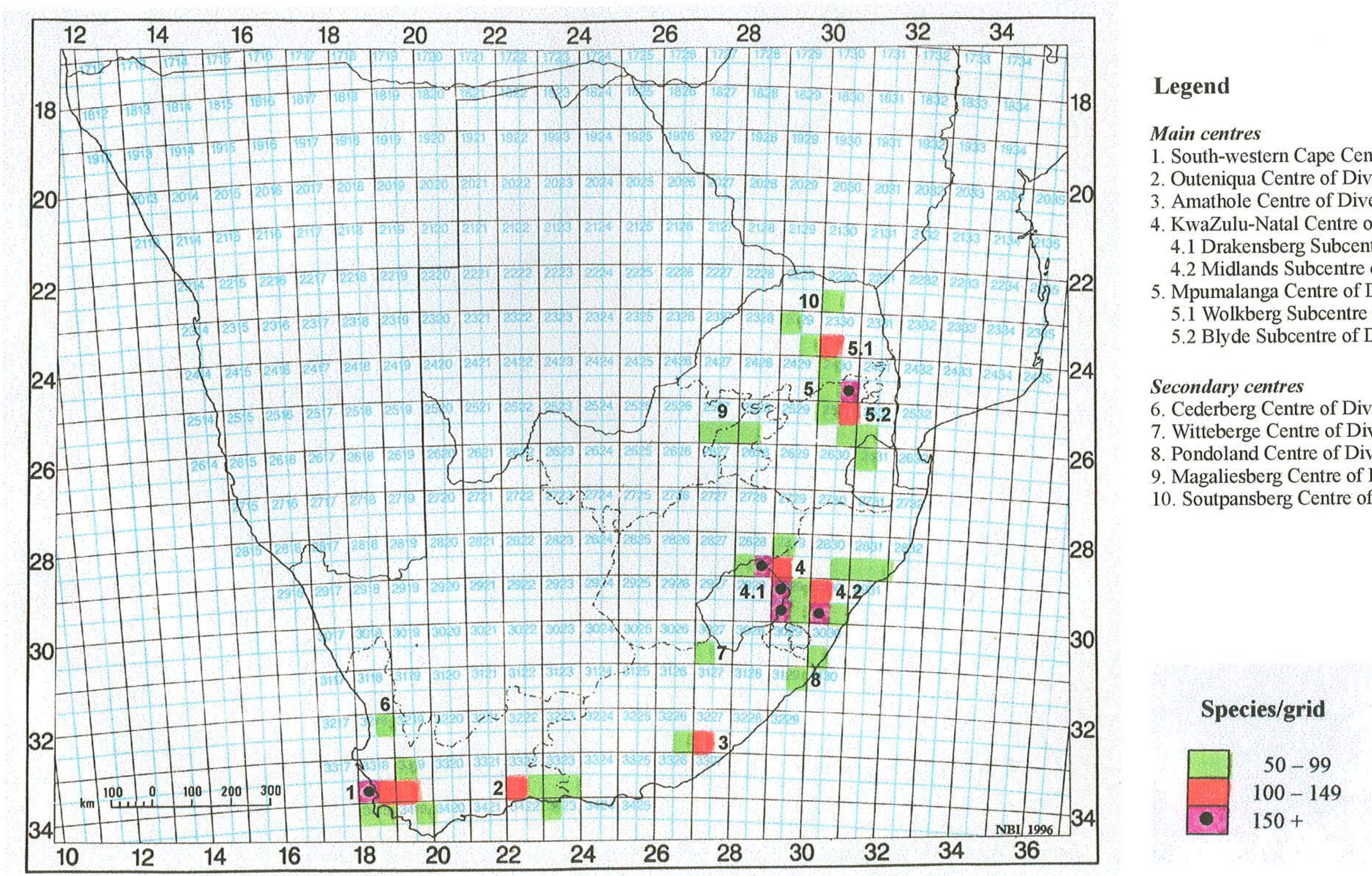


Figure 9. Centres of moss species/infraspecific diversity in southern Africa. The top three classes of a four class, number of species/infraspecific per ½° grid square interval is shown.

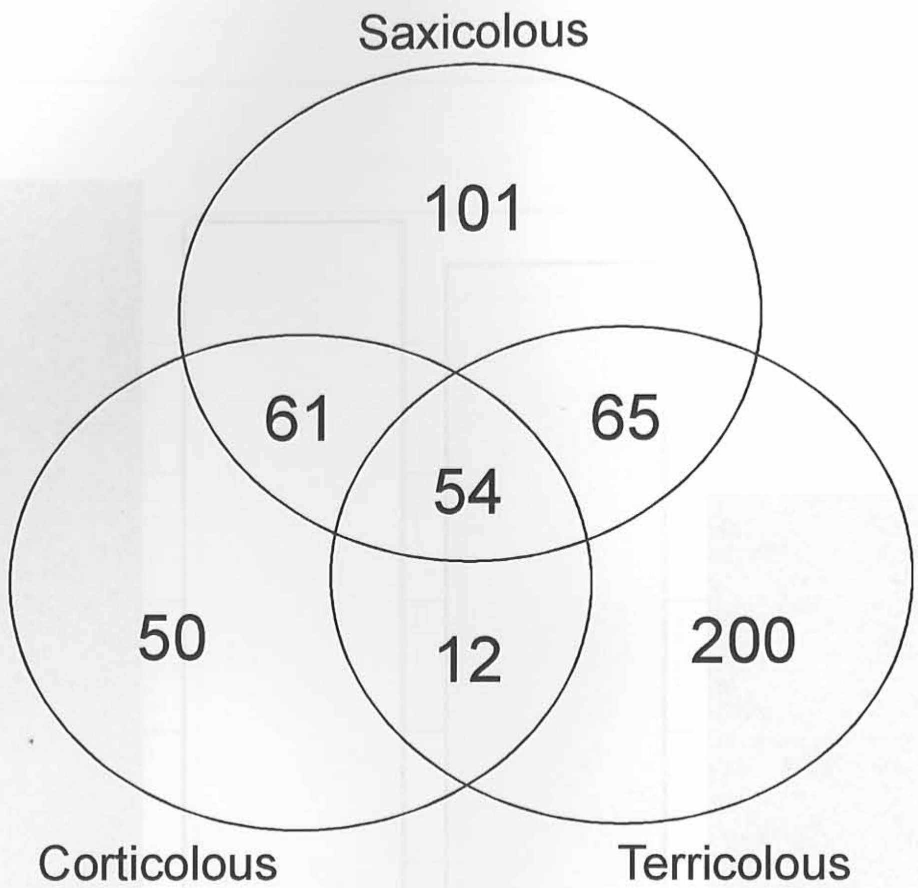


Figure 10. Venn diagram showing the distribution of southern African moss species/infraspecific taxa in the three basic types of substrate (**saxicolous**, **terricolous** and **corticolous**).

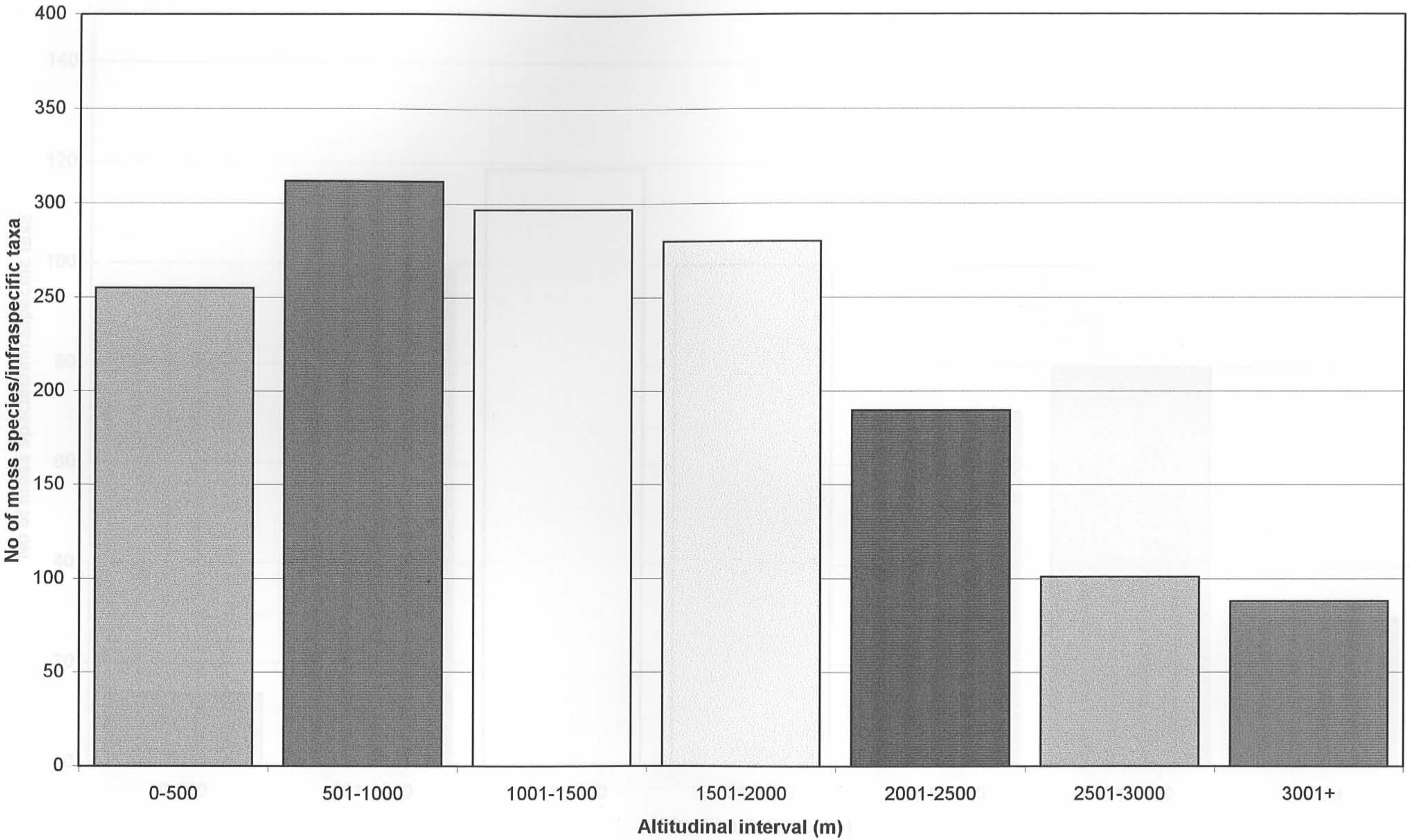


Figure 11. Altitudinal distribution of southern African mosses as represented by specimen data in PRECIS.

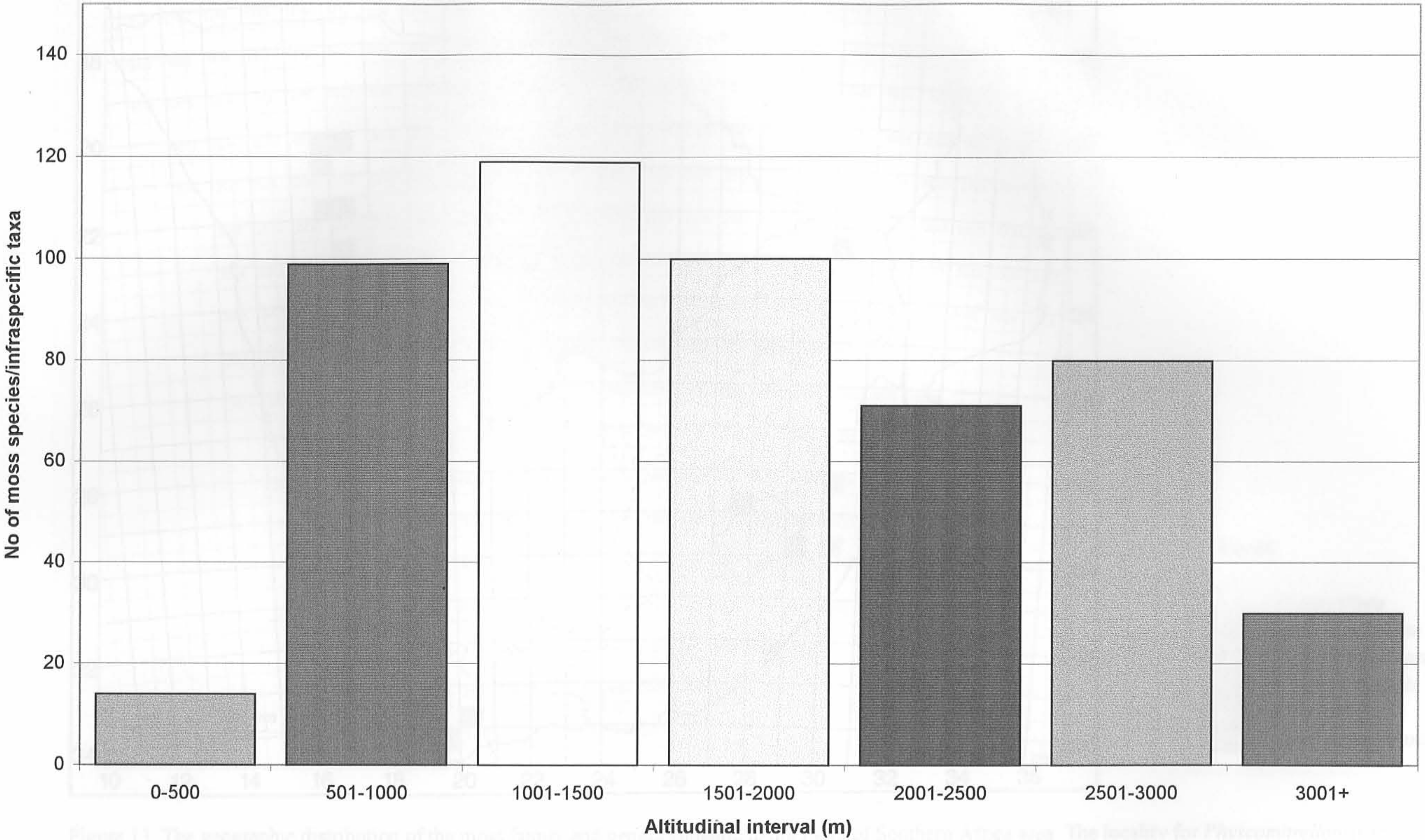


Figure 12. Altitudinal distribution of southern African mosses, as represented by specimen data in PRECIS, along a geographic transect, running from Durban on the KwaZulu-Natal coast (0 m) to the Sani Pass – Sehlabathebe area on top of the Drakensberg Mountains in Lesotho (3394 m), and between latitudes 29° 30′ and 30° 00′ (grid squares 2929 C & D, 2930 C & D, and 2931 C).

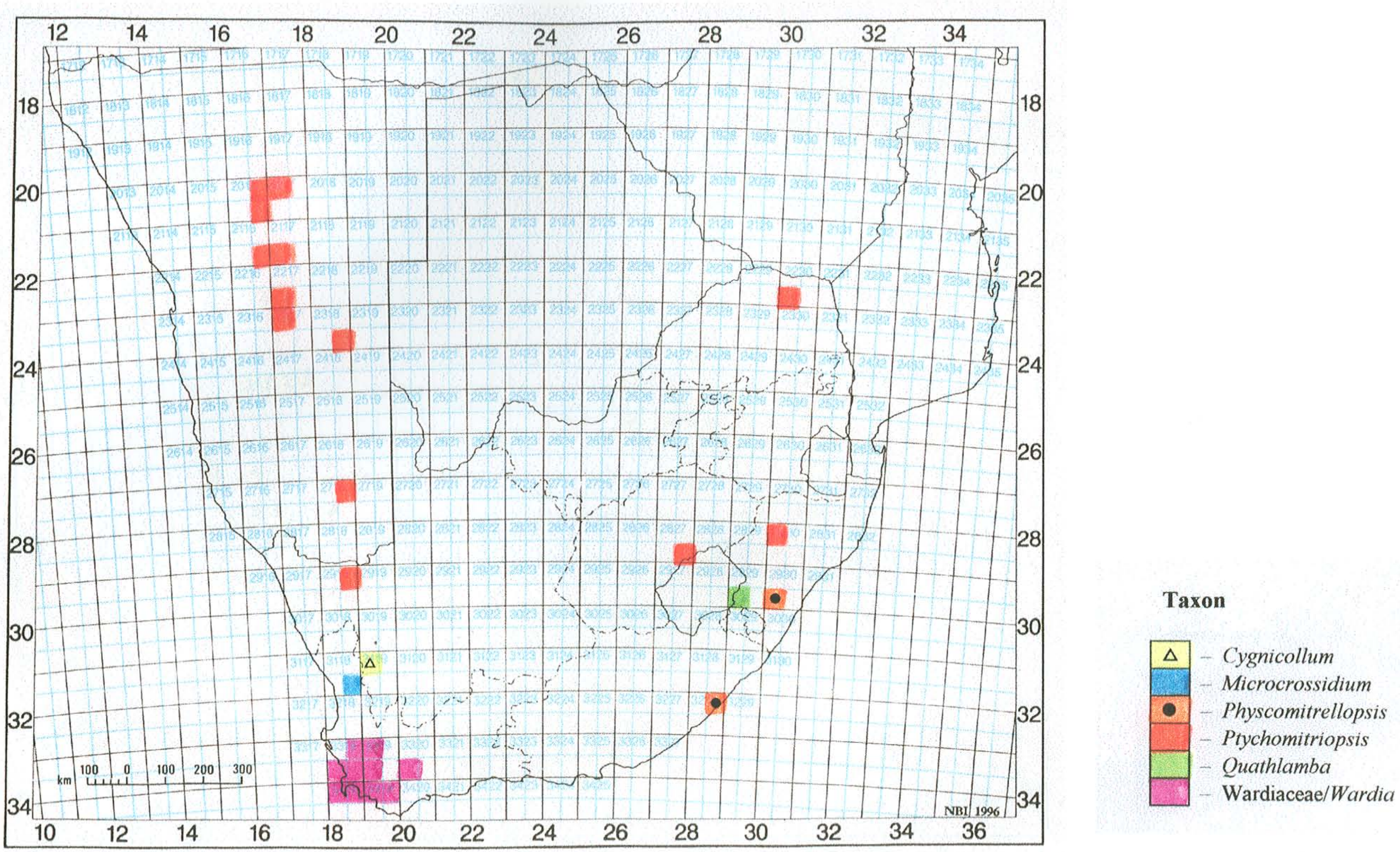


Figure 13. The geographic distribution of the moss family and genera endemic to the Flora of Southern Africa area. The locality for *Physcomitrellopsis* in KwaZulu-Natal is not precise.

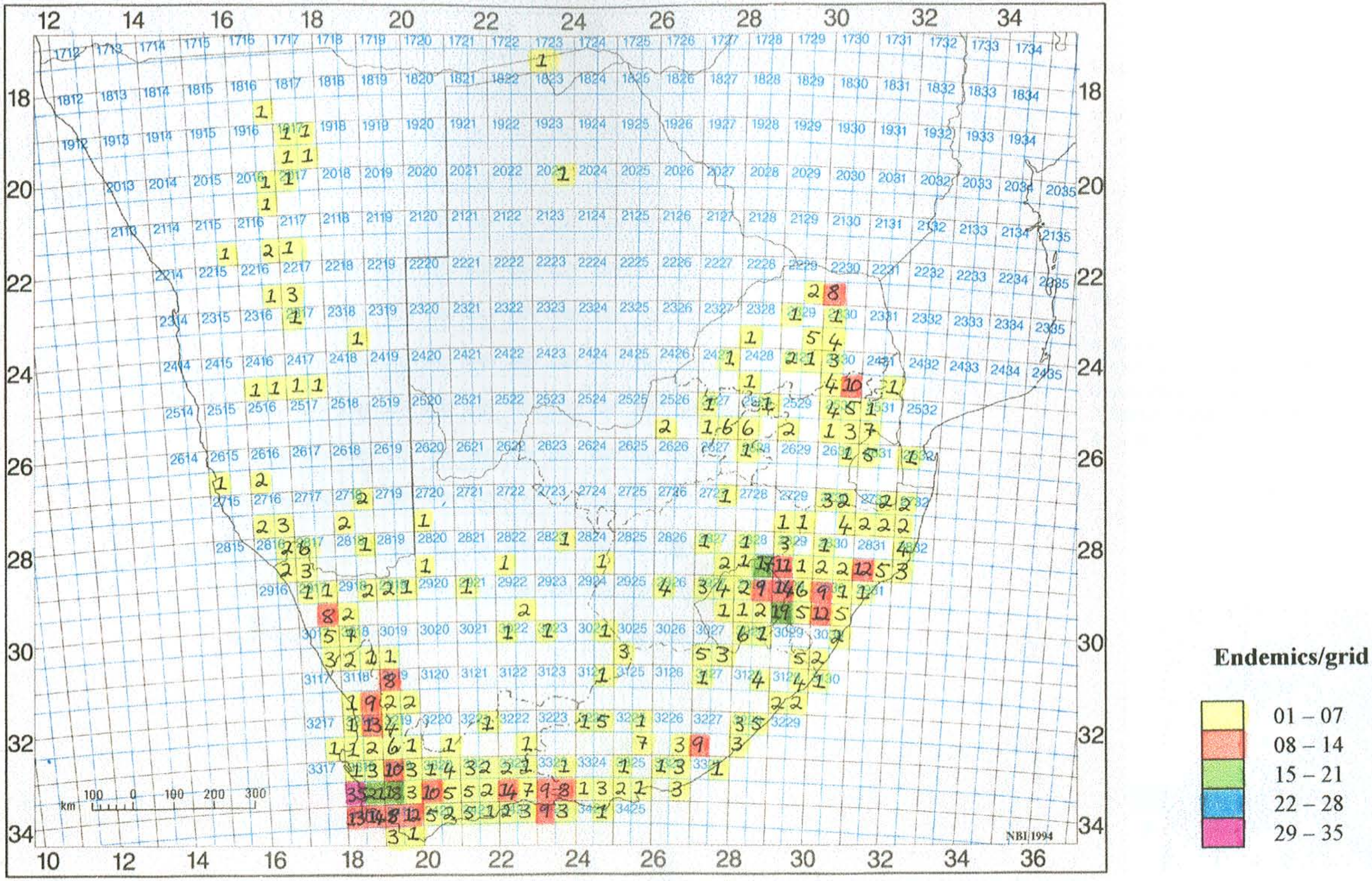
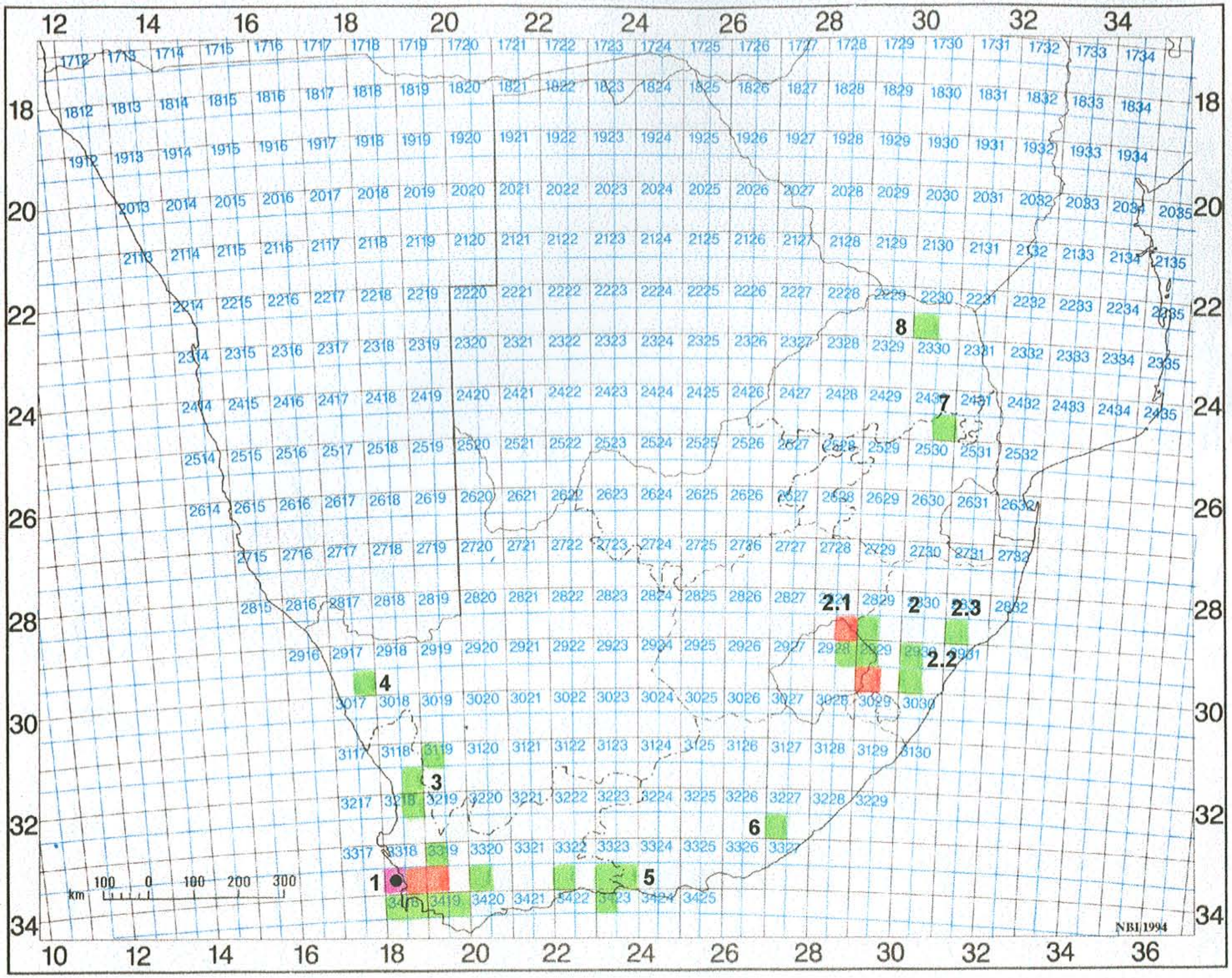


Figure 14. The geographic distribution of southern African endemics (moss species/infraspecific taxa endemic to the FSA area) showing the number of endemics per ½° grid square.



Legend

Main centres

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

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

Endemics/grid

08 – 14
15 – 21
22 – 28
29 – 35

Figure 15. Centres of moss endemism in southern Africa. Only ½° grid squares with eight or more endemics recorded are shown.

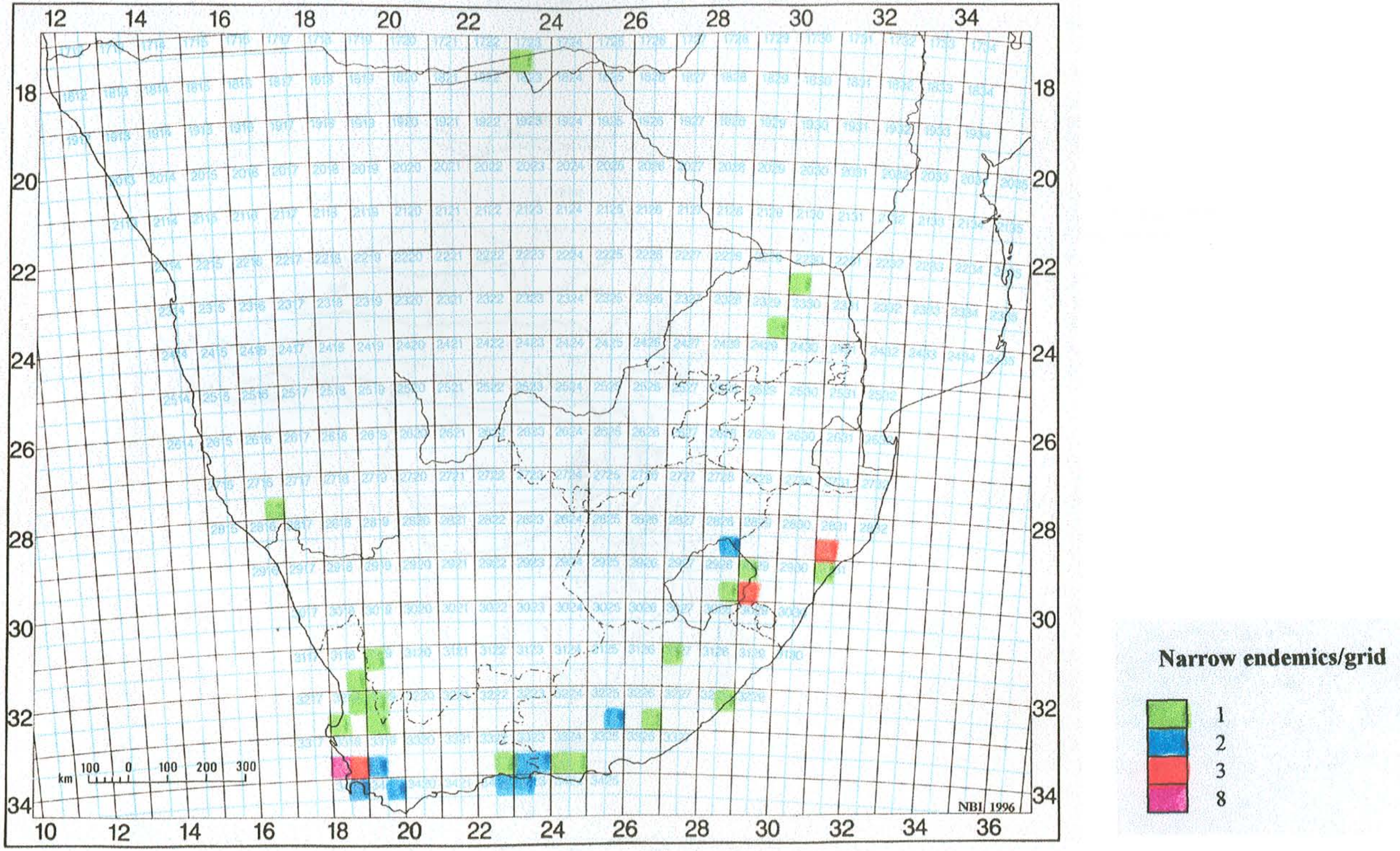
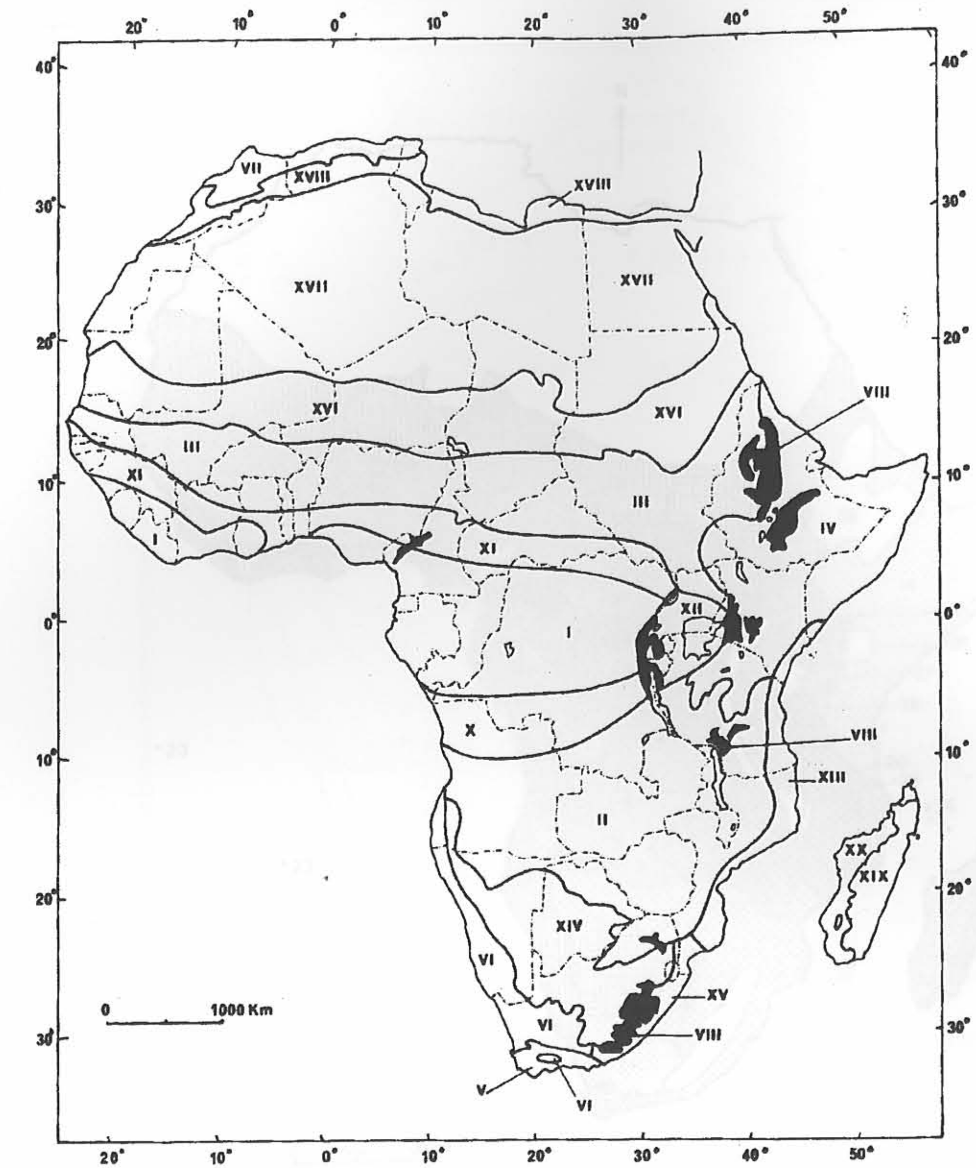
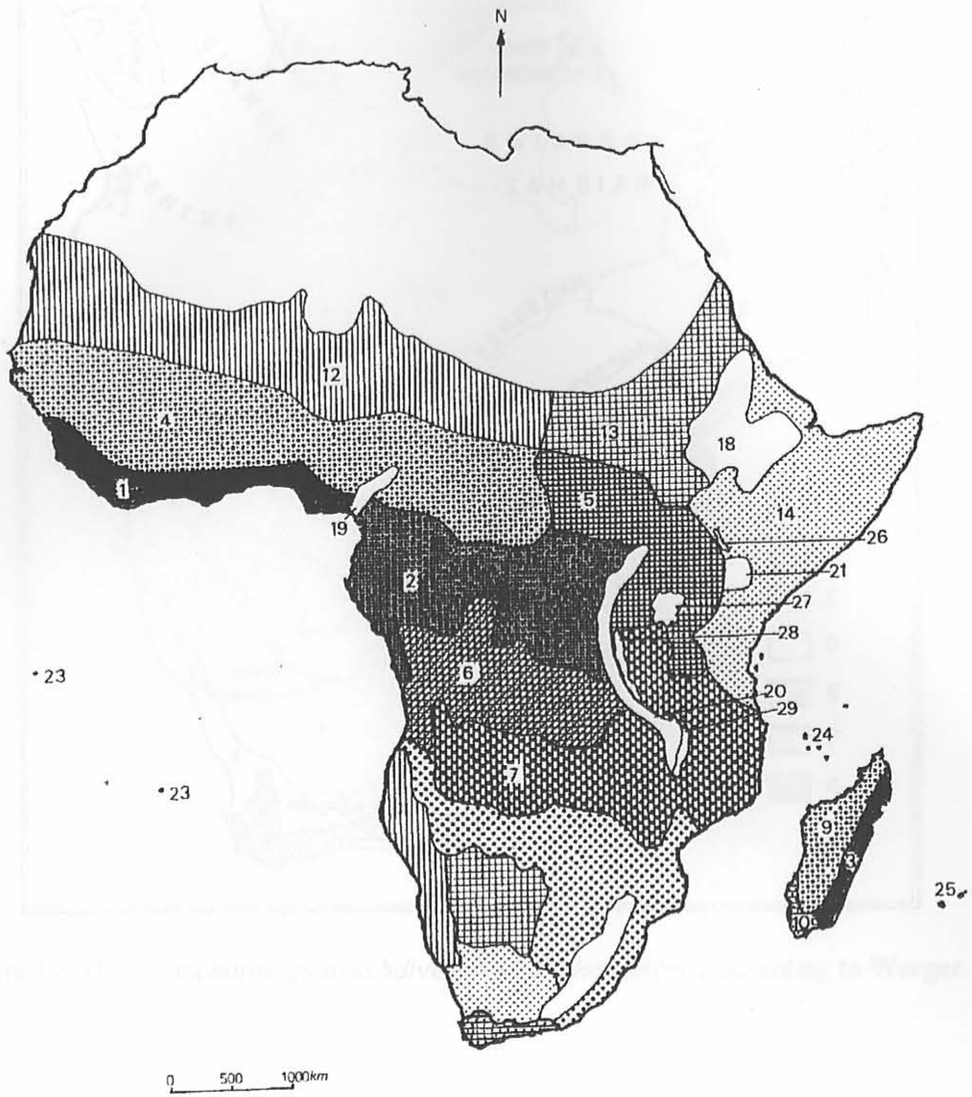


Figure 16. The distribution of narrow moss endemics (species/infraspecific taxa more or less restricted to an area the size of 1° grid square) per ½° grid square, showing the centres of narrow moss endemism in southern Africa.



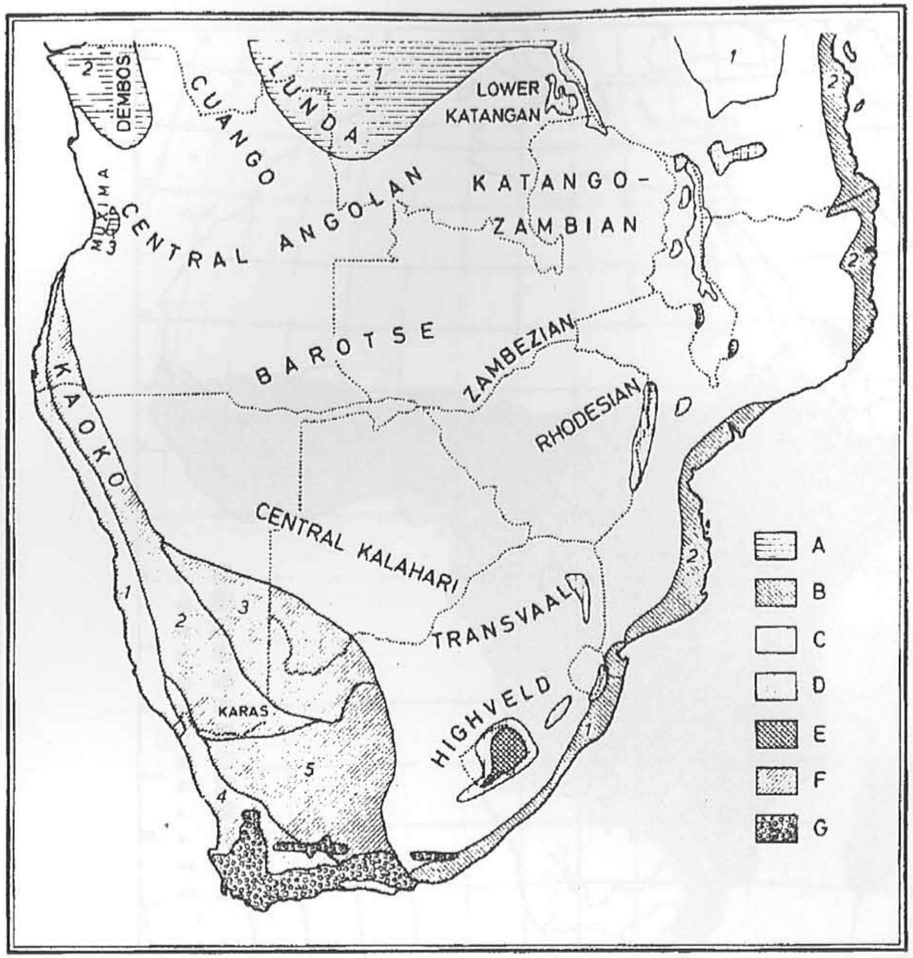
I. Guineo-Congolian regional centre of endemism.
II. Zambezian regional centre of endemism.
III. Sudanian regional centre of endemism.
IV. Somalia – Masai regional centre of endemism.
V. Cape regional centre of endemism.
VI. Karoo-Namib regional centre of endemism.
VII. Mediterranean regional centre of endemism.
VIII. Afromontane archipelago-like regional centre of endemism, including IX, Afroalpine archipelago-like region of extreme floristic impoverishment (not shown separately).
X. Guinea- Congolia/Zambezia regional transition zone.
XI. Guinea-Congolia/Sudania regional transition zone.
XII. Lake Victoria regional mosaic.
XIII. Zanzibar-Inhambane regional mosaic.
XIV. Kalahari-Highveld regional transition zone.
XV. Tongaland-Pondoland regional mosaic.
XVI. Sahel regional transition zone.
XVII. Sahara regional transition zone.
XVIII. Mediterranean/Sahara regional transition zone.
XIX. East Malagasy regional centre of endemism.
XX. West Malagasy regional centre of endemism

Figure 17. The *main phytochoria of Africa and Madagascar* according to **White** (1983).



1. Guinean Rain Forest
2. Congo Rain Forest
3. Malagasy Rain Forest
4. West African Woodland/savanna
5. East African Woodland/savanna
6. Congo Woodland/savanna
7. Miombo Woodland/savanna
8. South African Woodland/savanna
9. Malagasy Woodland/savanna
10. Malagasy Thorn Forest
11. Cape Sclerophyll
12. Western Sahel
13. Eastern Sahel
14. Somalian
15. Namib
16. Kalahari
17. Karoo
18. Ethiopian Highlands
19. Guinean Highlands
20. Central African Highlands
21. East African Highland
22. South African Highlands
23. Ascension and St. Helena Islands
24. Comores and Aldabra
25. Mascarene Islands
26. Lake Rudolf
27. Lake Ukerewe (Victoria)
28. Lake Tanganyika
29. Lake Malawi (Nyasa)

Figure 18. The *Biogeographical Provinces* of the *Afrotropical Realm* according to **Udvardy** (1975).



A. Guineo- Congolian Region
A1. Congolian Domain
A2. Nigerian – Cameroonian Domain (including Littoral South Atlantic Domain)
A3. Amboim Section of A2
B. Indian Ocean Coastal Belt
B1. Tongaland – Pondoland Regional Mosaic
B2. Zanzibar – Inhambane Regional Mosaic
C. Sudano – Zambezian Region (Zambezian Domain)
Cl. Oriental Domain
D. Afromontane Region
E. Afro-alpine Region (Austral Domain)
F. Karoo-Namib Region
F1. Namib Domain
F2. Namaqualand Domain
F3. Southern Kalahari Subdomain
F4. Western Cape Domain
F5. Karoo Domain
G. Capensis

Figure 19. The *phytochorological subdivision of southern Africa* according to **Werger** (1978).

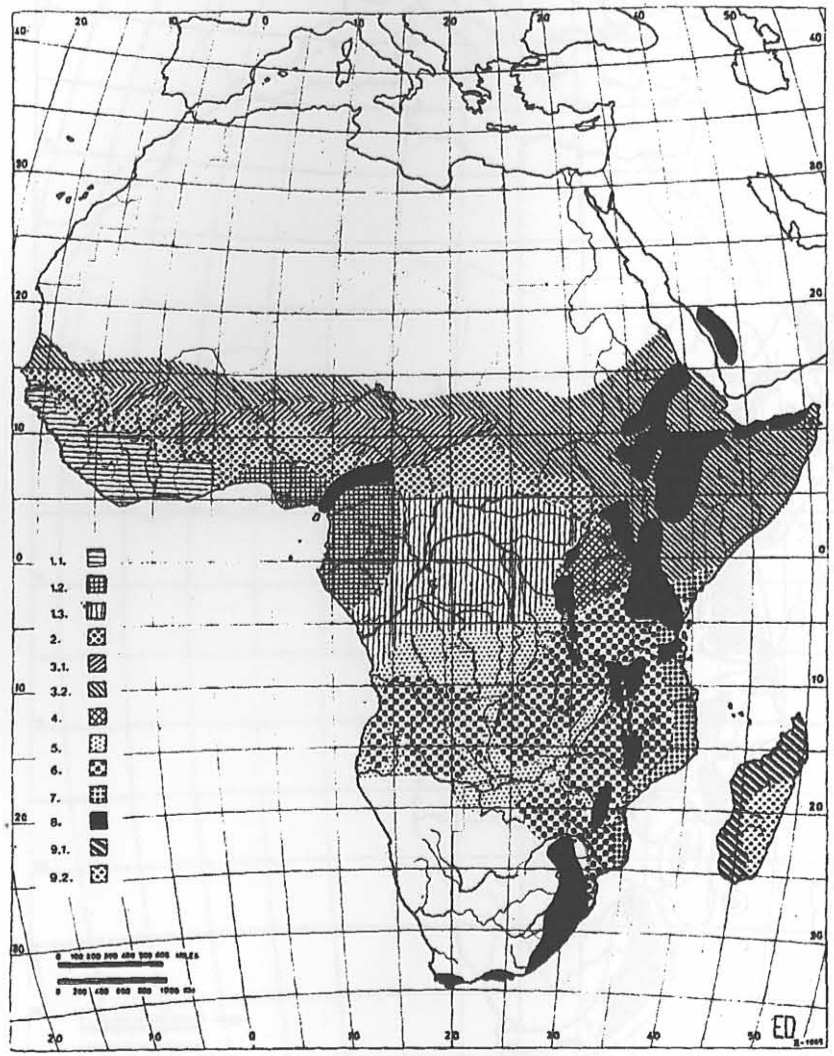


Figure 20. The *phytogeographical division of Africa* by **Denys** (1979, 1980). 1, Guineo-Congolian Region (1.1 Upper Guinea Domain, 1.2 Lower Guinea Domain, 1.3 Congo Basin Domain); 2, Guinea-Congolia/Sudanian Region; 3, Sudanian Region (3.1 Southern Subregion, 3.2 Northern Subregion); 4, Region of the Central African Lakes; 5, Guinea-Congolia/Zambezia Transition Region; 6, Zambezian Region; 7, Region of the Indian Ocean Coastal Belt; 8, Afromontane Region; 9, Madagascan Region (9.1 Occidental Domain, 9.2 Oriental Domain).

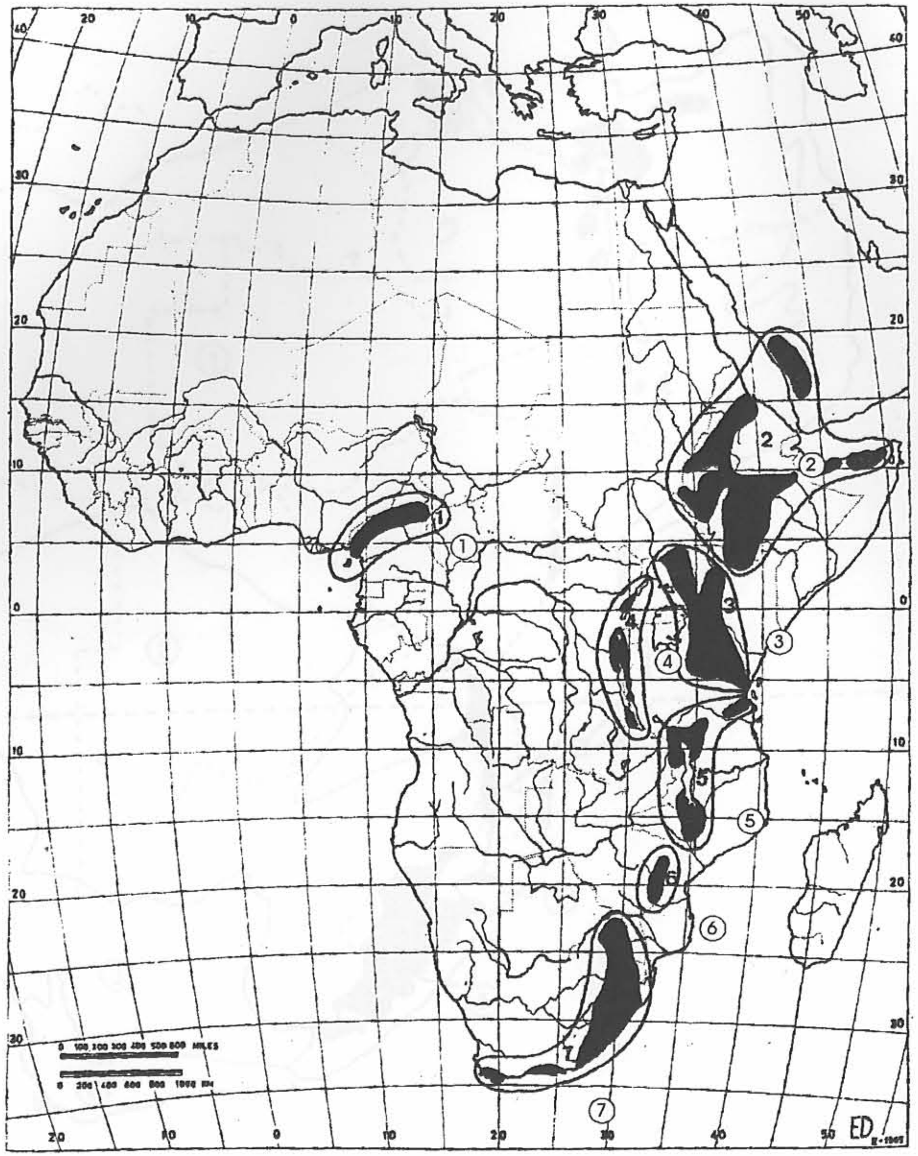


Figure 21. The seven *Mountain Domains* of the *Afromontane Region* according to **Denys** (1979). 1 = West African Domain, 2 = Ethiopian Domain, 3 = Imatongs-Usambara Domain, 4 = Kivu-Ruwenzori Domain, 5 = Uluguru-Mlanje Domain, 6 = Chimanimani Domain, 7 = Drakensberg Domain.

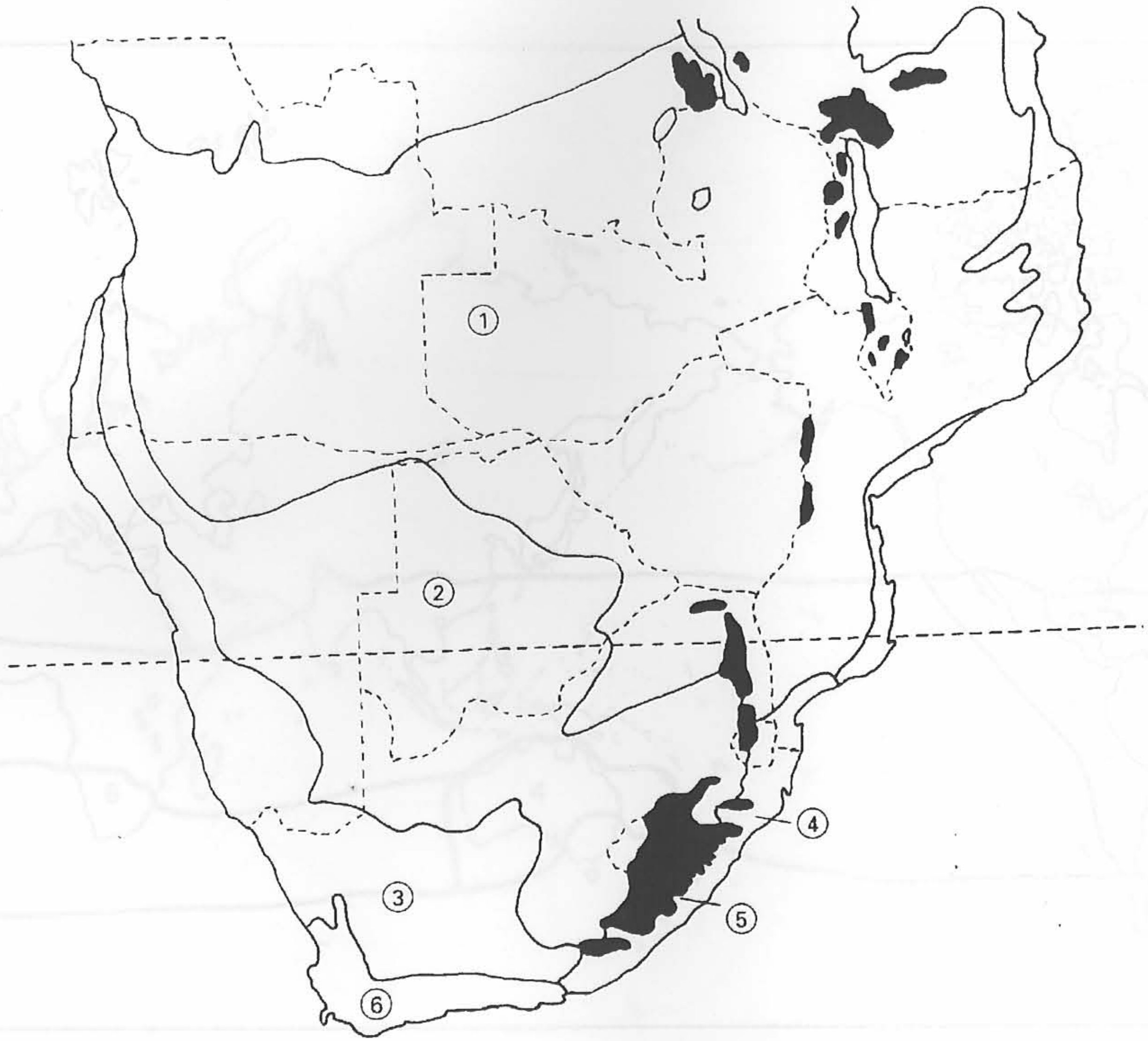


Figure 22. The *phytogeographical regions* of southern Africa according to **Goldblatt** (1978) and **Cowling & Hilton-Taylor** (1997). 1 = Zambezian Region, 2 = Kalahari-Highveld Transition Zone, 3 = Karoo-Namib Region, 4 = Tongaland-Pondoland Region, 5 = Afromontane Region, 6 = Cape Region.

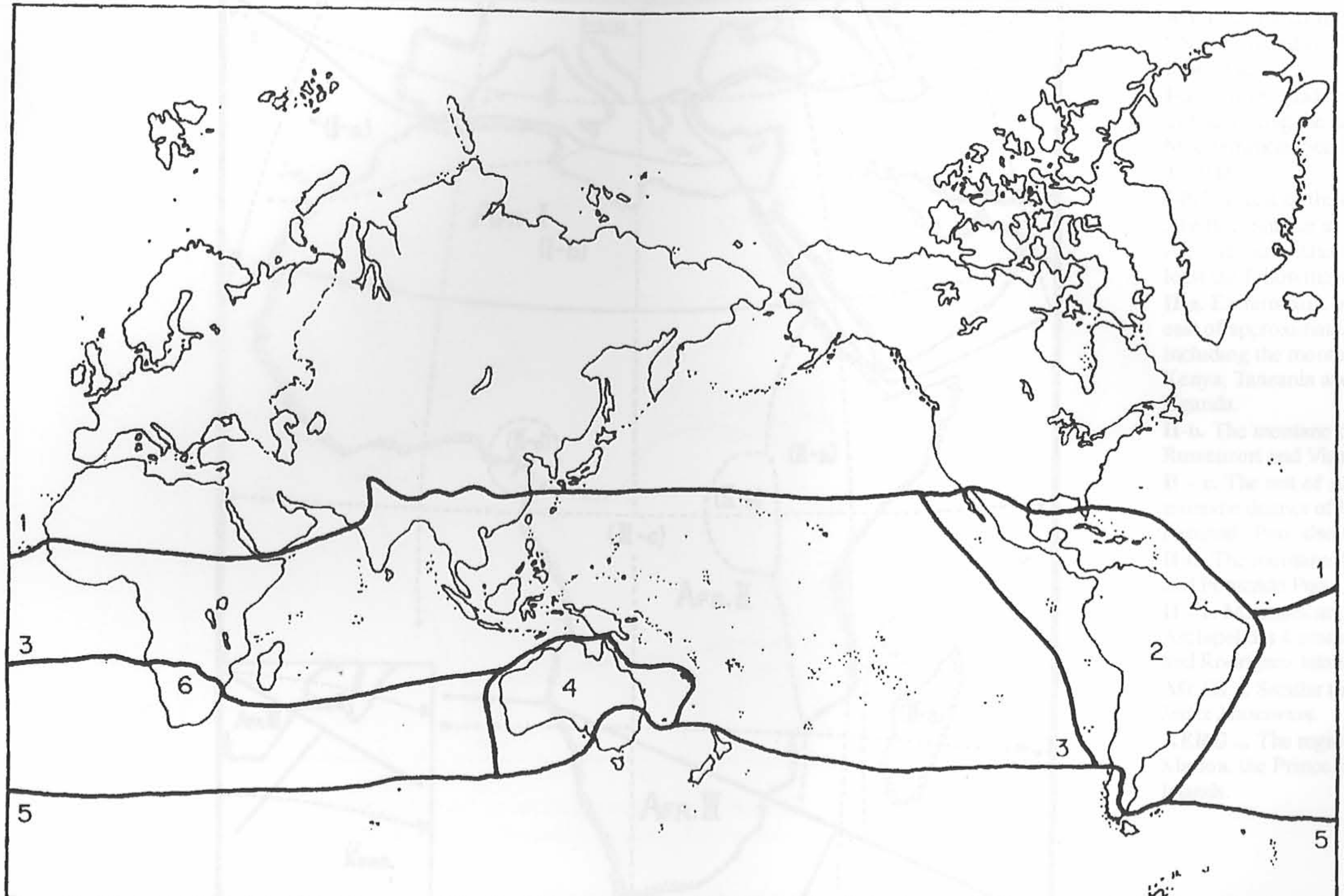
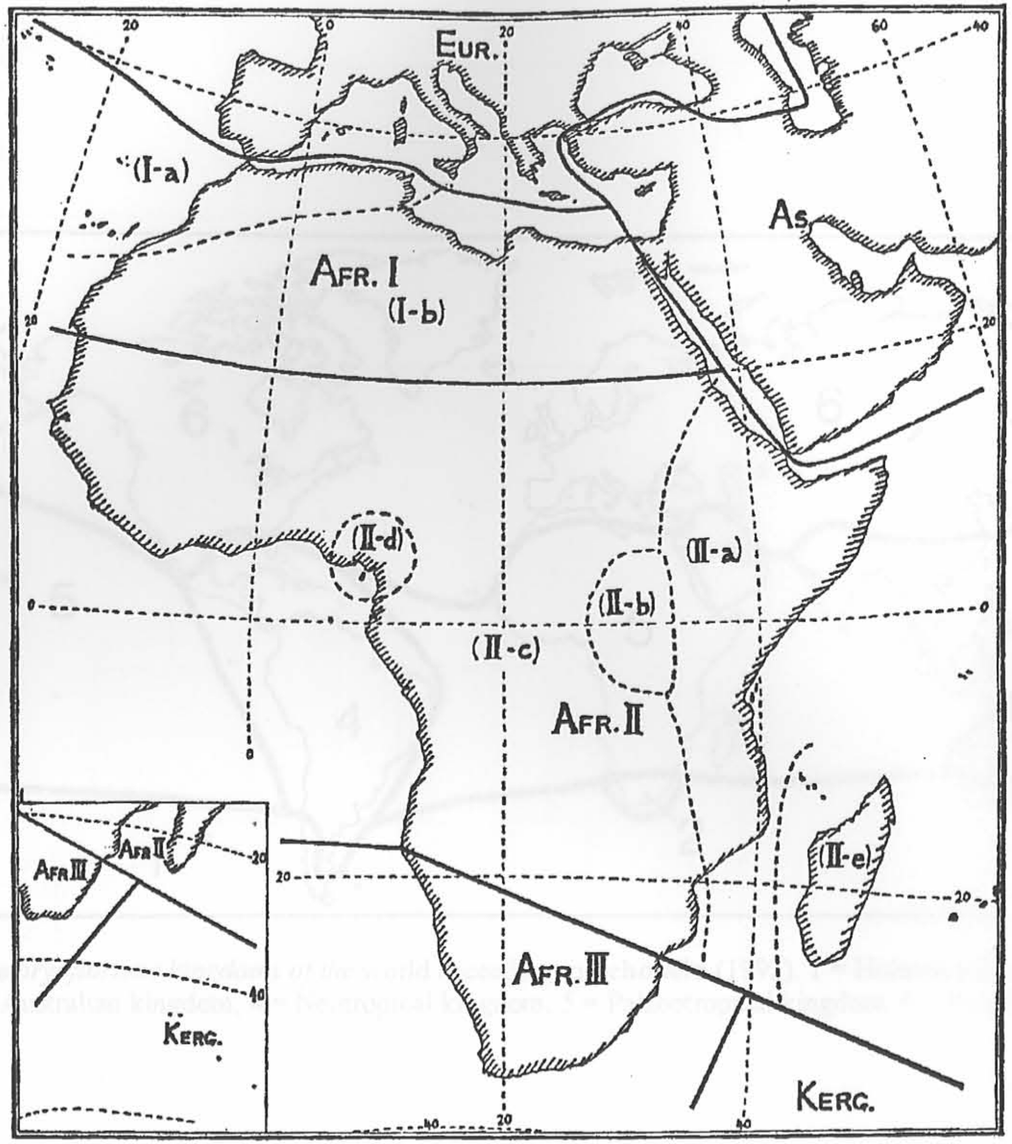


Figure 23. The *Florenreiche* of **Herzog** (1926) as presented by **Miller** (1982). 1 = Holarktisches Florenreich, 2 = Neotropisches Florenreich, 3 = Paläotropische Florenreich, 4 = Australisches Florenreich, 5 = Austral-antarktisches Florenreich, 6 = Südafrikanisches Florenreich.



Afr 1 ... Similar to Afr 1 in *Index Musrorum,* but further subdivided into the following:

I-a. Azores, Madeira, Canaries and the districts along the coast of the Mediterranean Sea in Morocco, Algeria and Tunisia.

I-b. The rest of the continental Afr 1.

Afr II ... Similar to the sum of Afr 2 and Afr 3 in *Index Muscorum,* and including at least the following subdivisions:

II-a. Eastern parts of the continental Afr 2: east of approximately 32° E Long., including the montane districts in Ethiopia, Kenya, Tanzania and eastern part of Uganda.

II-b. The montane districts including the Ruwenzori and Virunga Mts.

II – c. The rest of Afr 2, excepting the montane district of Mt. Cameroun and Fernando Poo, also including S. Tomé

II-d. The montane district of Mt. Cameroun and Fernando Poo.

II – e. Madagascar, possibly including Archipel des Comores, Reunion, Mauritius and Rodriguez Island also.

Afr III ... Similar to the continental Afr 4 in *Index Muscorum.*

KERG ... The region including Kerguelen, Marion, the Prince Edward and the Crozet Islands.

Figure 24. The *phytogeographical division of Africa, Madagascar and neighbouring islands* by **Ochi** (1973).

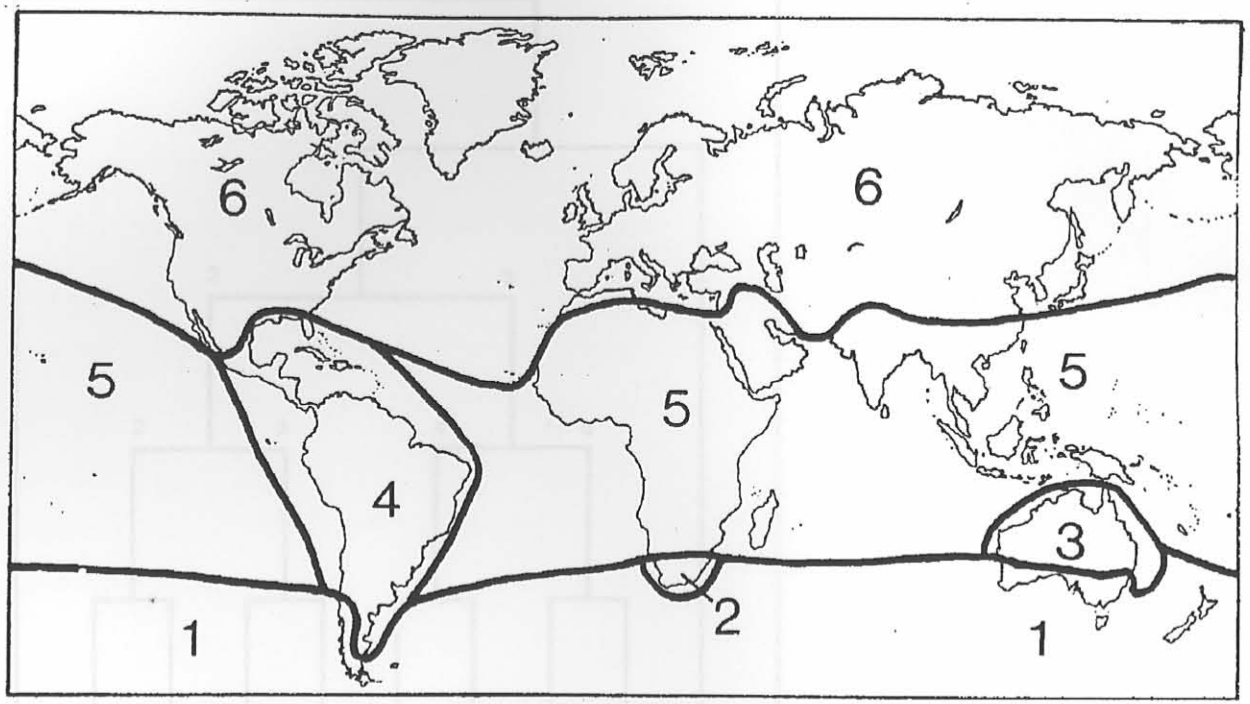


Figure 25. The *bryofloristic kingdoms of the* world according to **Schofield** (1992). 1 = Holantarctic kingdom, 2 = South African kingdom, 3 = Australian kingdom, 4 = Neotropical kingdom, 5 = Palaeotropical kingdom, 6 = Holarctic kingdom.

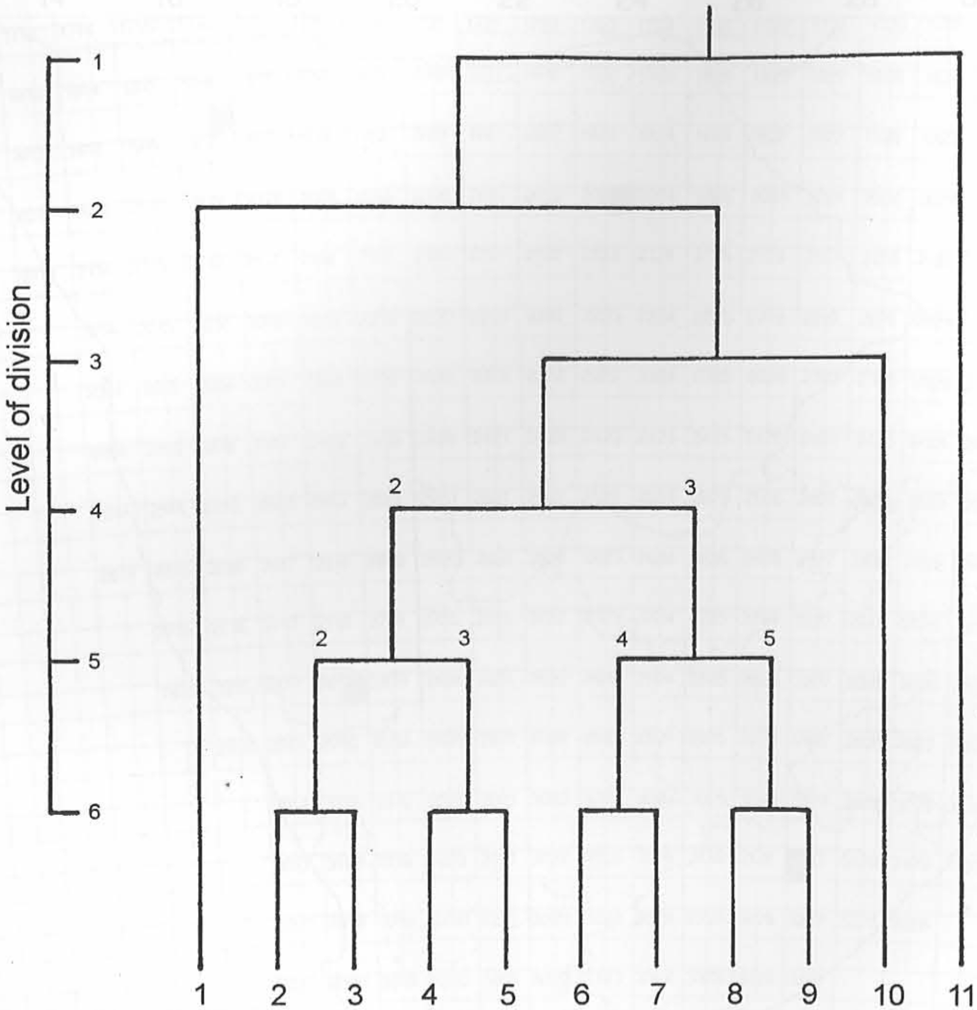


Figure 26. Dendrogram of the **TWINSPAN Complete** classification of grid squares into **bryofloristic regions**.

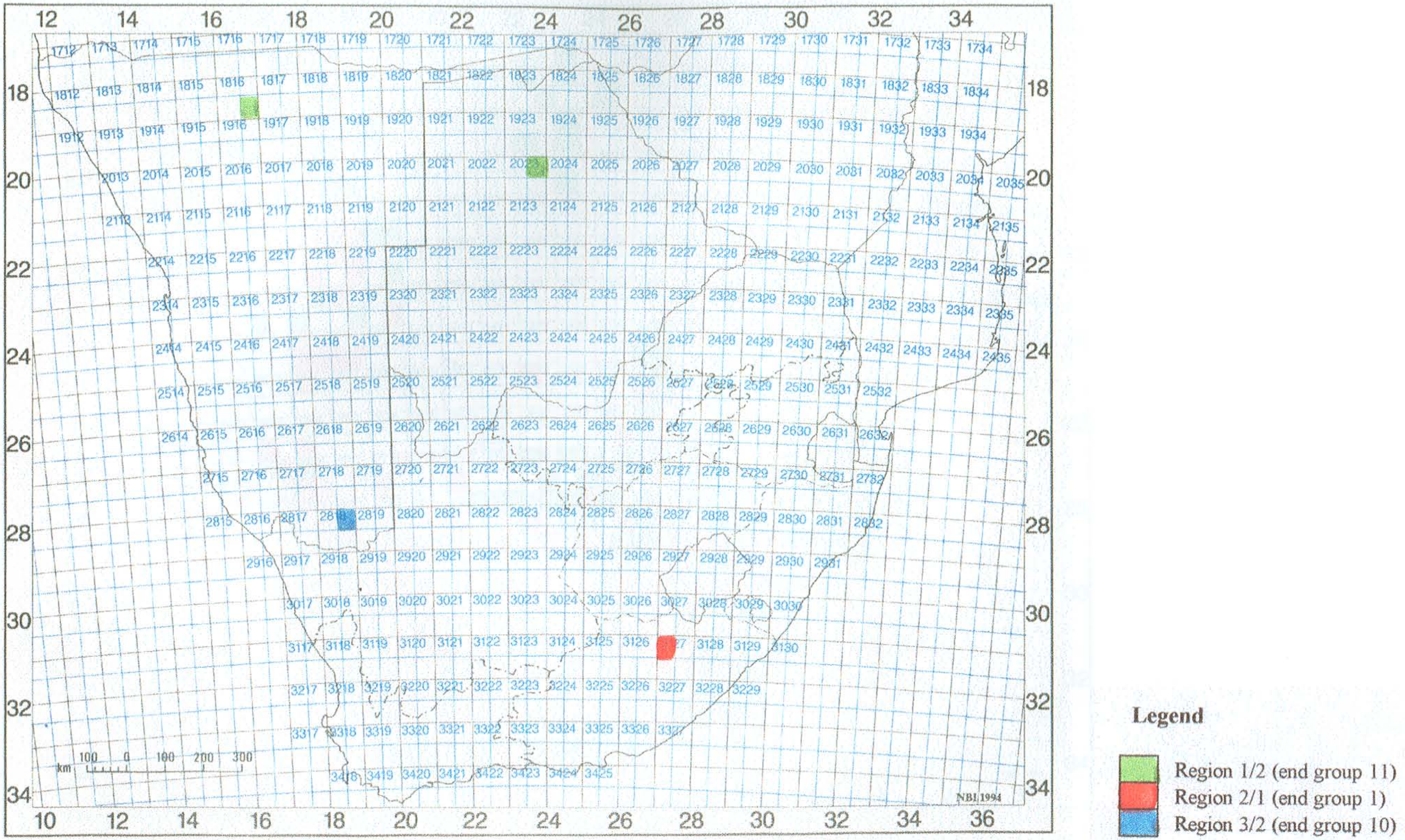


Figure 27. The bryogeographic regions delimited at the first three divisions of the TWINSPAN Complete grid classification (regions 1/2, 2/1 and 3/2 or end groups 1, 10 and 11). The numbering of the groups is the same as in the dendrogram of the TWINSPAN Complete grid classification (Figure 26).

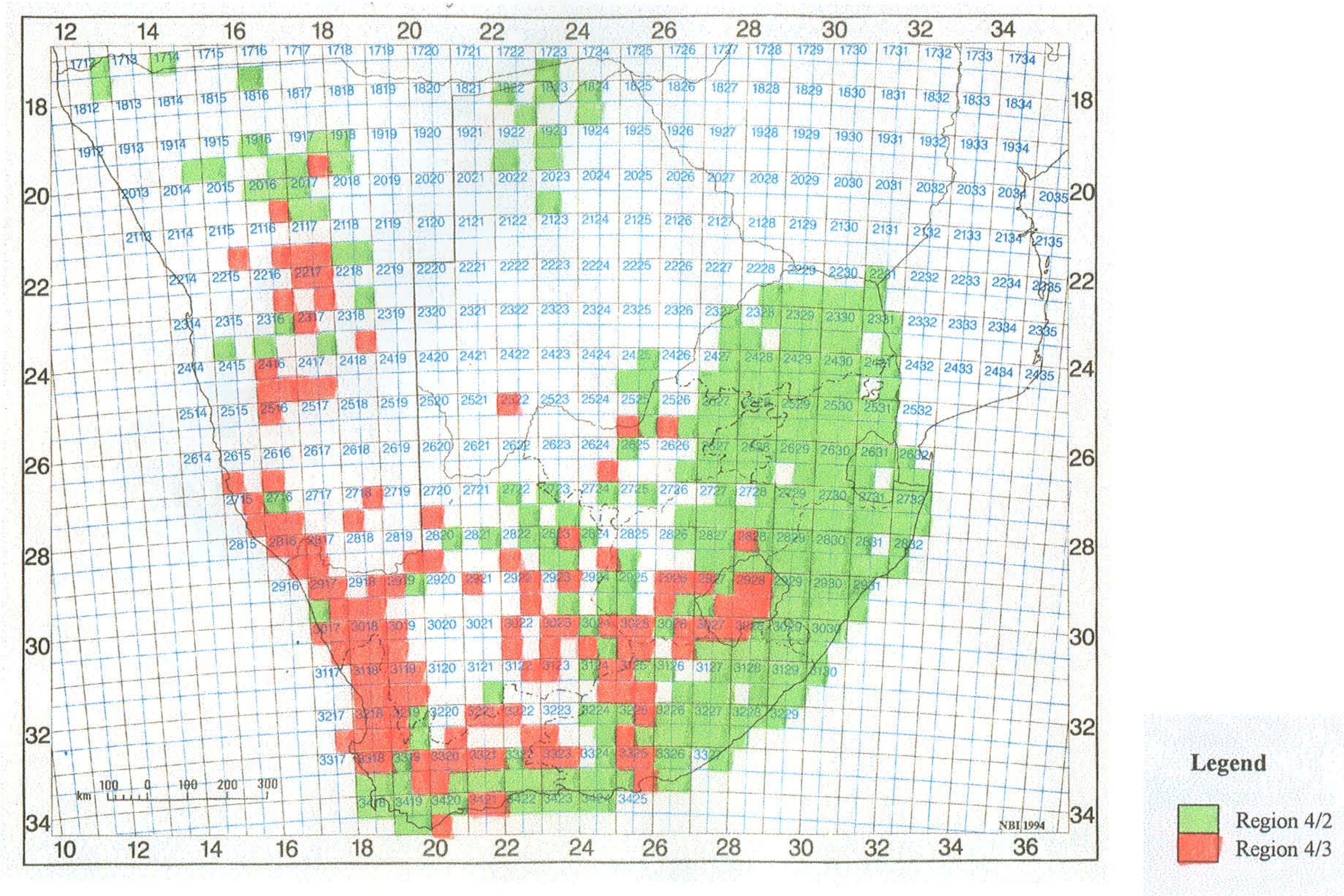


Figure 28. The two main bryogeographic regions in southern Africa (regions 4/2 and 4/3) as delimited by the **TWINSPAN Complete** grid classification (4th level of division, regions 2 & 3). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN Complete grid classification (Figure 26).

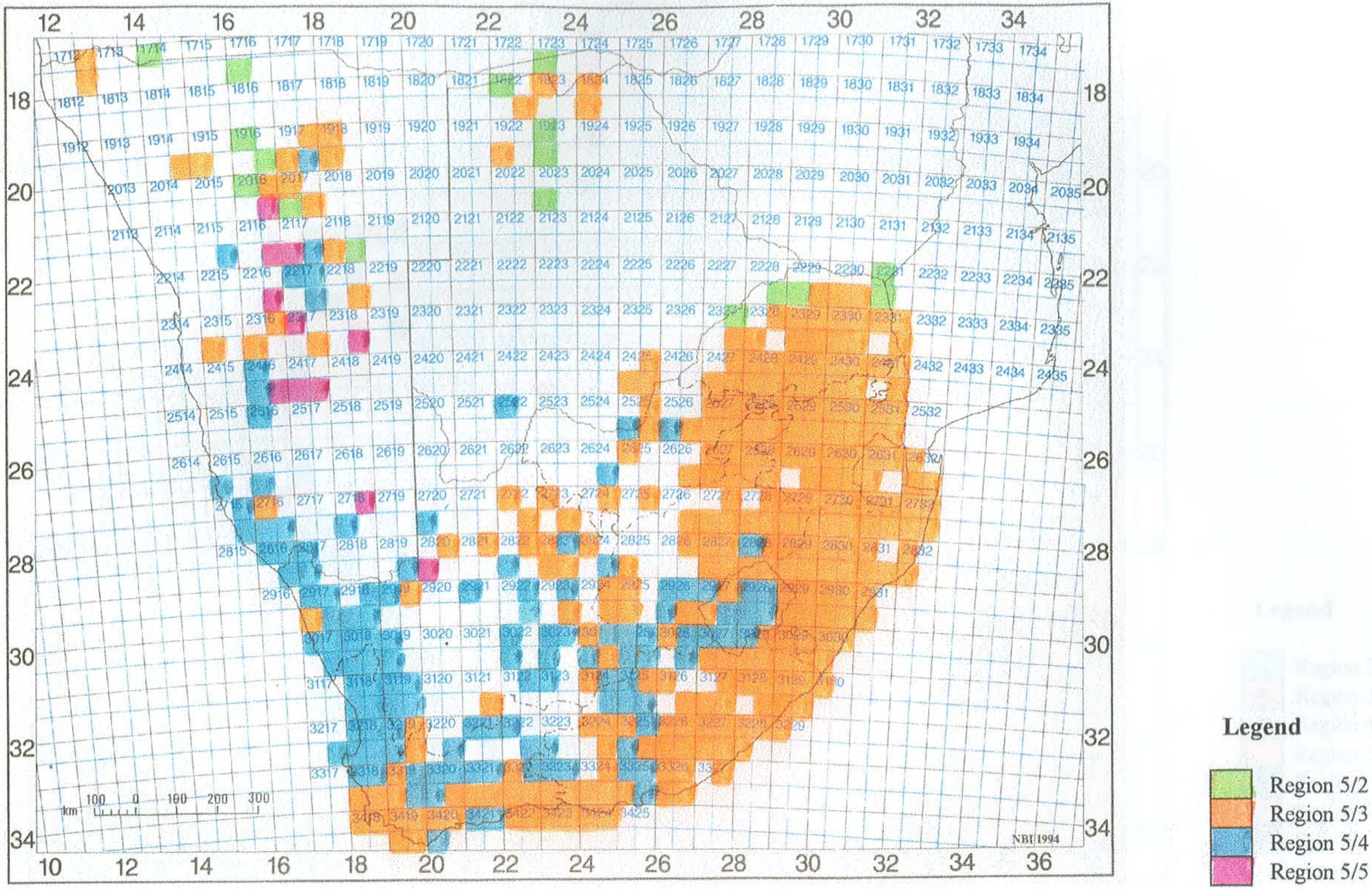


Figure 29. The four main bryogeographic regions in southern Africa (regions 5/2, 5/3, 5/4 and 5/5) as delimited by the TWINSPAN Complete grid classification (5th level of division, groups 2–5). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN Complete grid classification (Figure 26).

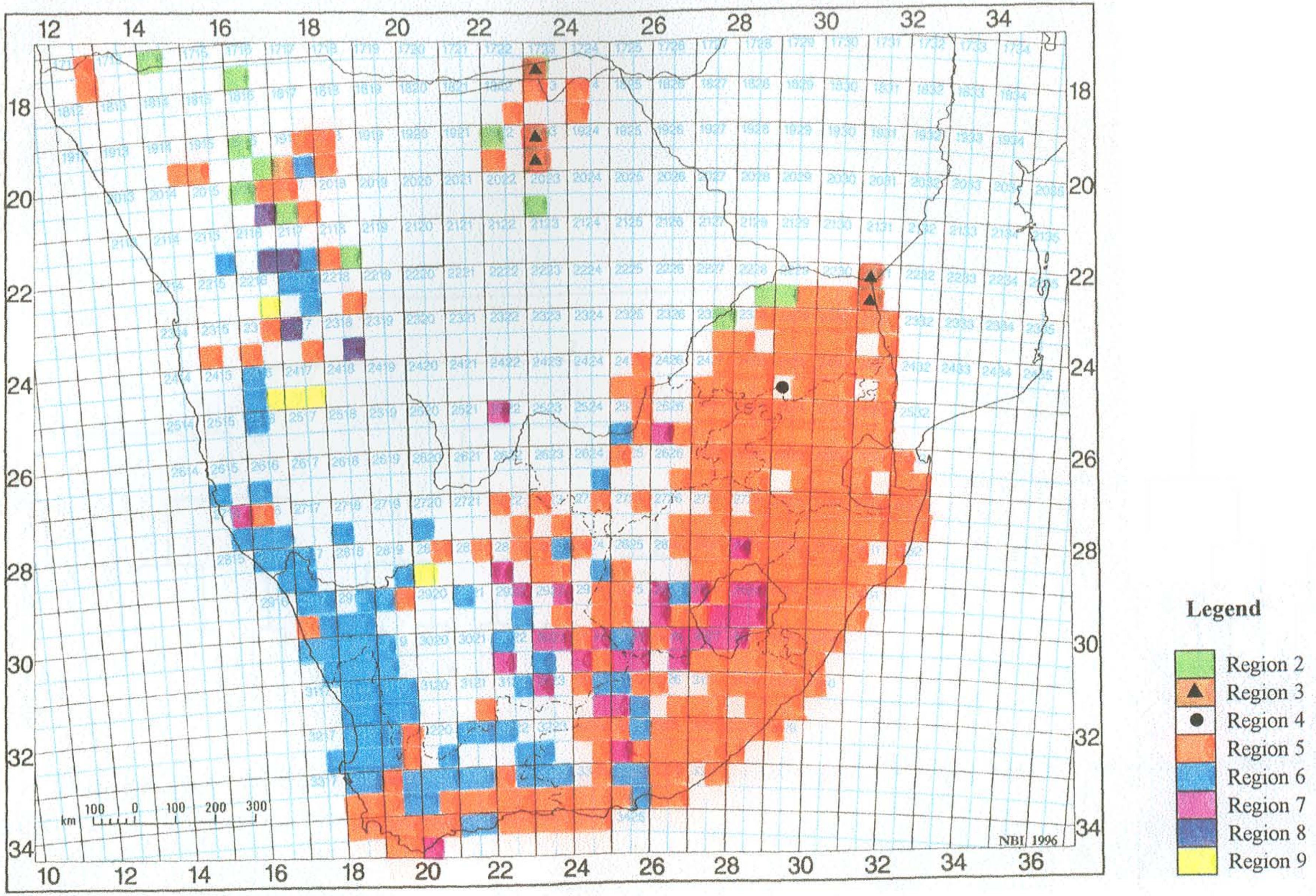


Figure 30. The eight main bryogeographic regions in southern Africa (end groups or regions 2-9) delimited by the TWINSPAN Complete grid classification. The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN Complete grid classification (Figure 26).

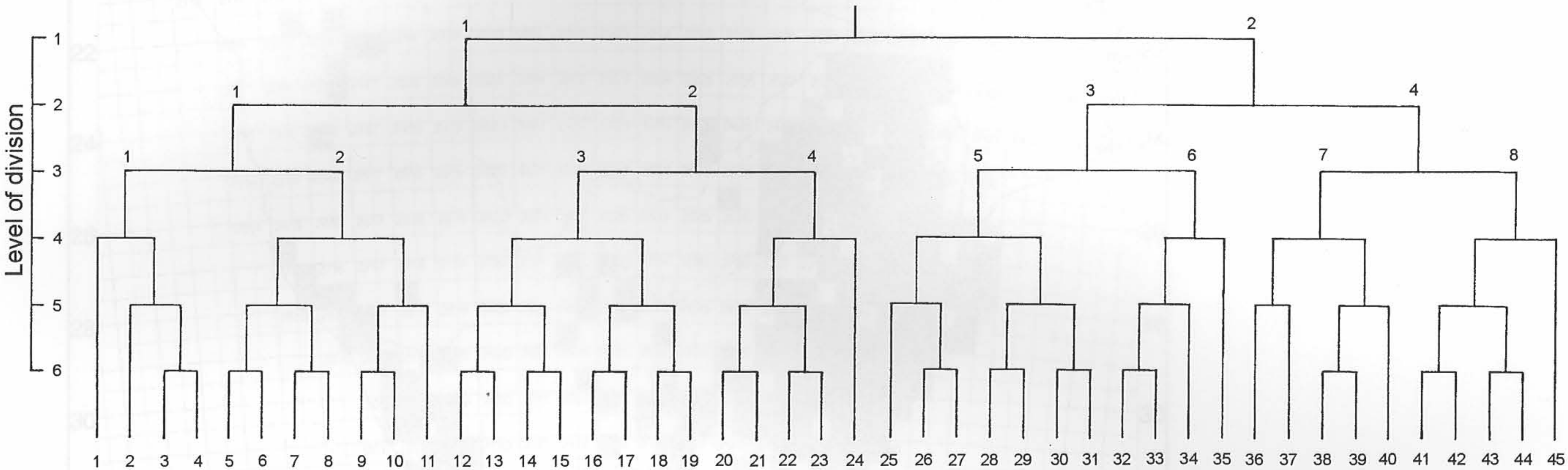


Figure 31. Dendrogram of the **TWINSPAN 3+** classification of grid squares into **bryofloristic regions**. The regions at the different levels of division have been numbererd in the order of the two-way matrix.

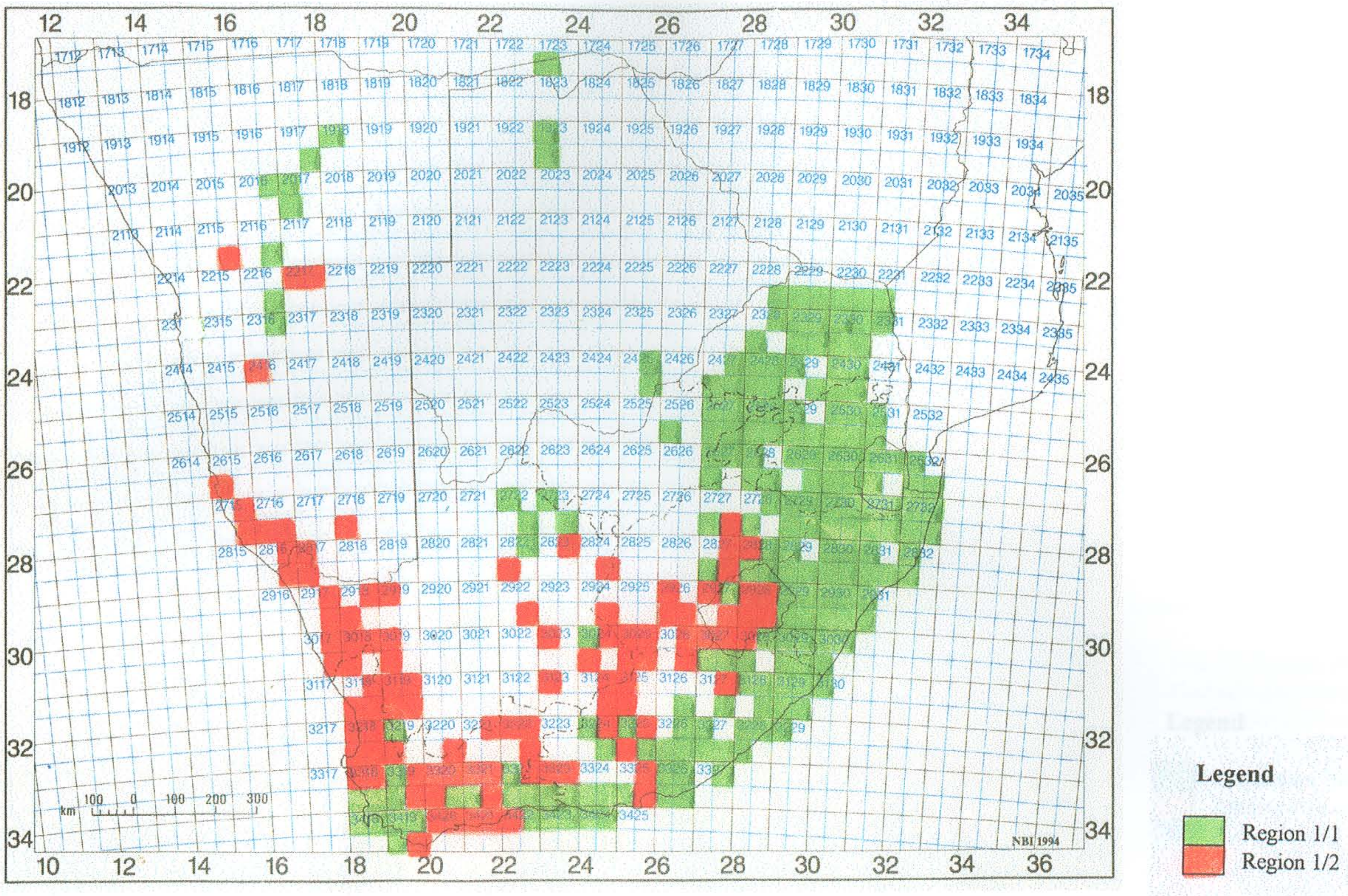


Figure 32. The two main bryogeographic regions in southern Africa (regions 1/1 and 1/2) as delimited by the **TWINSPAN 3+** grid classification (1st level of division, groups 1 & 2). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ grid classification (Figure 31).

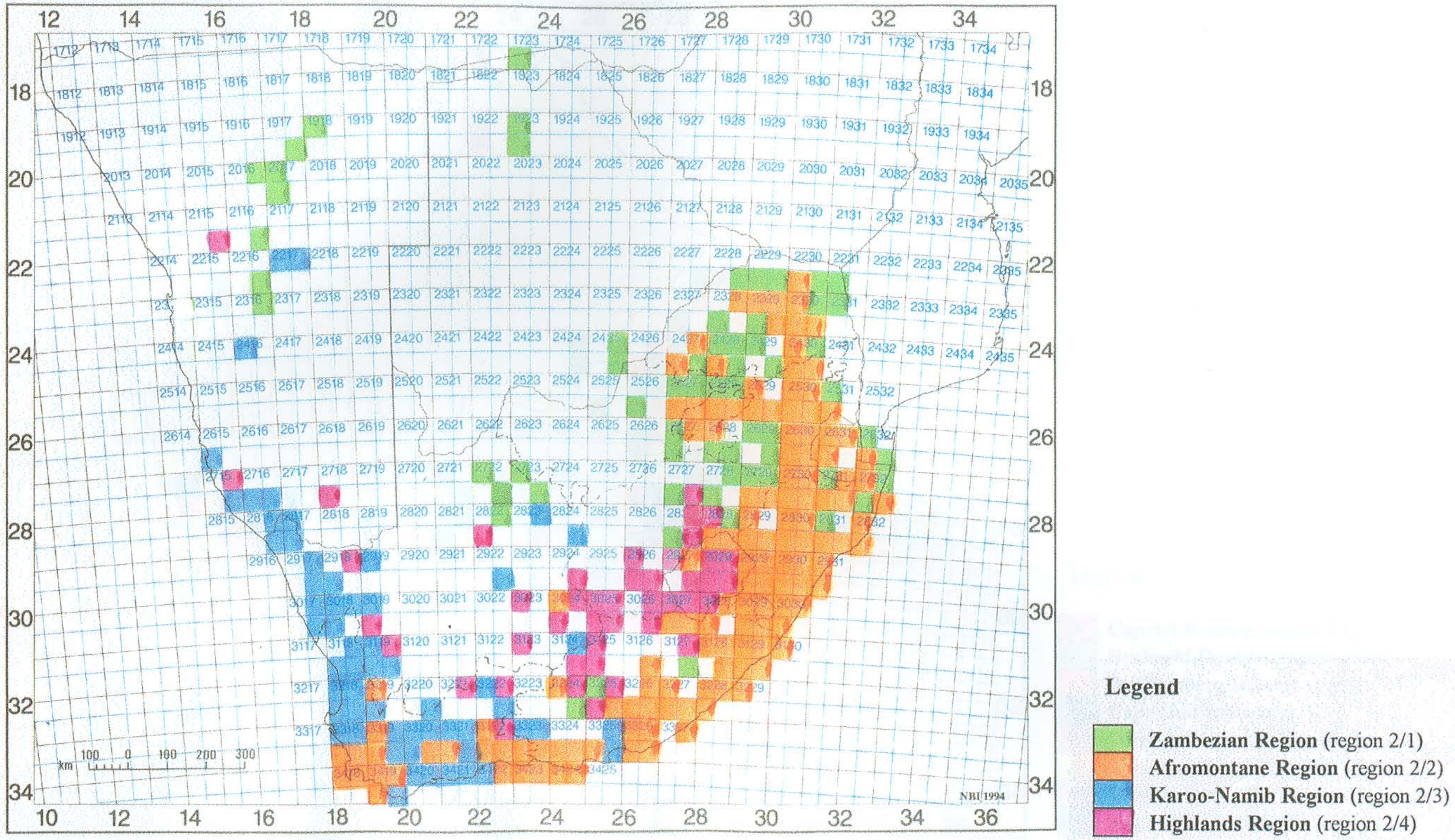


Figure 33. The **Bryogeographic Regions** of southern Africa as delimited by the **TWINSPAN 3+** grid classification (2nd level of division, groups 1–4). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ grid classification (Figure 31).

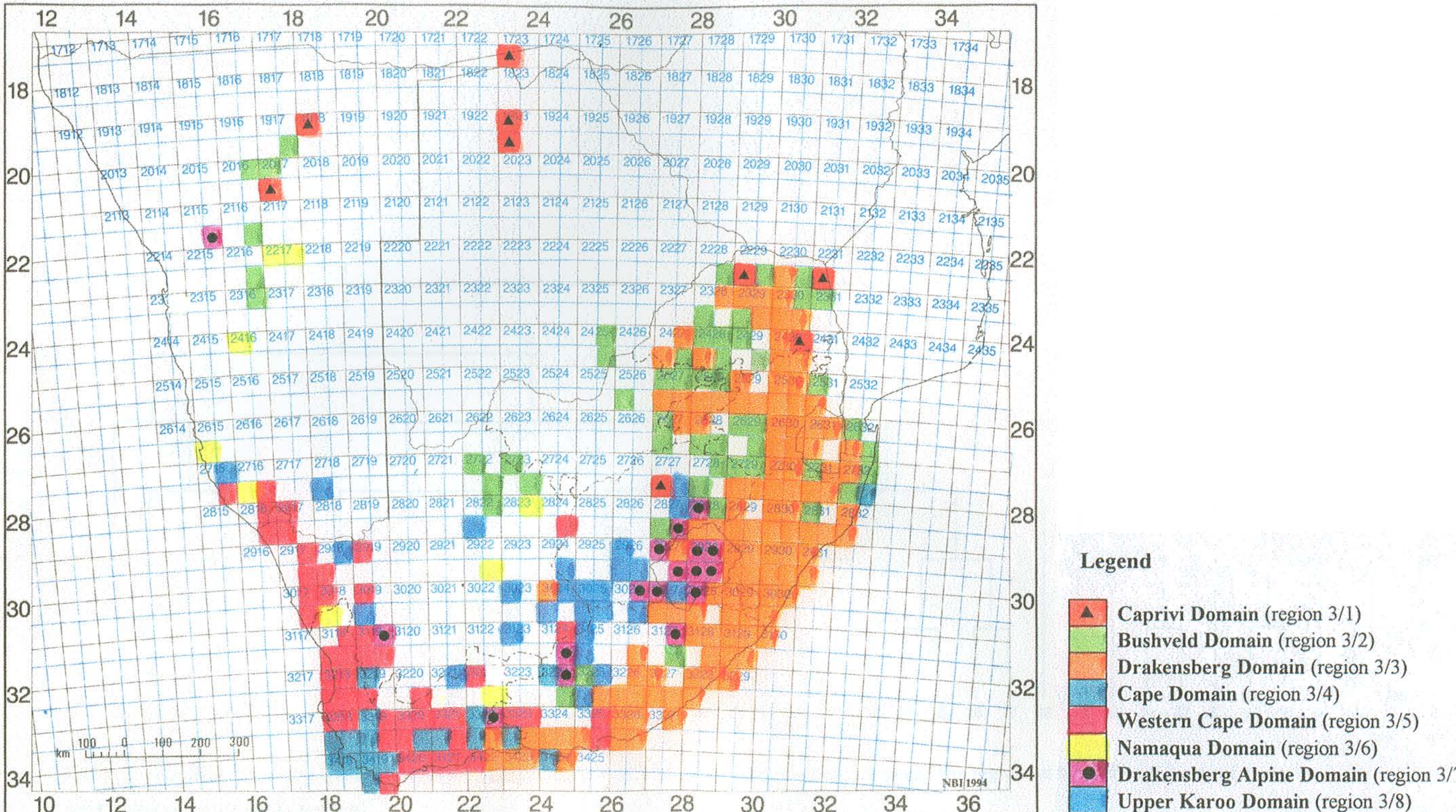


Figure 34. The **Bryogeographic Domains** of southern Africa as delimited by the **TWINSPAN 3+** grid classification (3rd level of division, groups 1–8). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN 3+ grid classification (Figure 31).

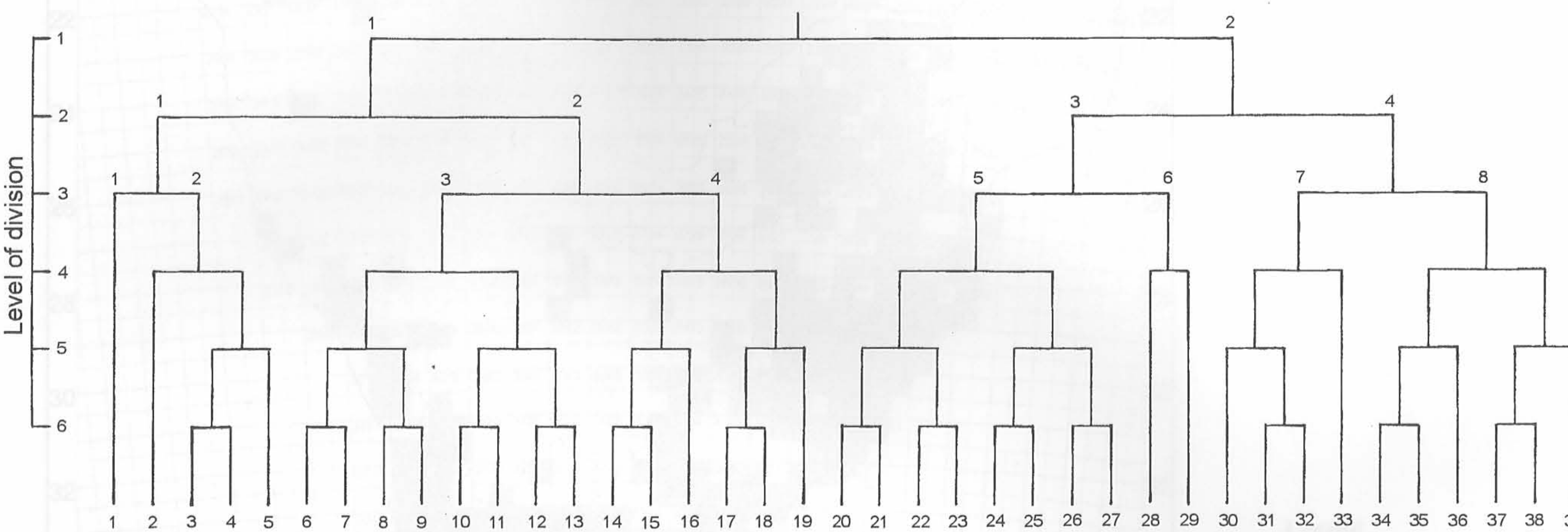


Figure 35. Dendrogram of the **TWINSPAN 5+** classification of grid squares into **bryofloristic regions**. The regions at the different levels of division have been numbererd in the order of the two-way matrix.

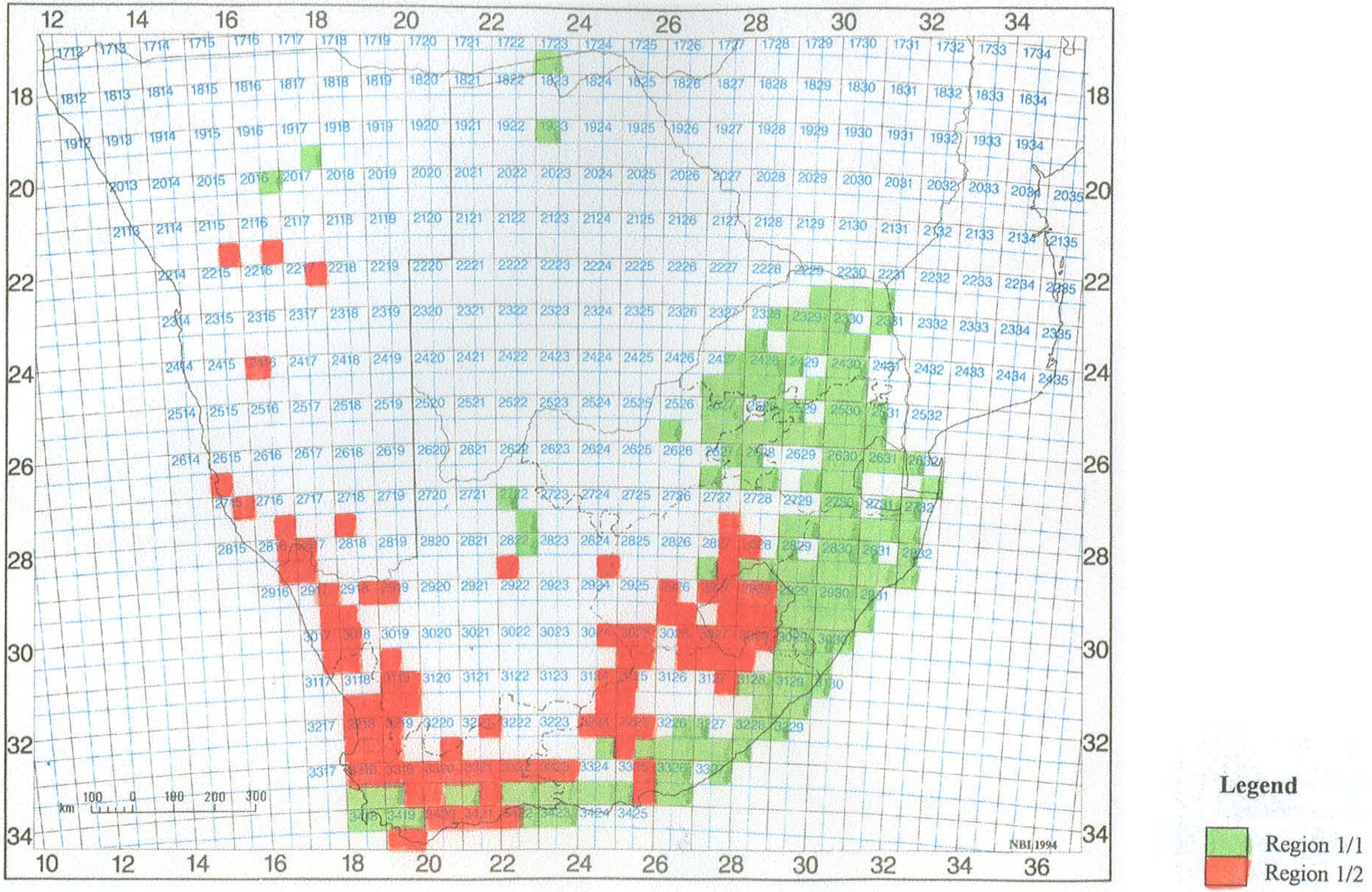


Figure 36. The two main bryogeographic regions in southern Africa (regions 1/1 and 1/2) as delimited by the **TWINSPAN 5+** grid classification (1st level of division, groups 1 & 2). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN 5+ grid classification (Figure 35).

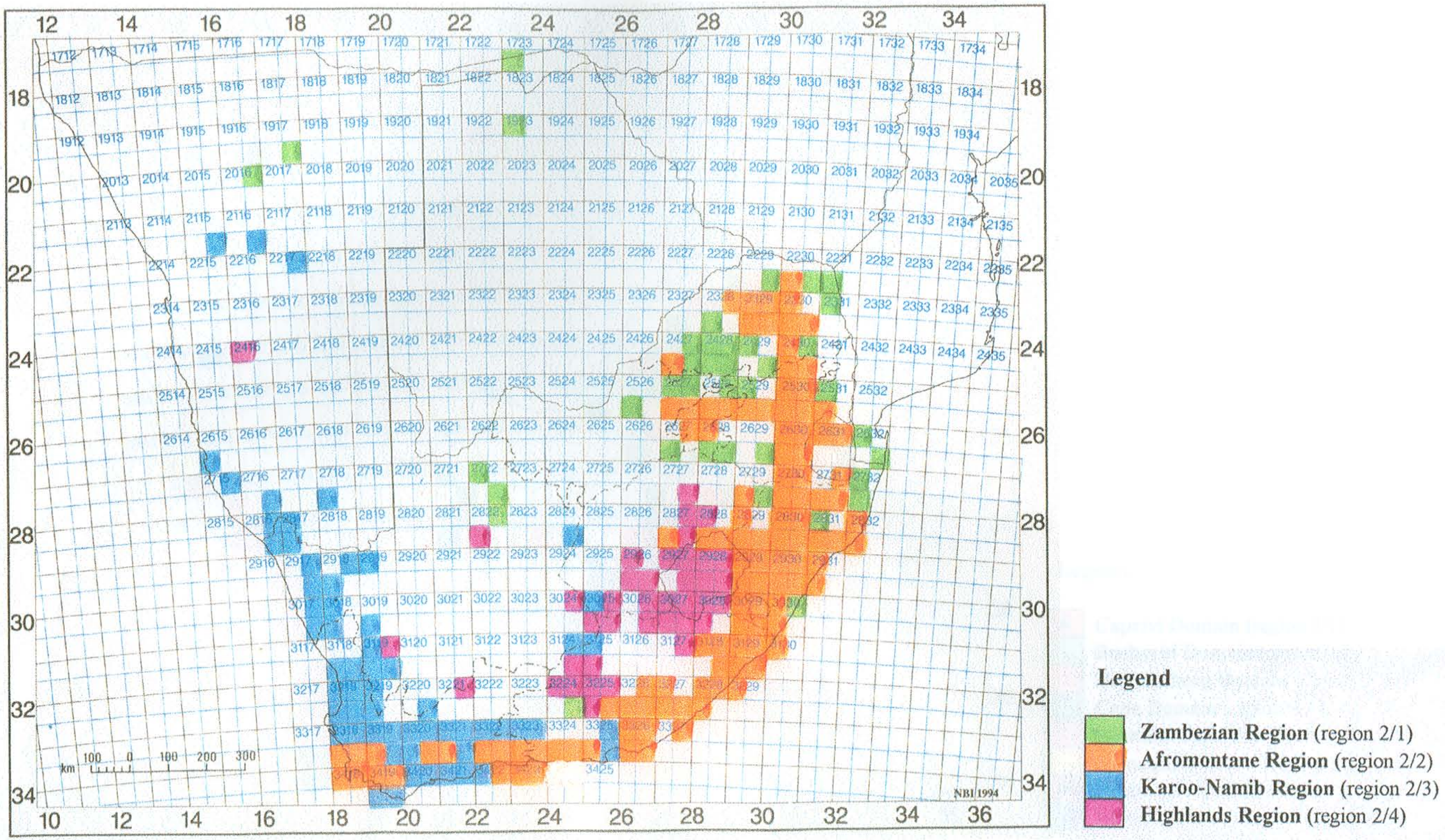


Figure 37. The **Bryogeographic Regions** of southern Africa as delimited by the **TWINSPAN 5+** grid classification (2nd level of division, groups 1–4). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN 5+ grid classification (Figure 35).

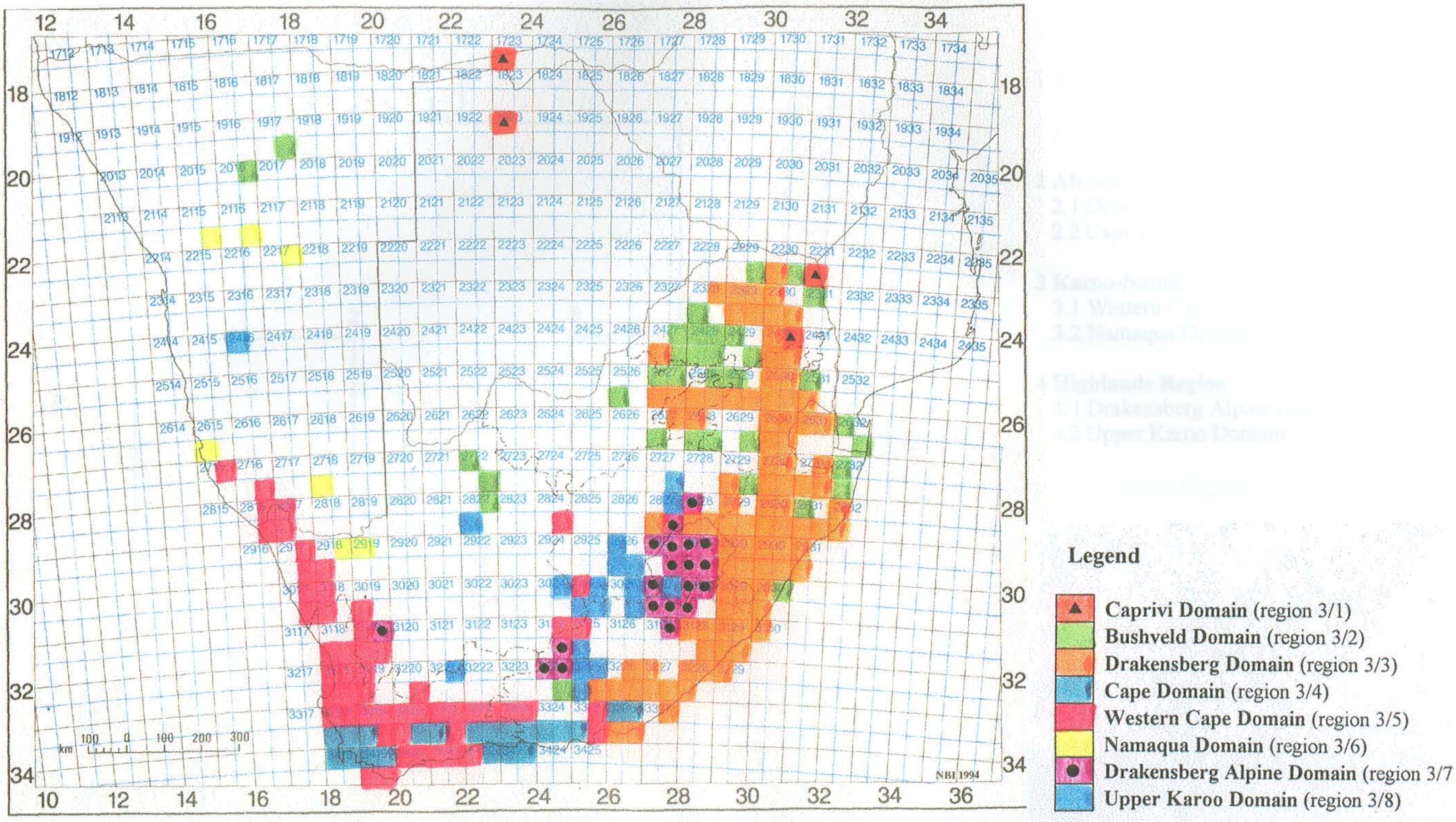
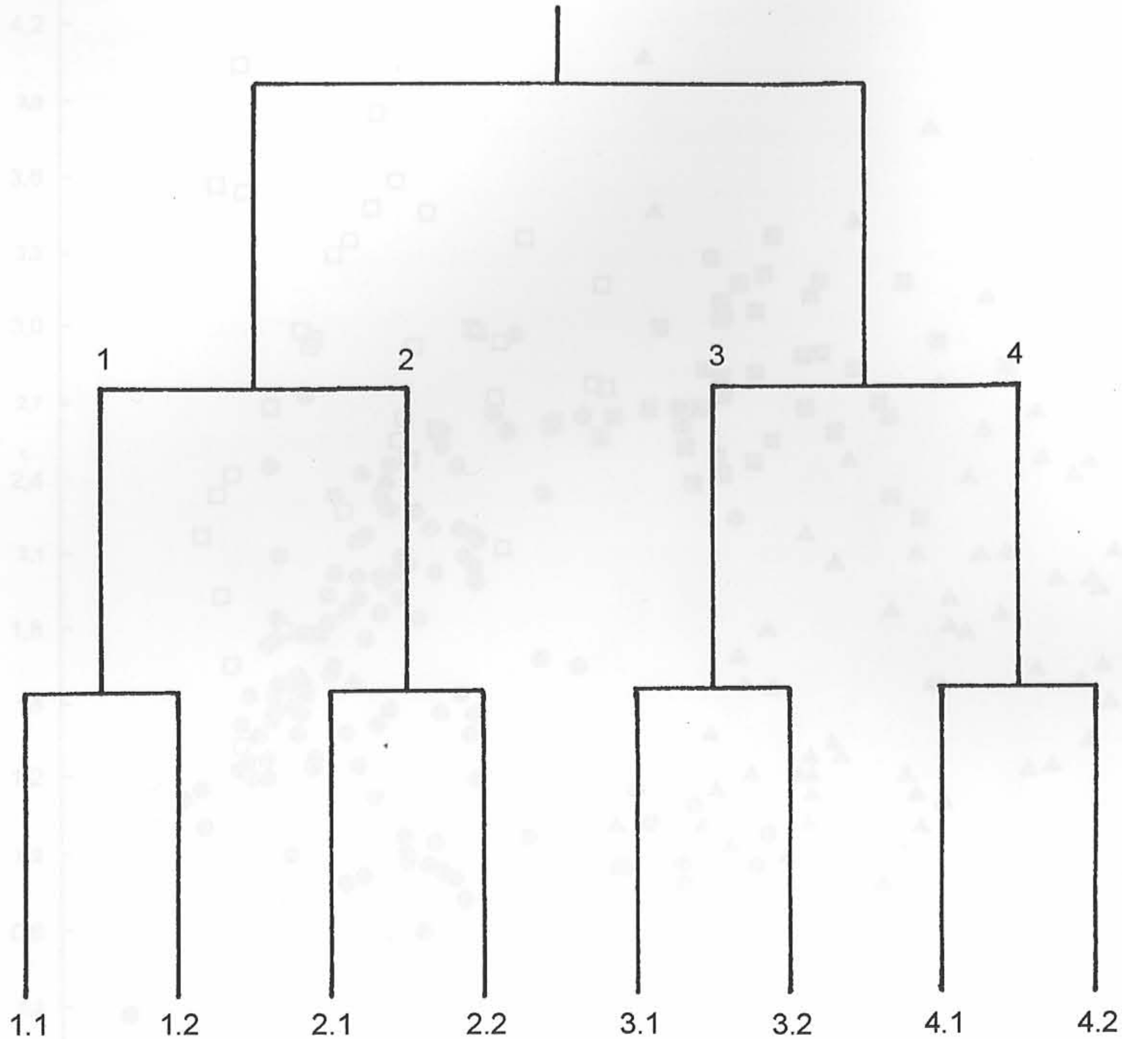


Figure 38. The **Bryogeographic Domains** of southern Africa as delimited by the **TWINSPAN 5+** grid classification (3rd level of division, groups 1–8). The numbering of the groups (regions) is the same as in the dendrogram of the TWINSPAN 5+ grid classification (Figure 35).



1 Zambezian Region
1.1 Caprivi Domain
1.2 Bushveld Domain

2 Afromontane Region
2.1 Drakensberg Domain
2.2 Cape Domain

3 Karoo-Namib Region
3.1 Western Cape Domain
3.2 Namaqua Domain

4 Highlands Region
4.1 Drakensberg Alpine Domain
4.2 Upper Karoo Domain

Figure 39. Hierarchical classification of the bryofloristic Regions and Domains of southern Africa.

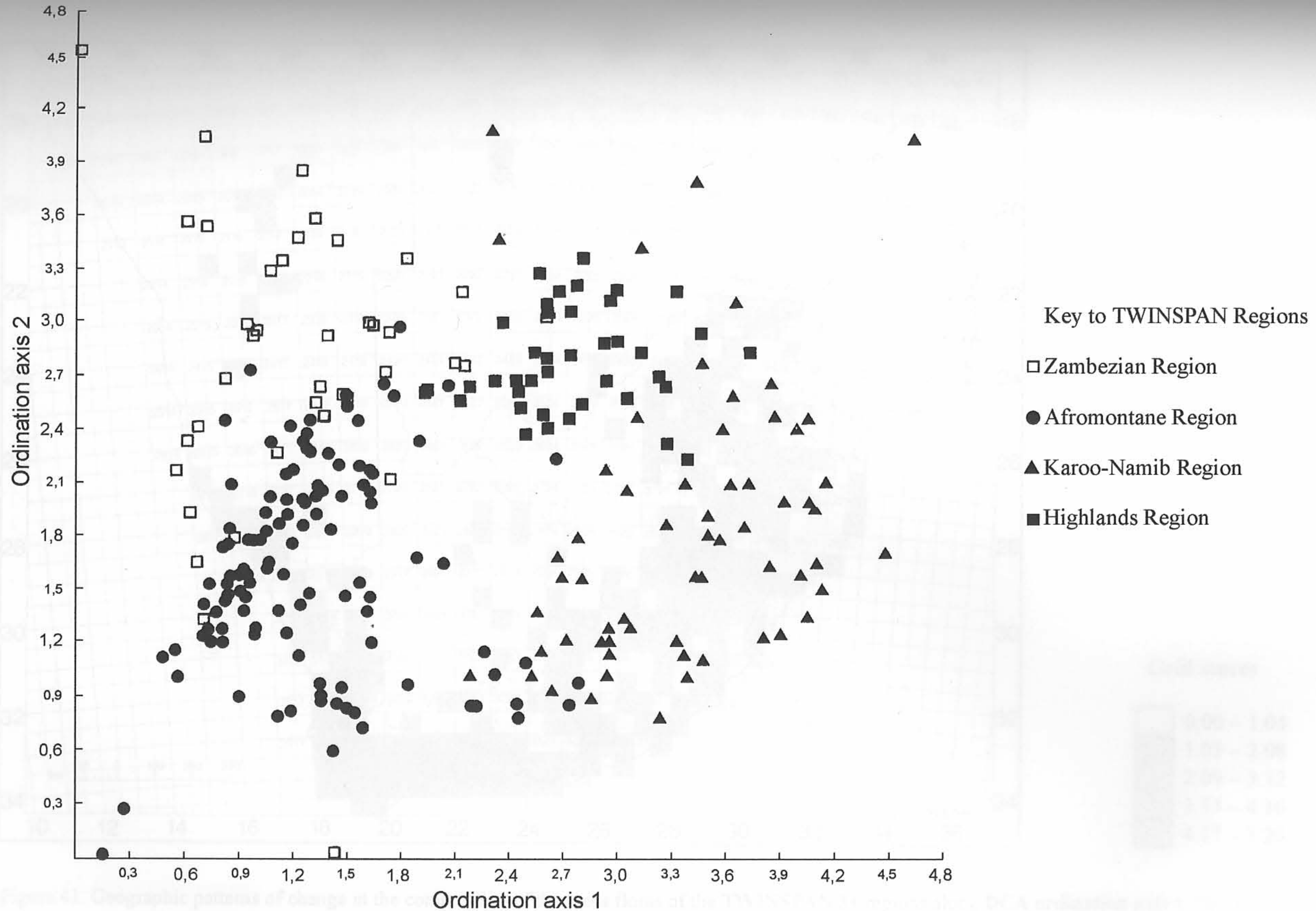


Figure 40. Distribution of **TWINSPAN 5+ Regions** along the first two axes of a **DCA ordination** of TWINSPAN 5+ grid squares. Scale marks are in standard deviation (SD) units.

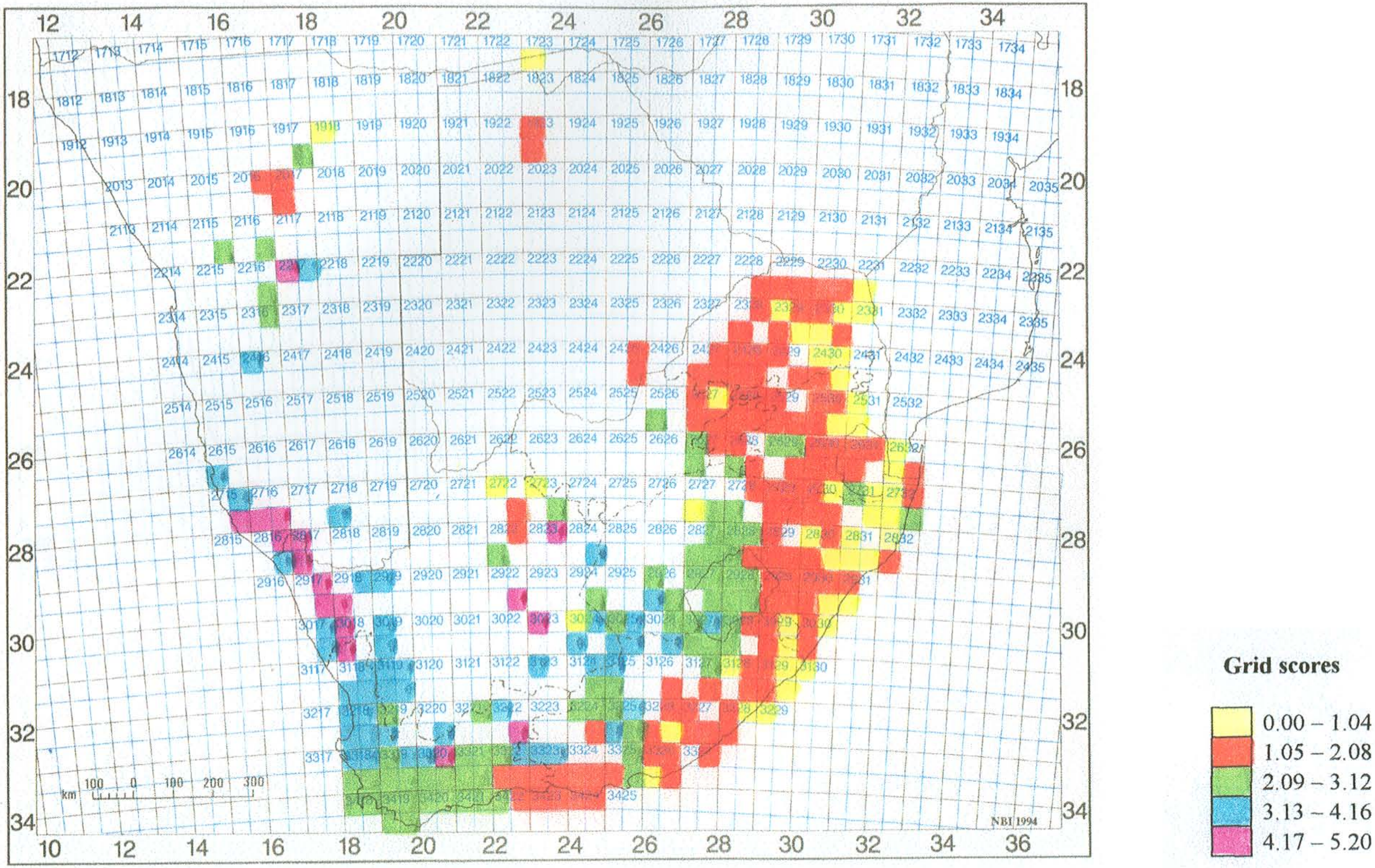


Figure 41. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 3+** regions along **DCA ordination axis 1**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

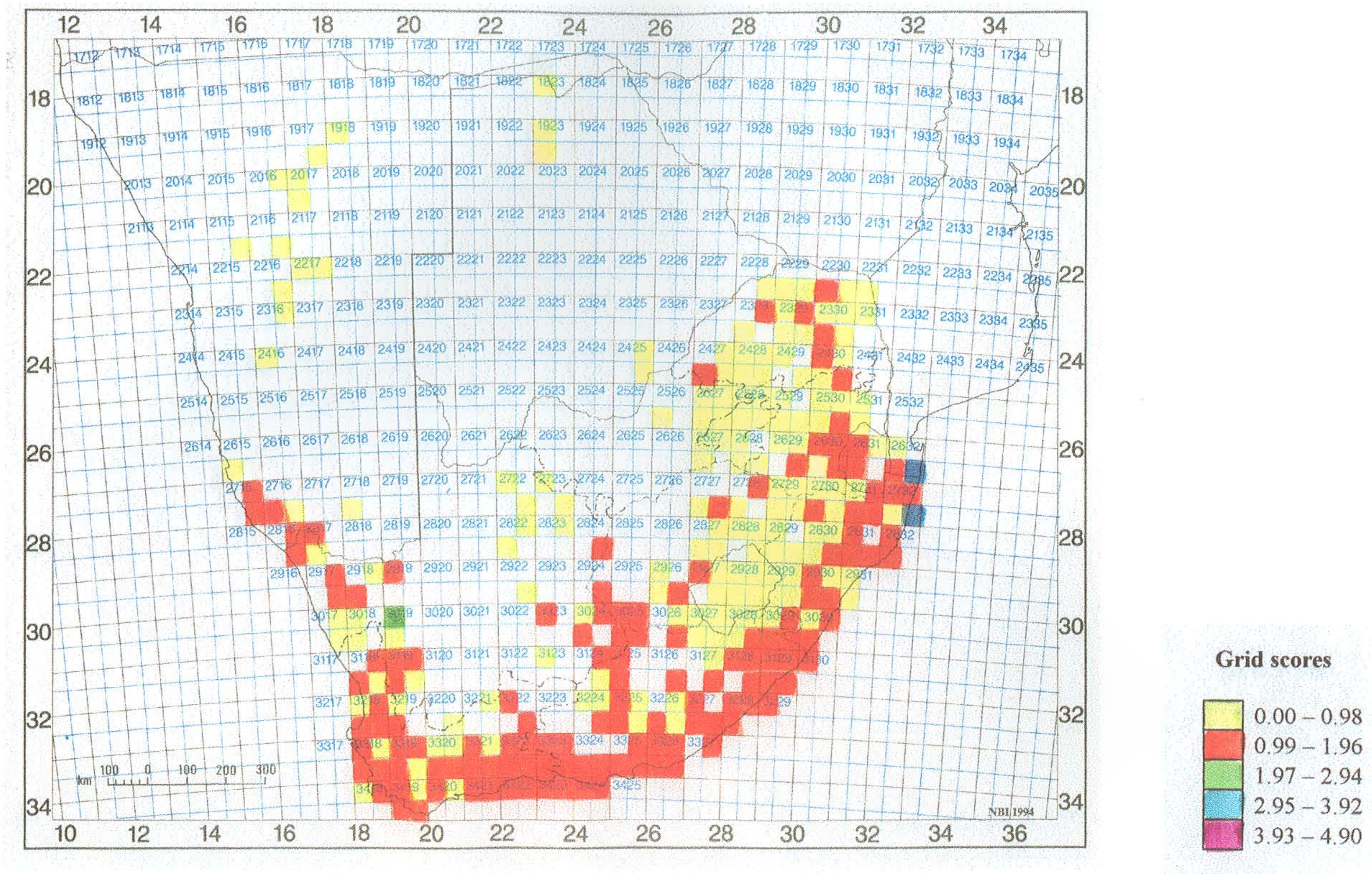


Figure 42. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 3+** regions along **DCA ordination axis 2**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

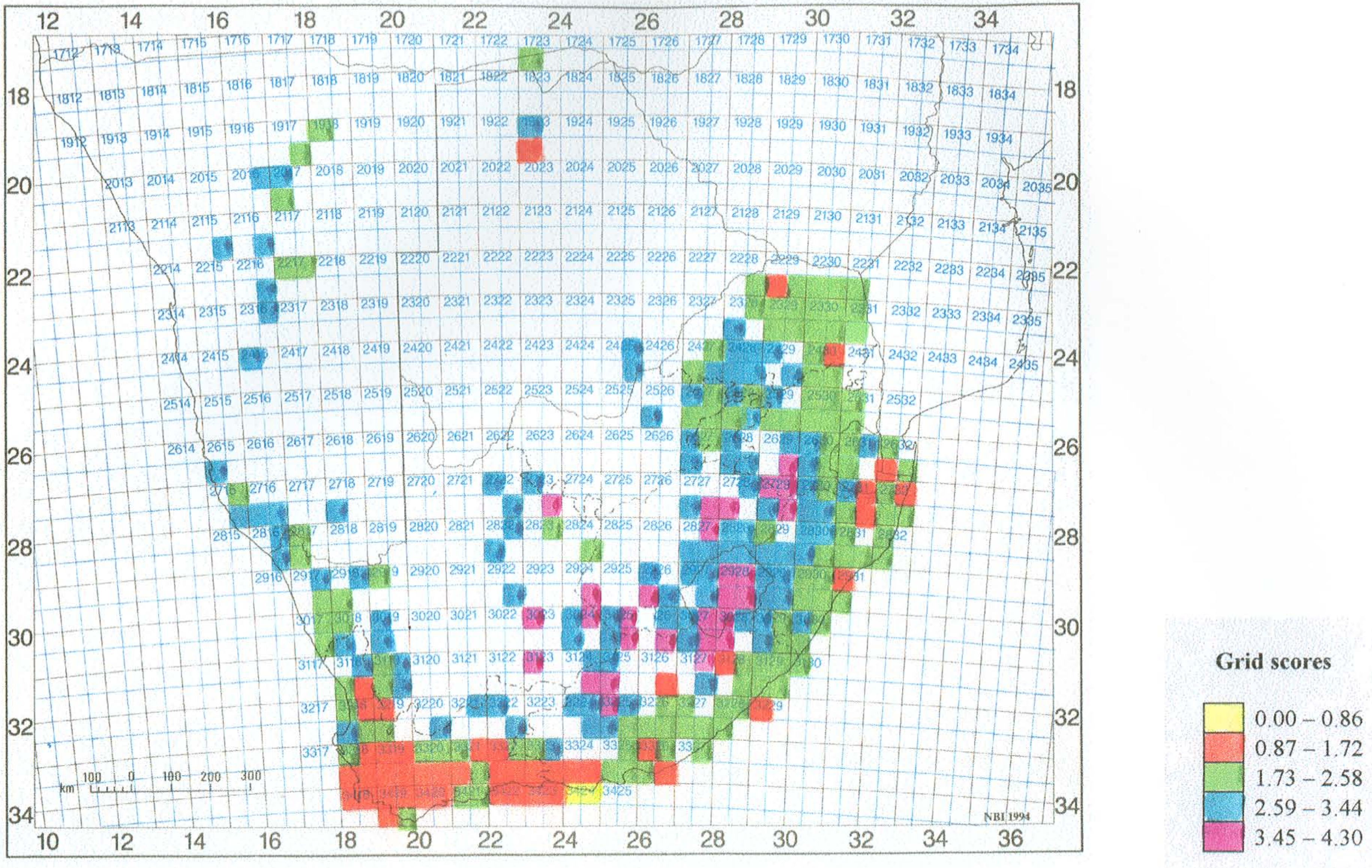


Figure 43. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 3+** regions along **DCA ordination axis 3**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

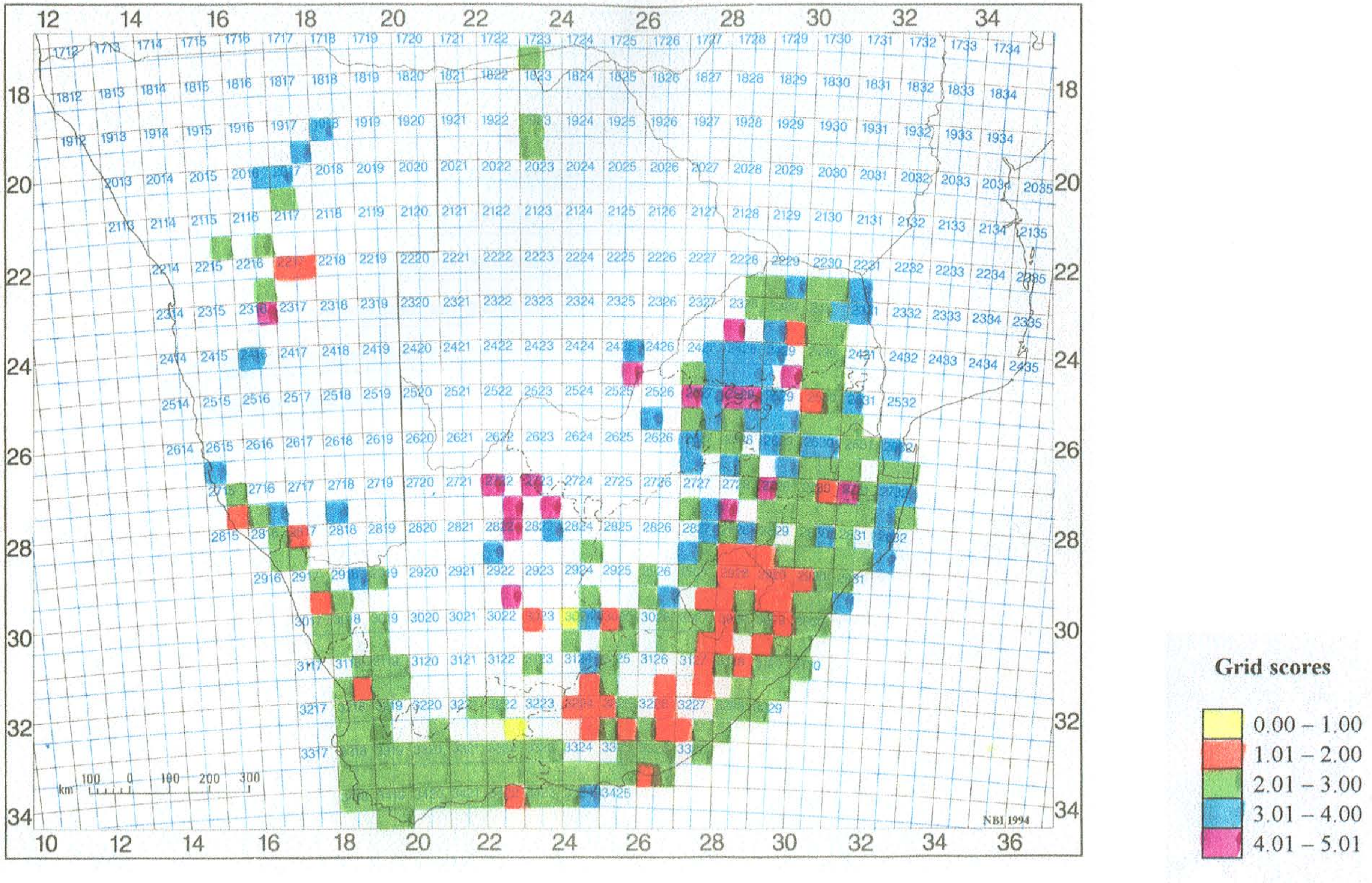


Figure 44. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 3+** regions along **DCA ordination axis 4**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

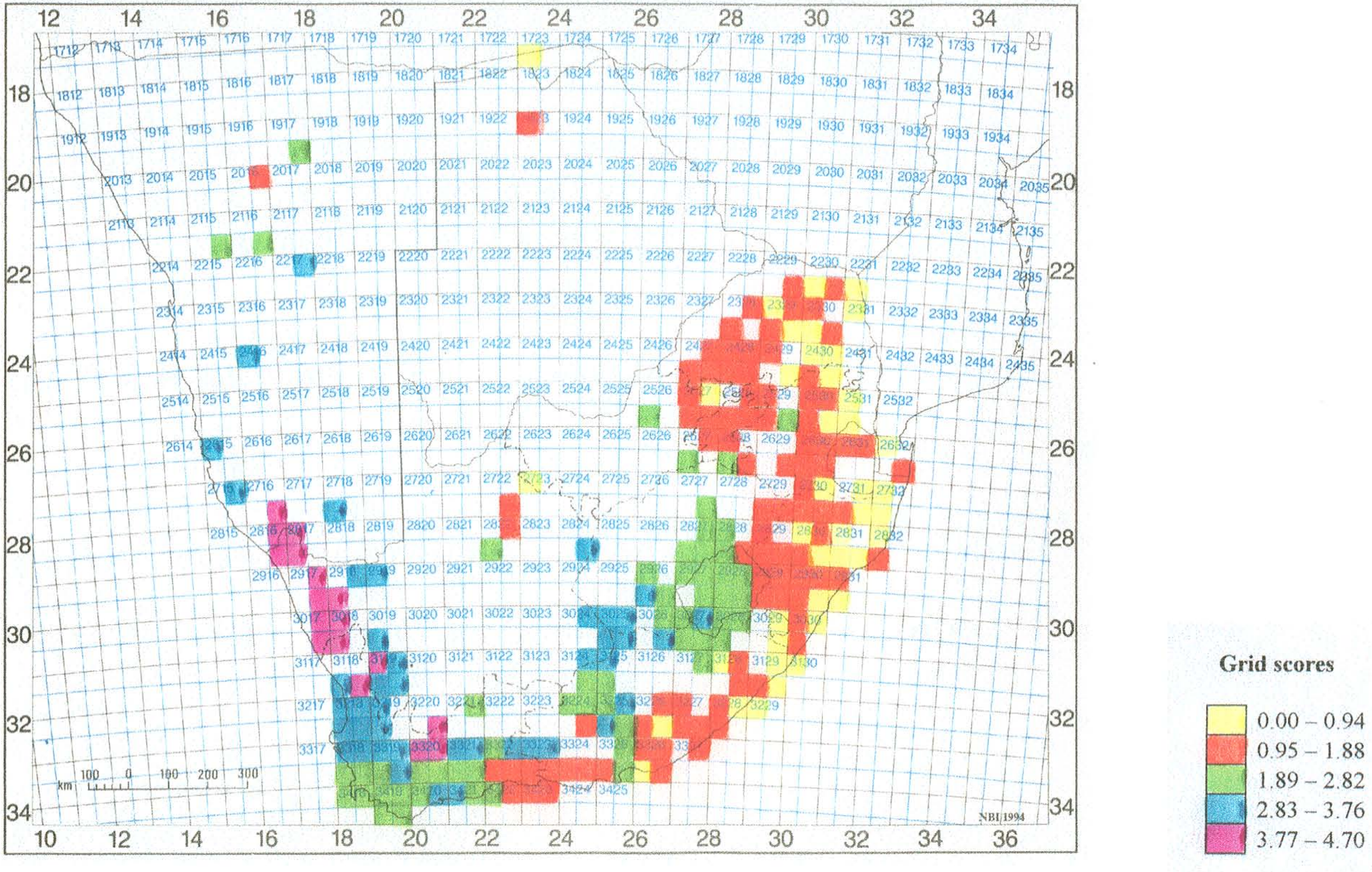


Figure 45. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 5+** regions along **DCA ordination axis 1**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

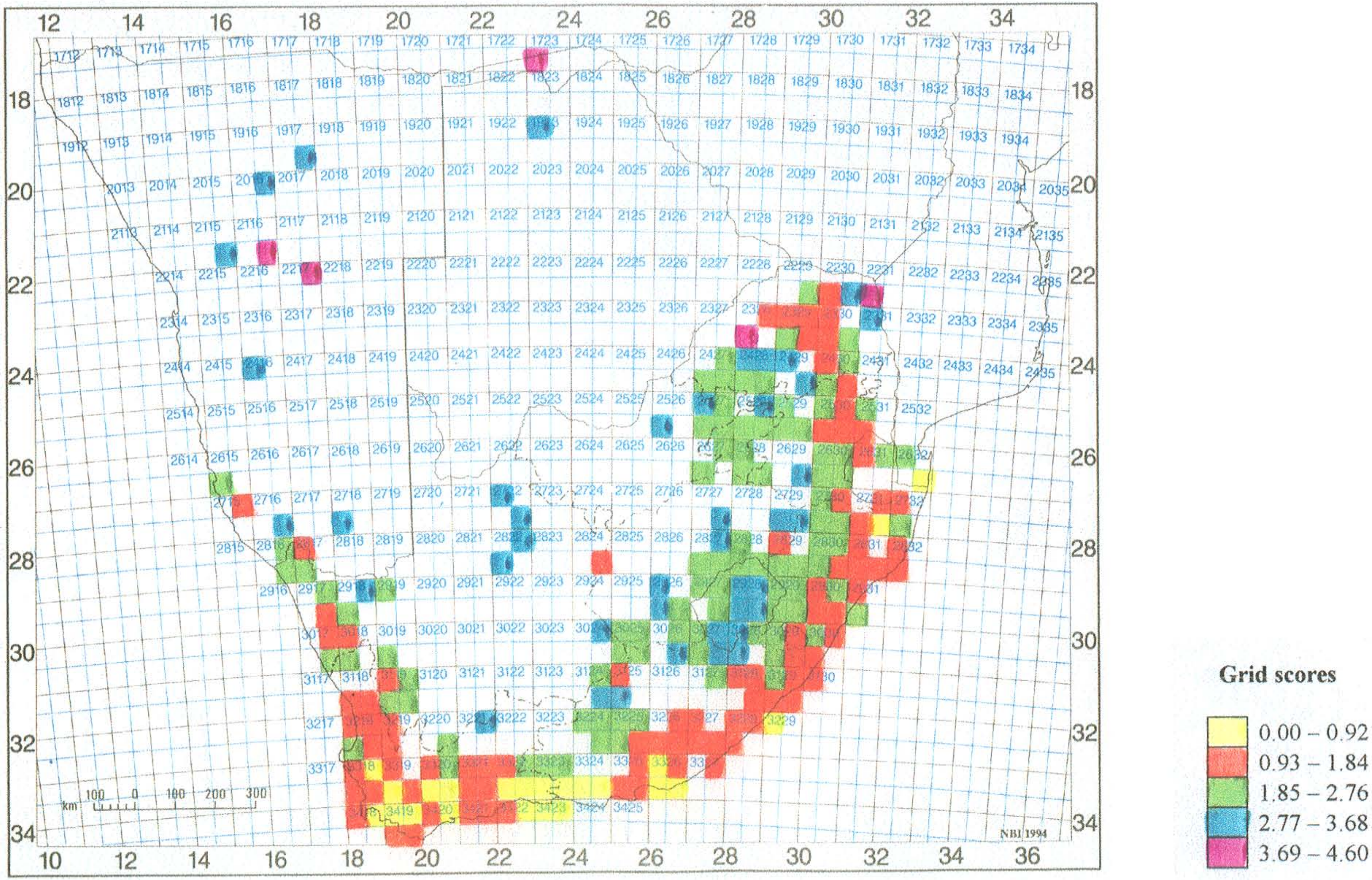


Figure 46. Geographic patterns of change in the composition of the moss flora of the **TWINSPAN 5+** regions along **DCA ordination axis 2**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

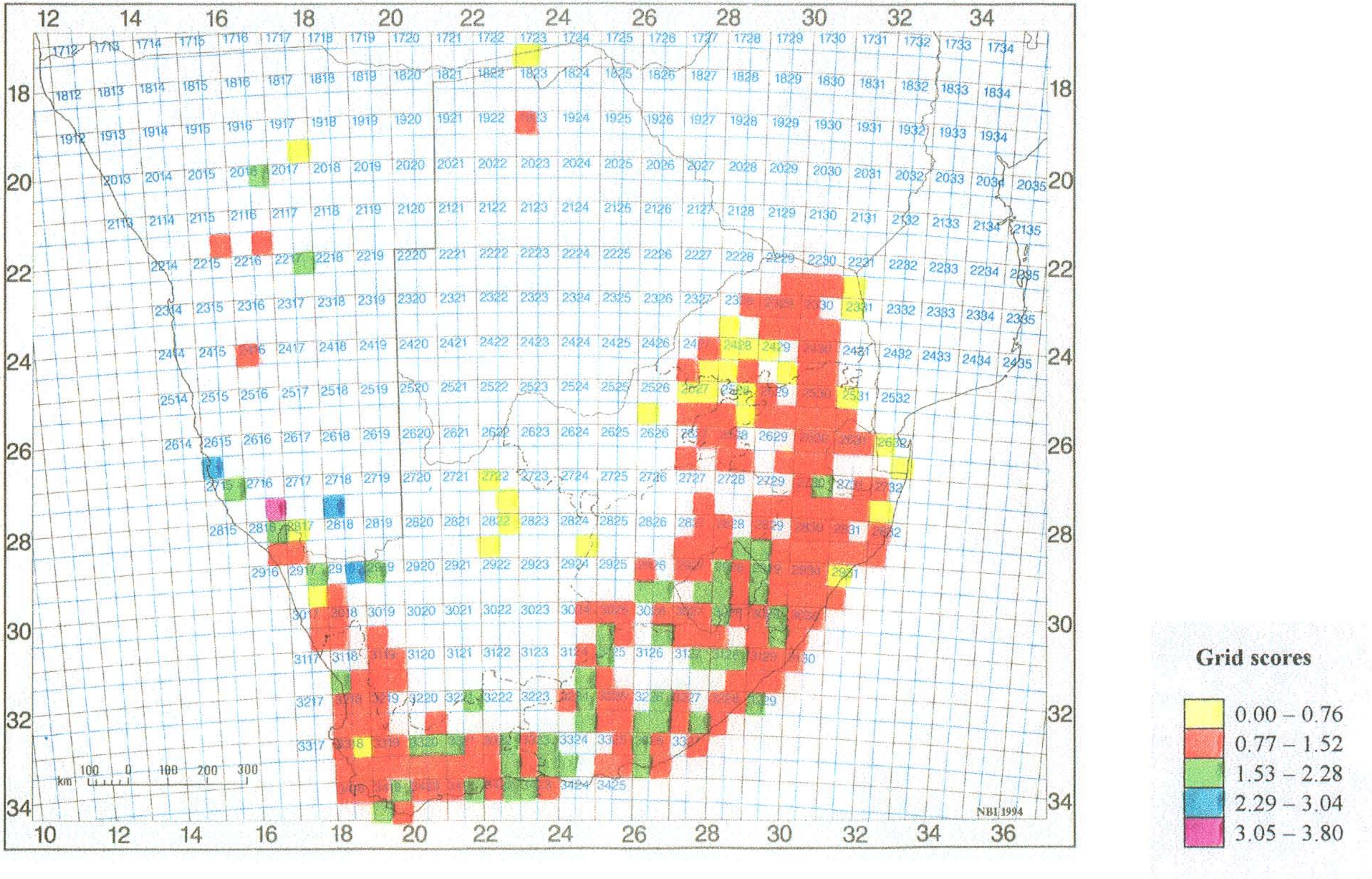


Figure 47. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 5+** regions along **DCA ordination axis 3**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

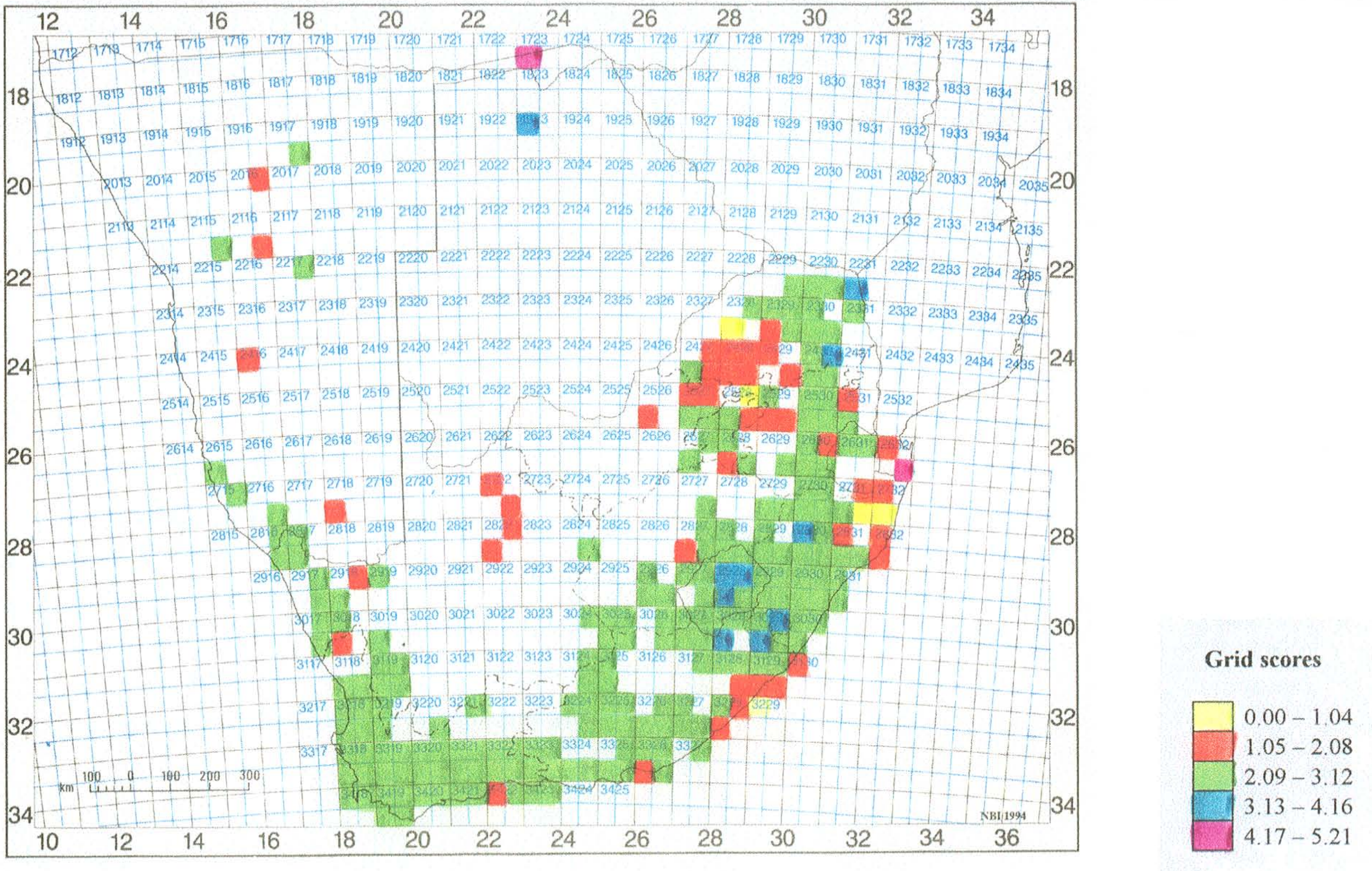


Figure 48. Geographic patterns of change in the composition of the moss floras of the **TWINSPAN 5+** regions along **DCA ordination axis 4**. The grid scores, given as standard deviation units (SD), have been divided into five intervals.

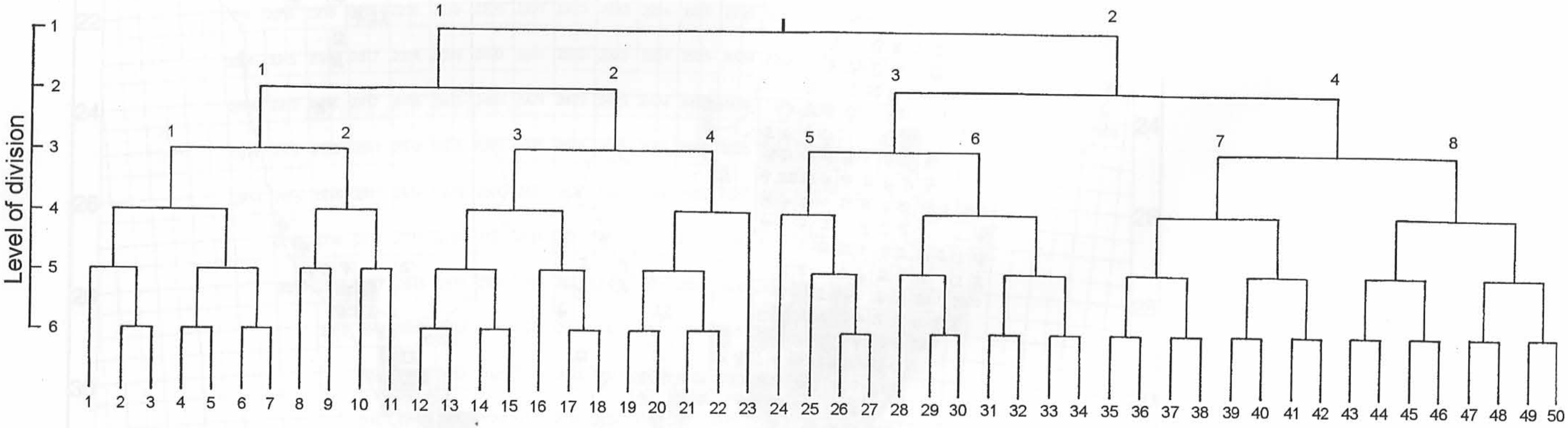


Figure 49. Dendrogram of the **TWINSPAN 3+** classification of species into **bryofloristic elements**.

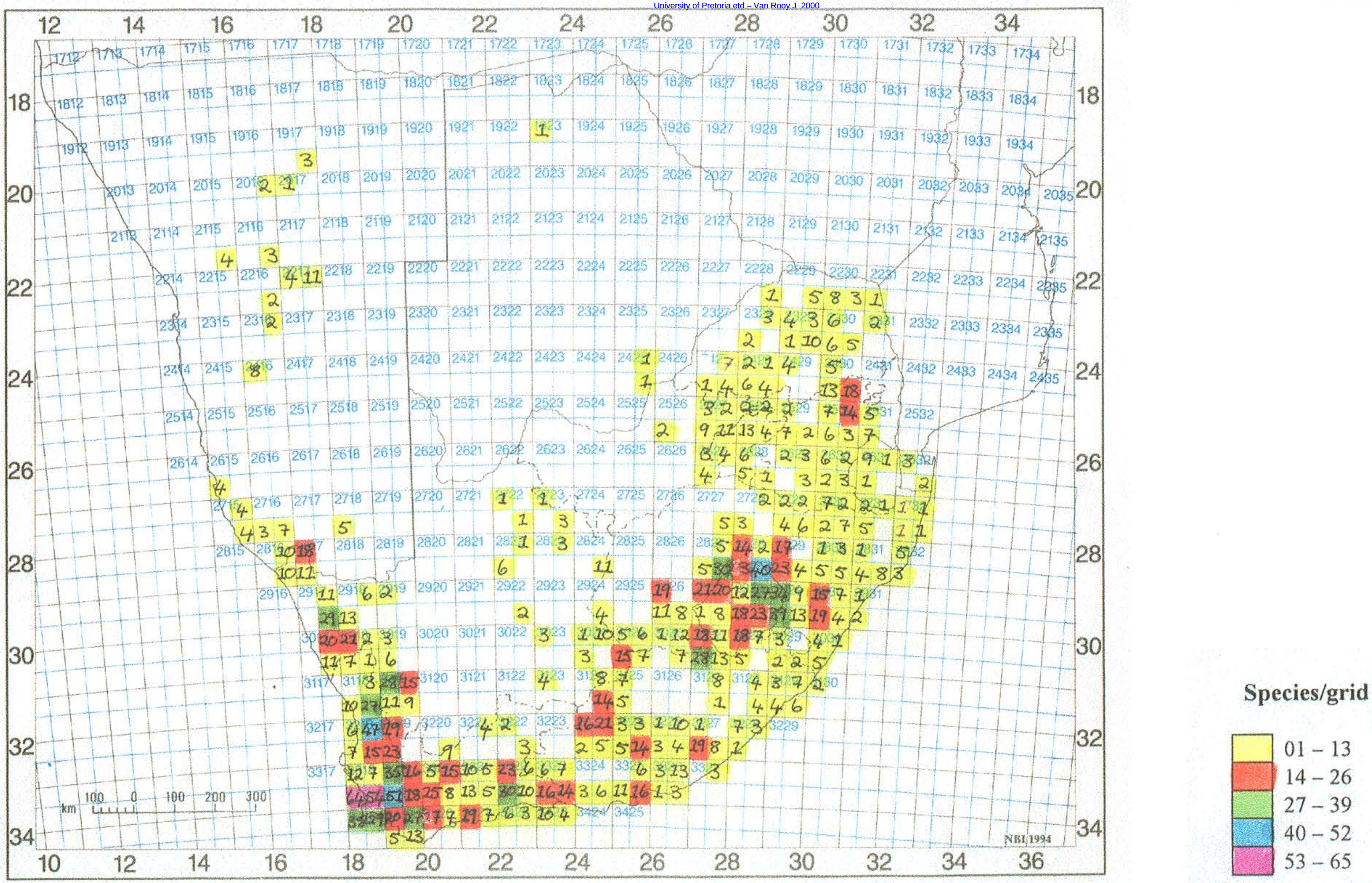


Figure 50. The geographic distribution of bryofloristic element 1/1 (TWINSPAN 3+ species classification, 1st level of division, group 1). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

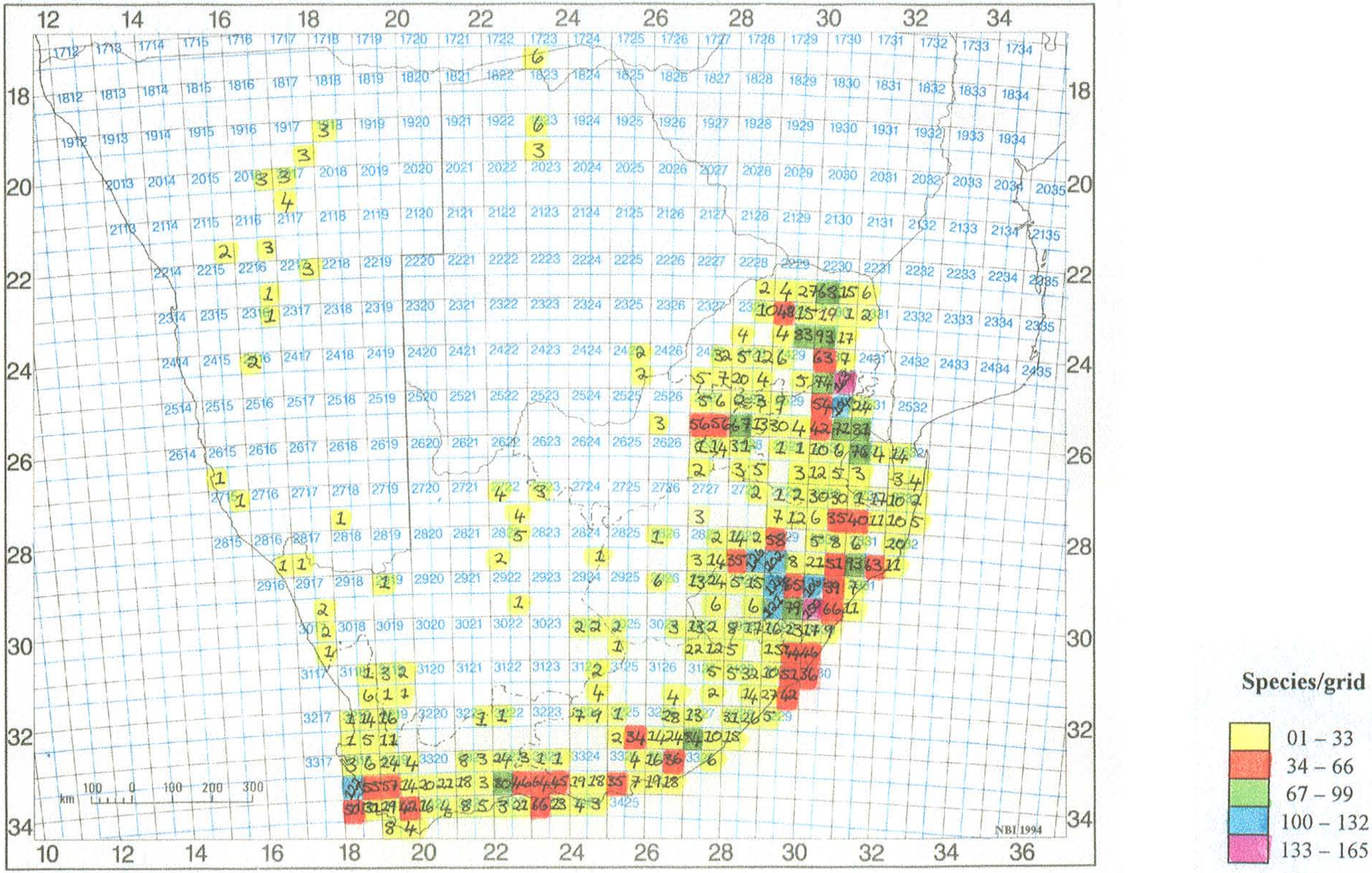


Figure 51. The geographic distribution of bryofloristic element 1/2 (TWINSPAN 3+ species classification, 1st level of division, group 2). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

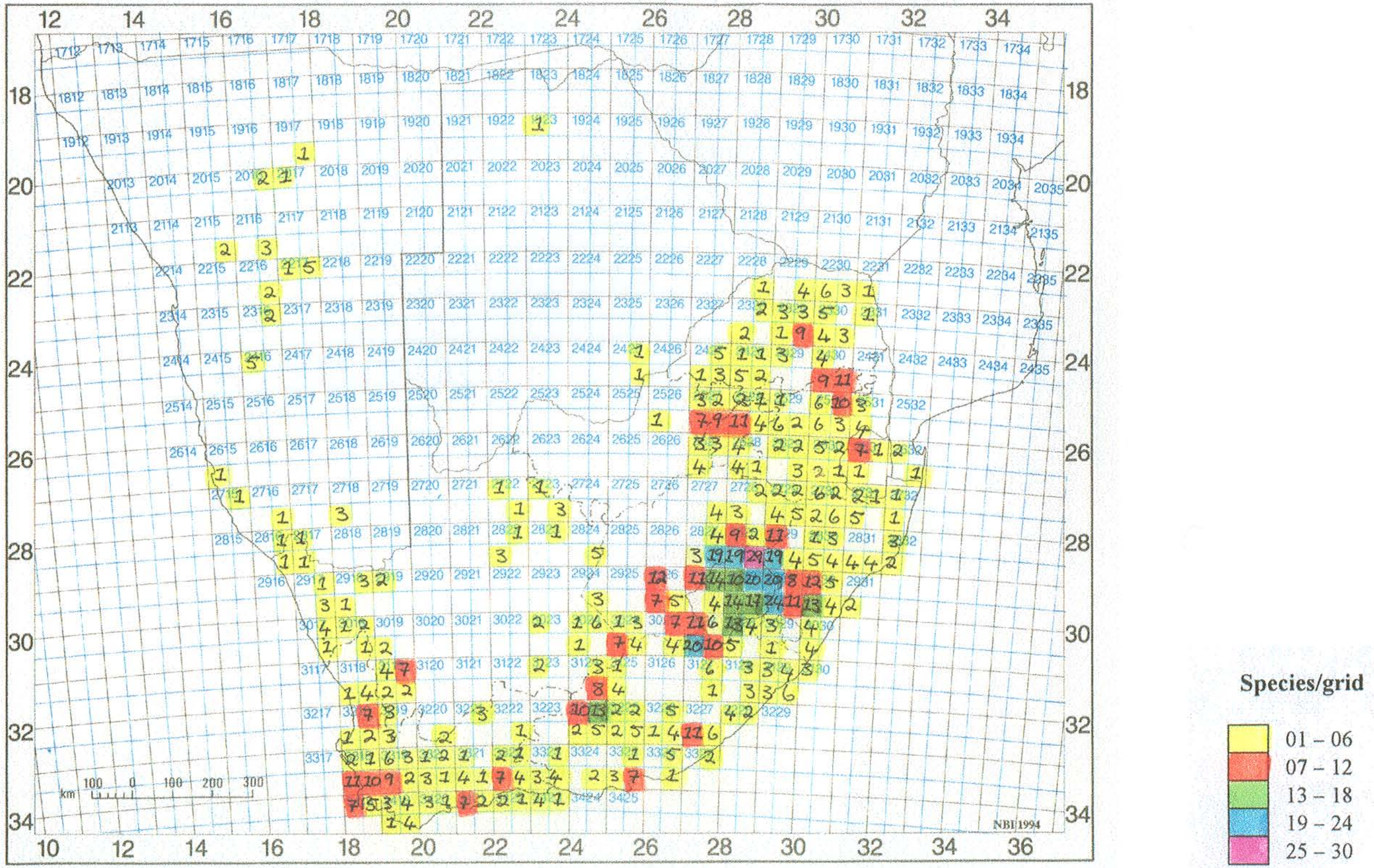


Figure 52. The geographic distribution of the **Eastern Highlands Element** or element 2/1 (TWINSPAN 3+ species classification, 2nd level of division, group 1). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

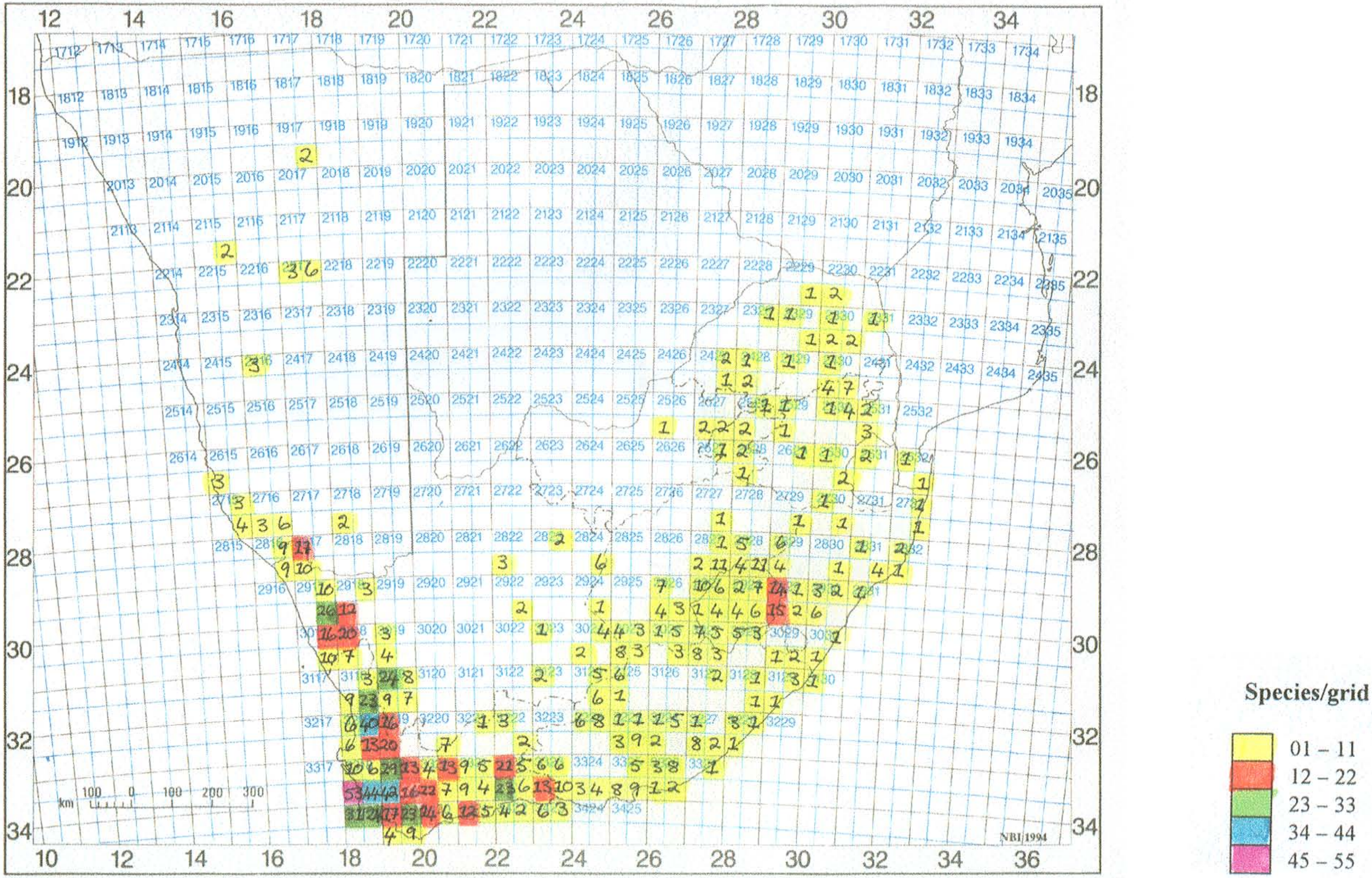


Figure 53. The geographic distribution of the **Cape Element** or element 2/2 (TWINSPAN 3+ species classification, 2nd level of division, group 2). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

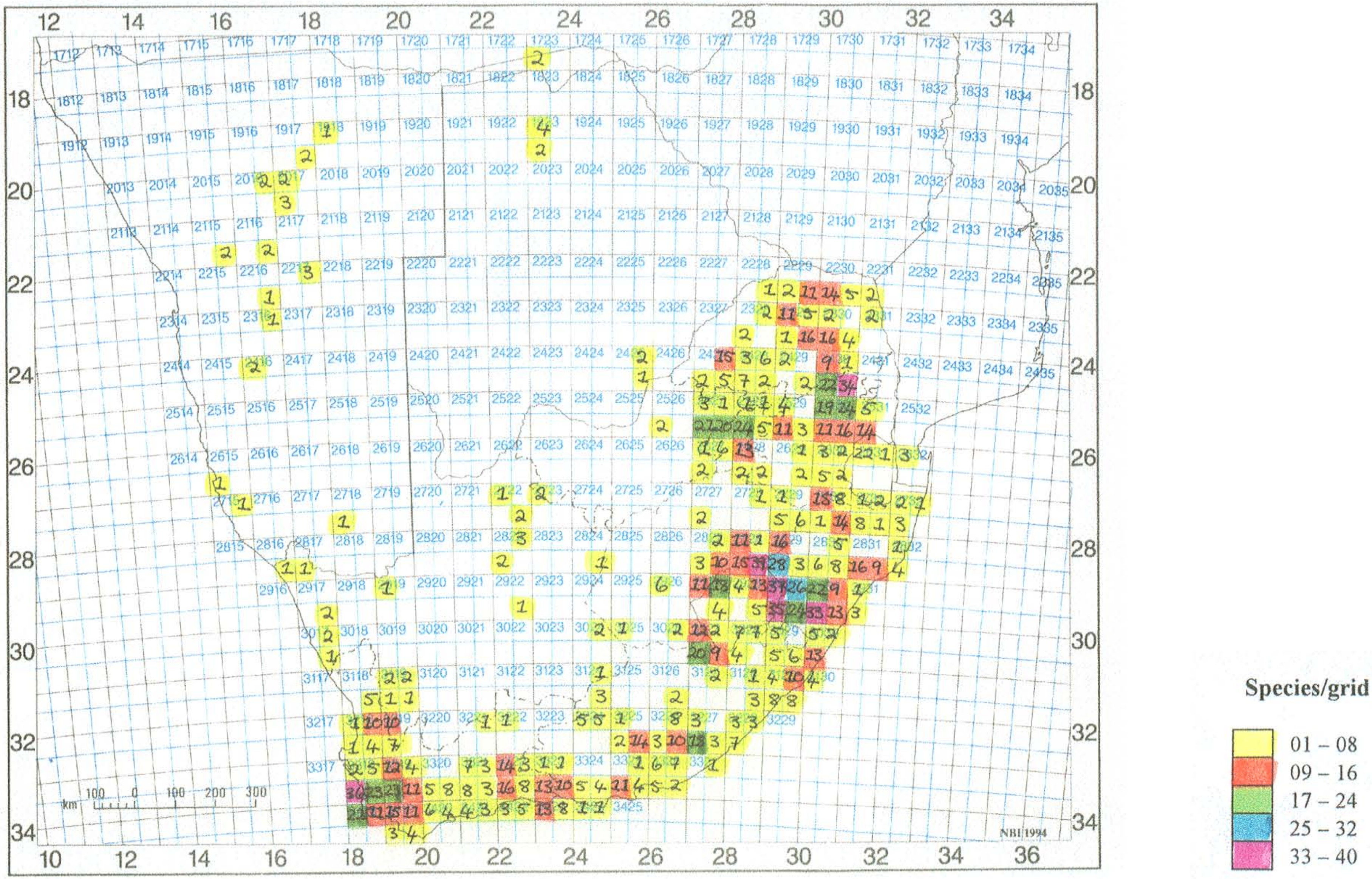


Figure 54. The geographic distribution of the **Afromontane Grassland Element** or element 2/3 (TWINSPAN 3+ species classification, 2nd level of division, group 3). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

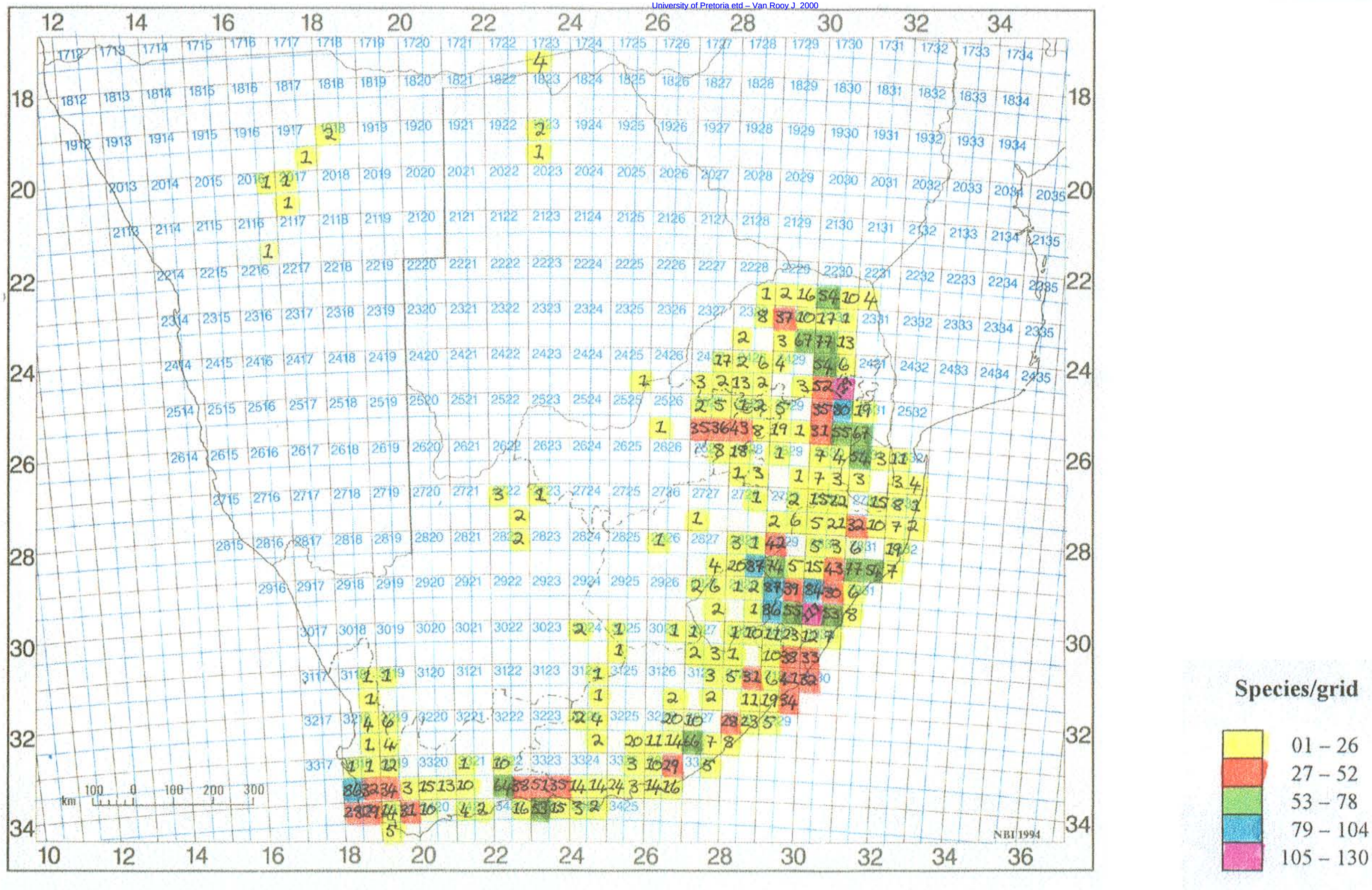


Figure 55. The geographic distribution of the **Afromontane Forest Element** or element 2/4 (TWINSPAN 3+ species classification, 2nd level of division, group 4). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

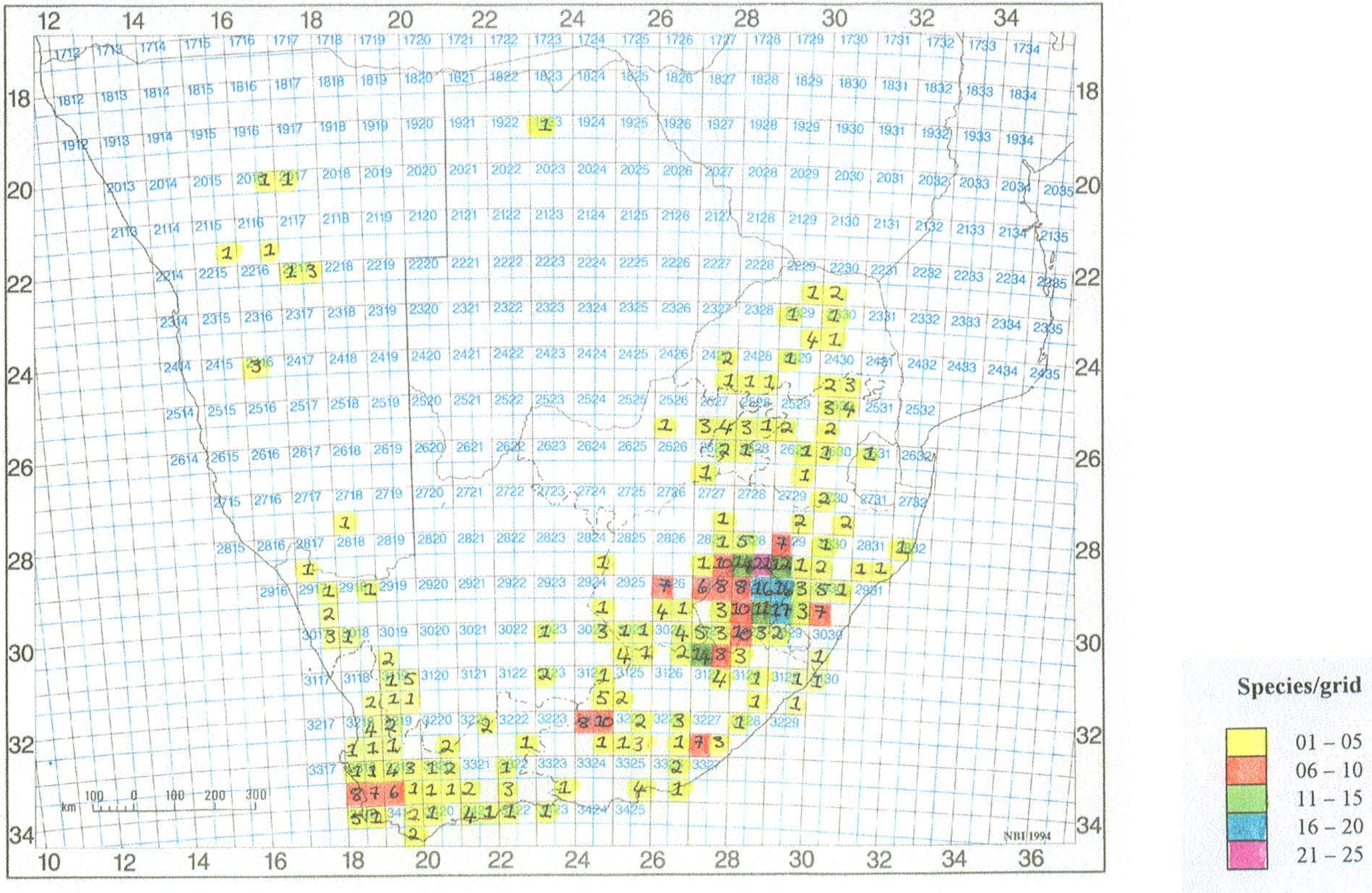


Figure 56. The geographic distribution of the **Mont Aux Sources Subelement** or element 3/1 (TWINSPAN 3+ species classification, 3rd level of division, group 1). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

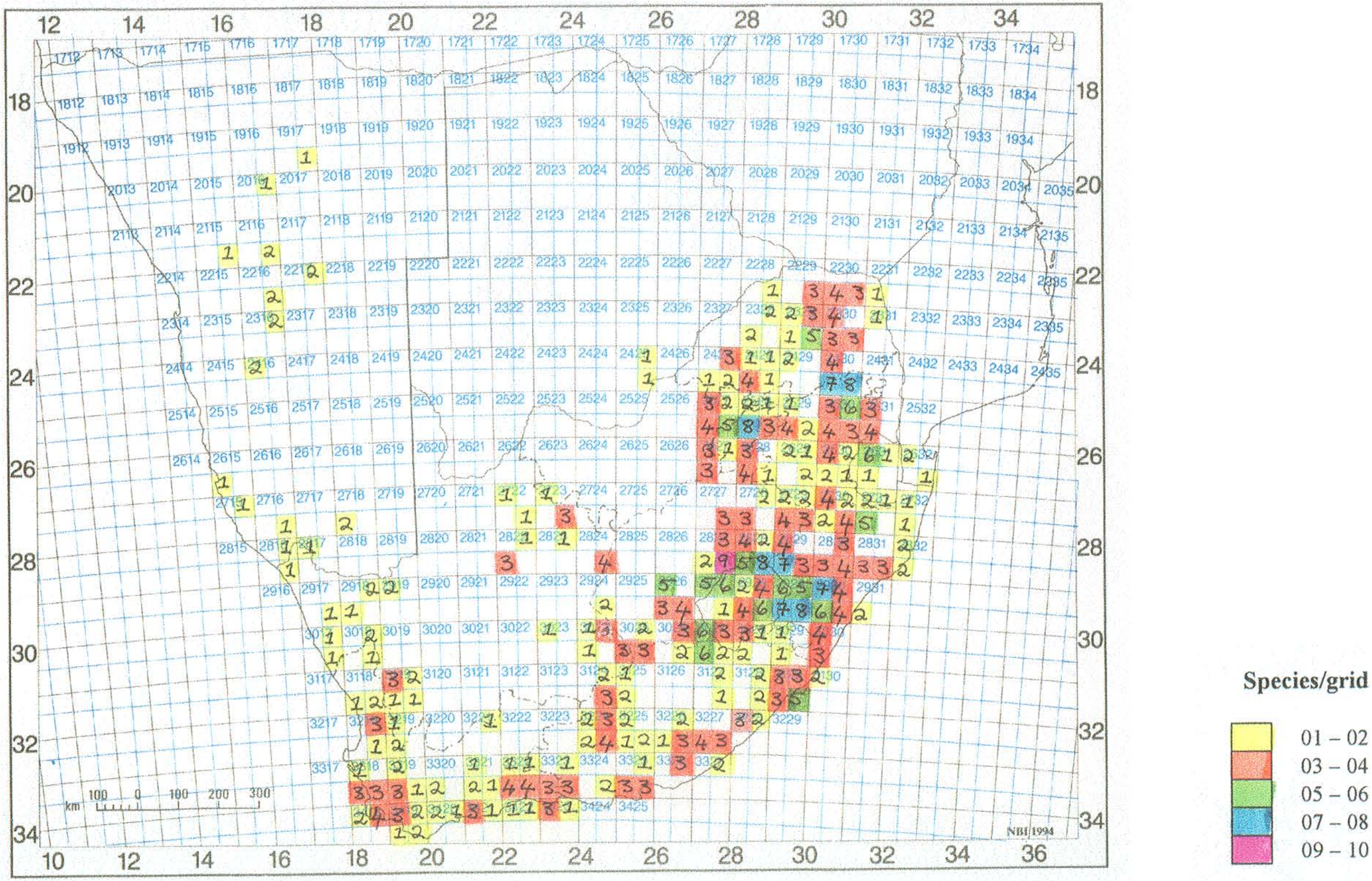


Figure 57. The geographic distribution of the **Widespread Subelement** or element 3/2 (TWINSPAN 3+ species classification, 3rd level of division, group 2). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

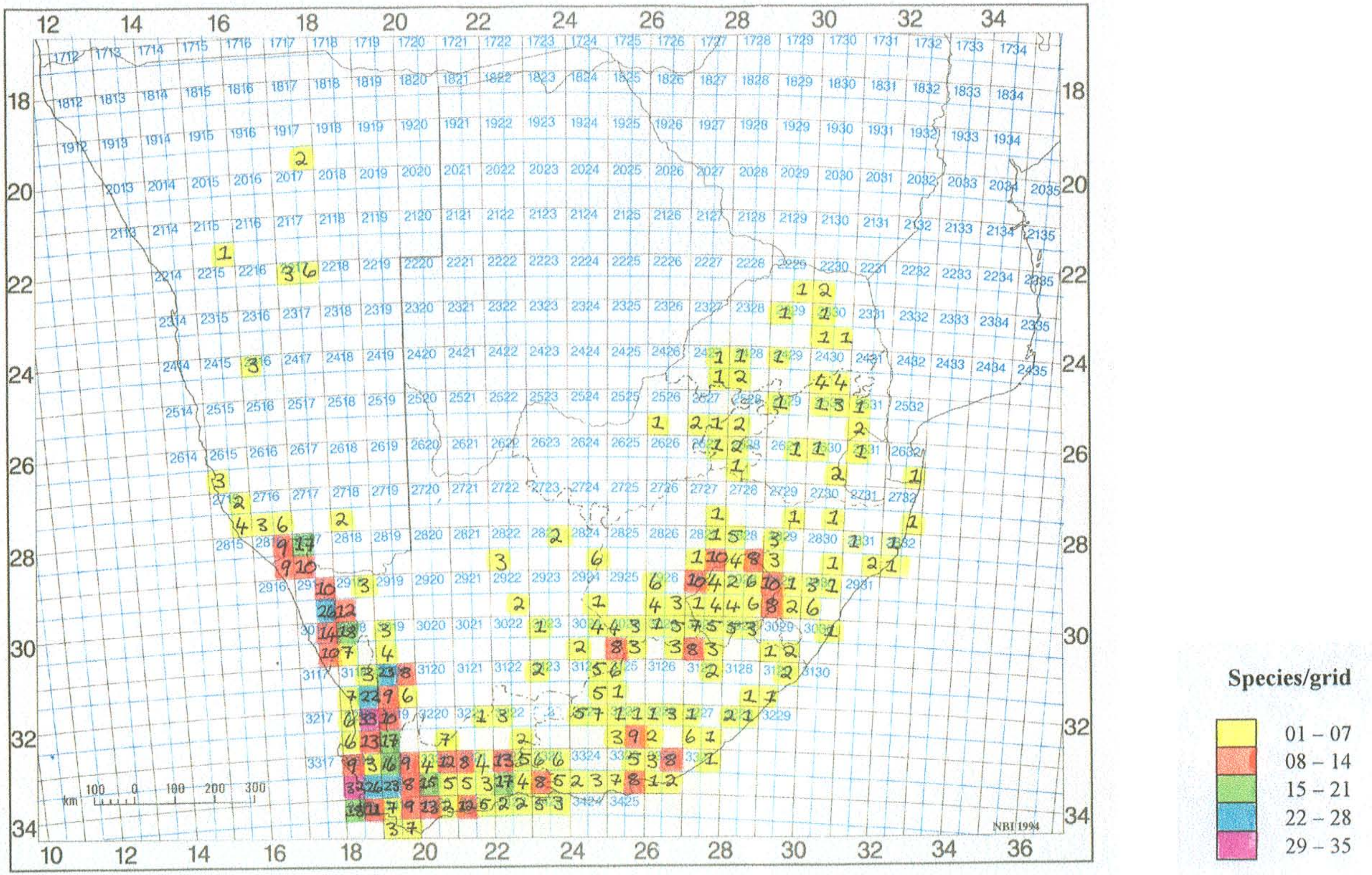


Figure 58. The geographic distribution of the **West Coast Subelement** or element 3/3 (TWINSPAN 3+ species classification, 3rd level of division, group 3). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

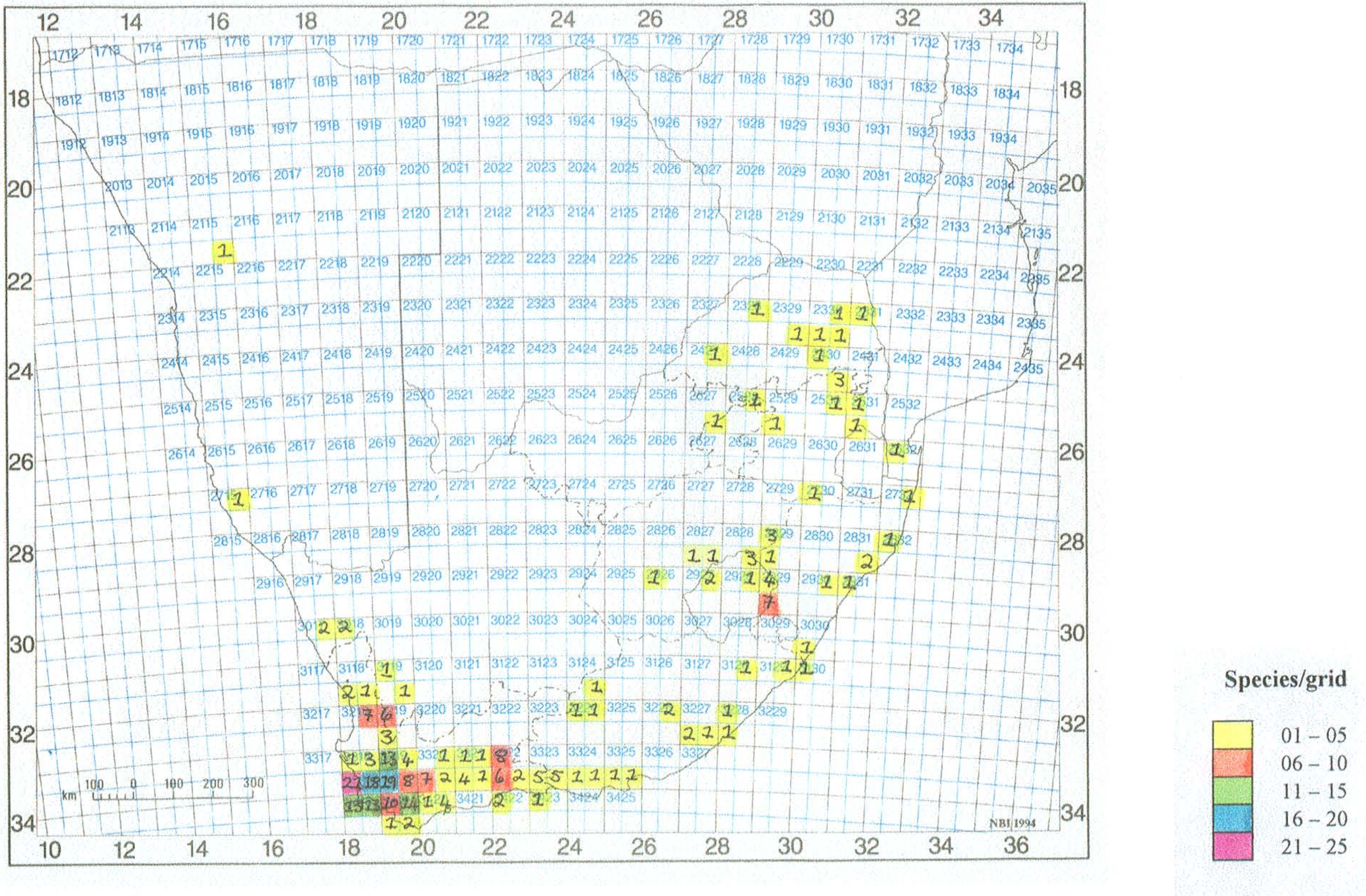


Figure 59. The geographic distribution of the **Boland Subelement** or element 3/4 (TWINSPAN 3+ species classification, 3rd level of division, group 4). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

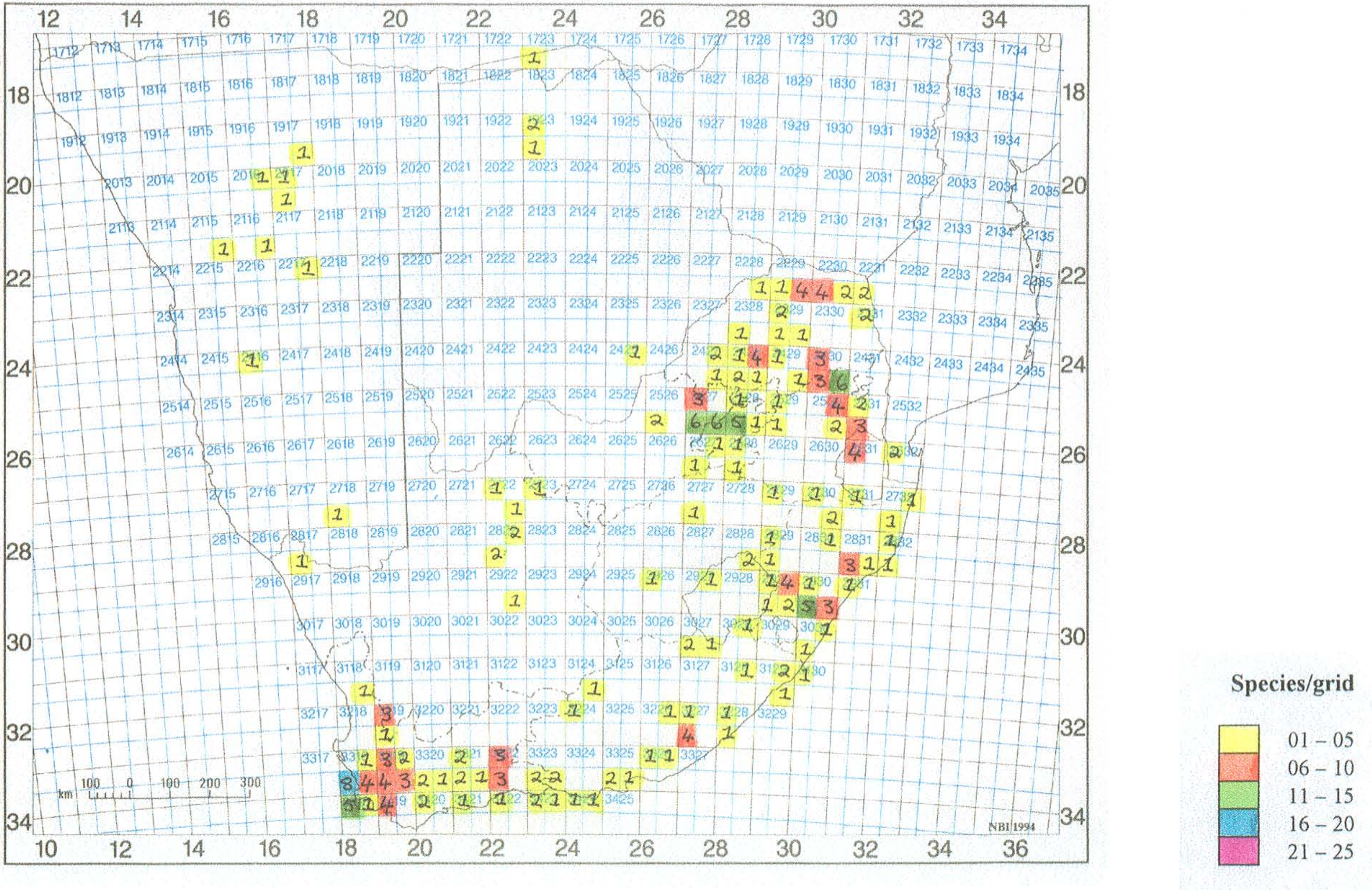


Figure 60. The geographic distribution of the **Disjunct Cape Peninsula Subelement** or element 3/5 (TWINSPAN 3+ species classification, 3rd level of division, group 5). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

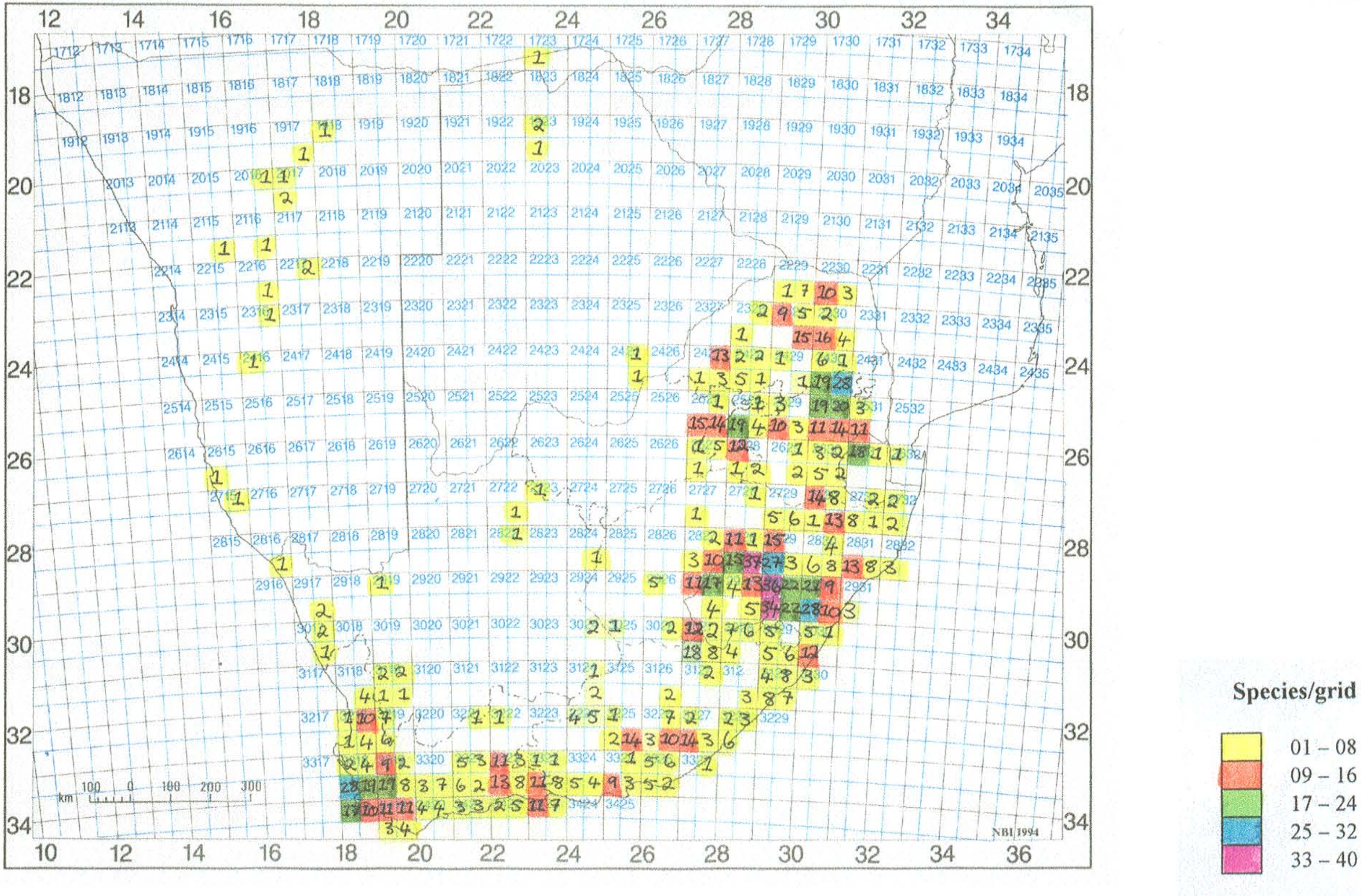


Figure 61. The geographic distribution of the **Drakensberg Subelement** or element 3/6 (TWINSPAN 3+ species classification, 3rd level of division, group 6). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

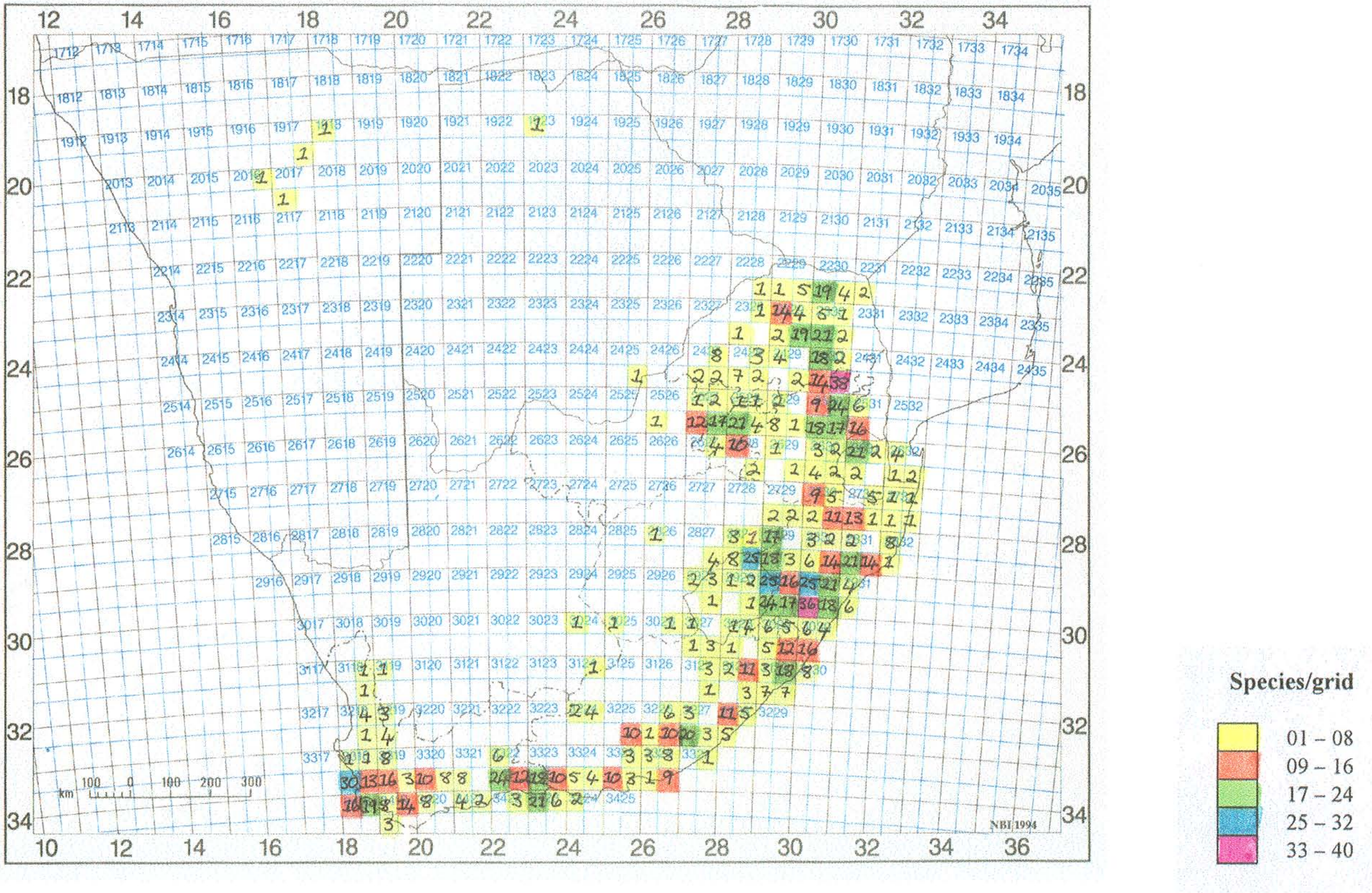


Figure 62. The geographic distribution of the **Widespread Afromontane Subelement** or element 3/7 (TWINSPAN 3+ species classification, 3rd level of division, group 7). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).

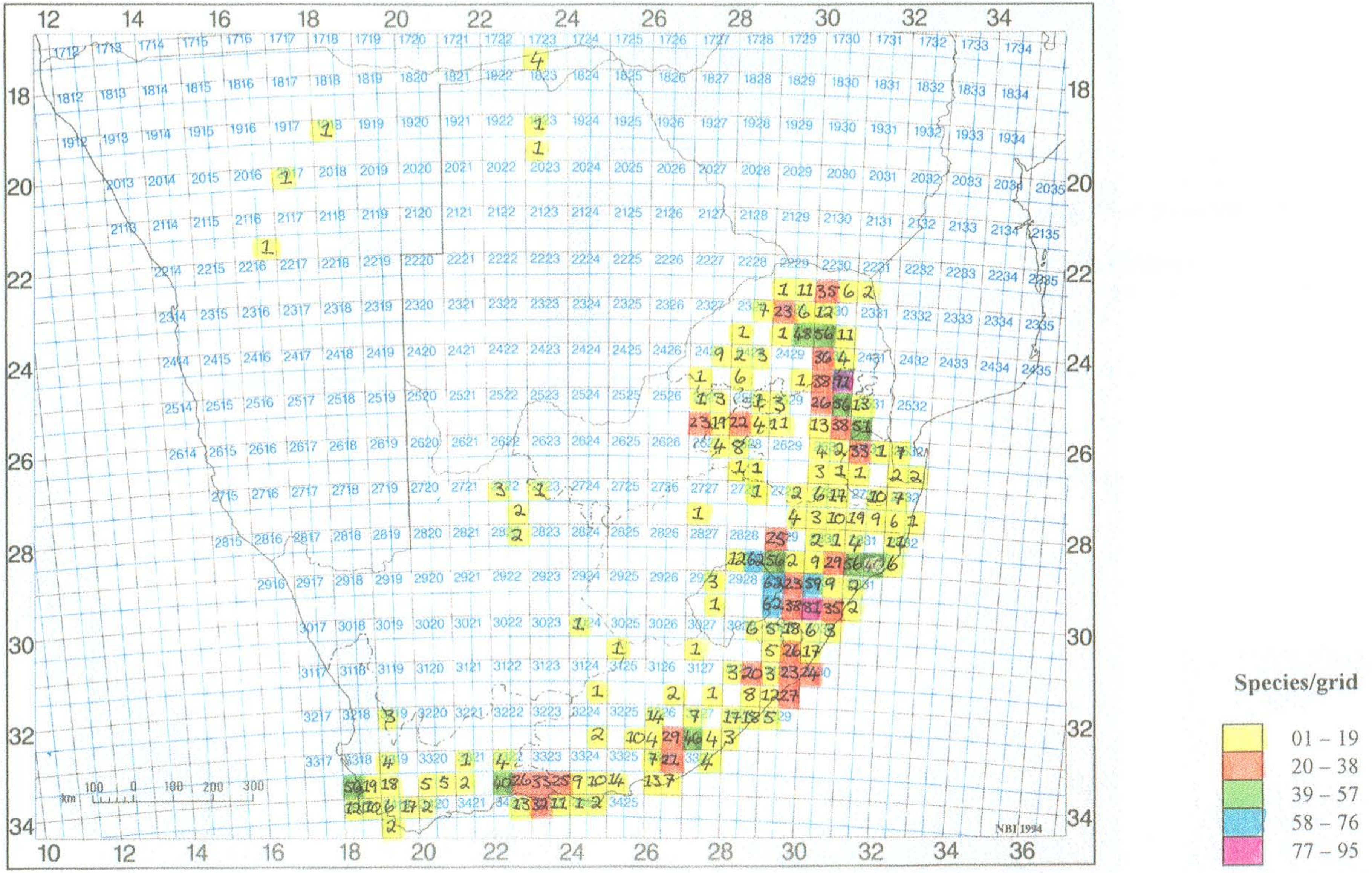
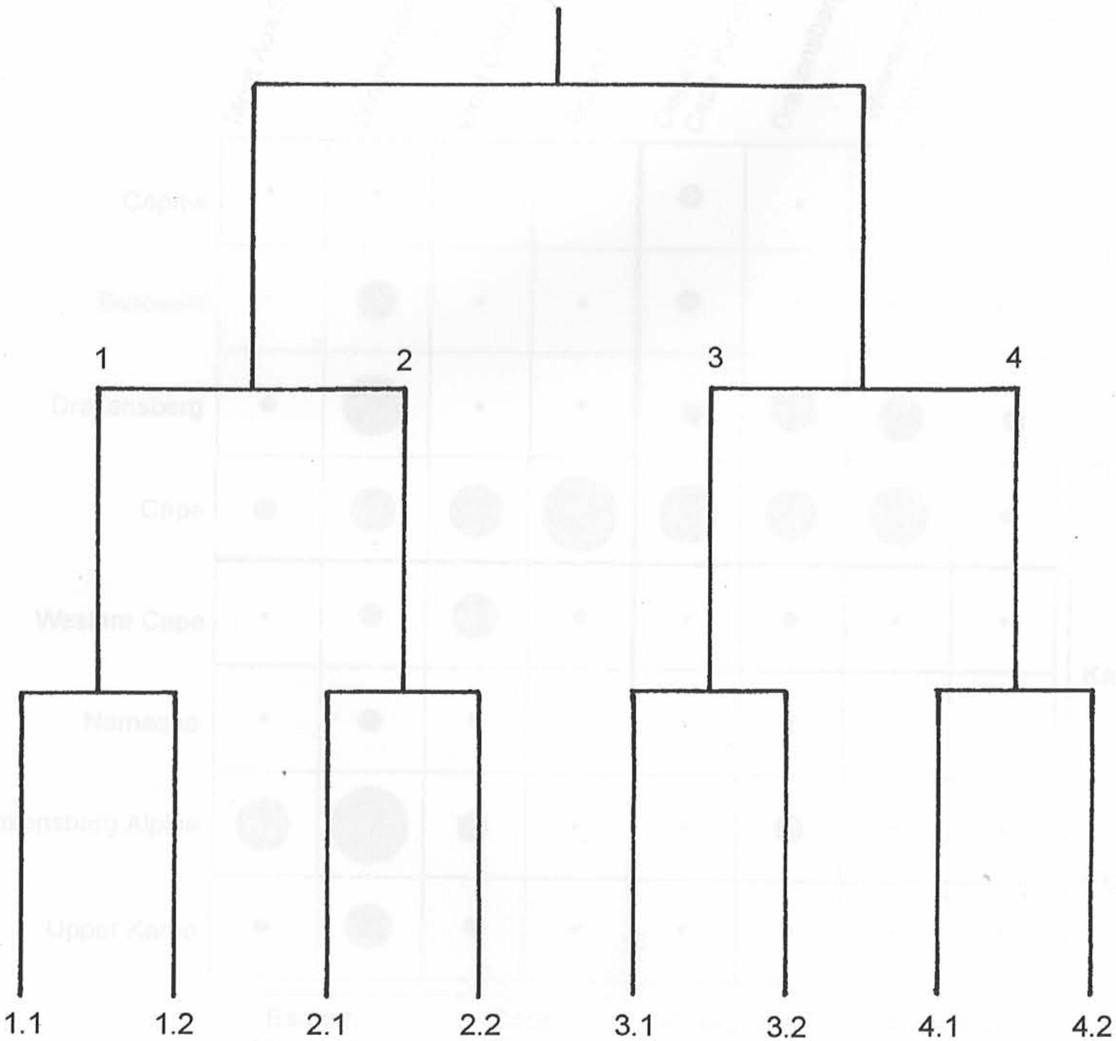


Figure 63. The geographic distribution of the **Tropical Afromontane Subelement** or element 3/8 (TWINSPAN 3+ species classification, 3rd level of division, group 8). The numbering of the groups is the same as in the dendrogram of the TWINSPAN 3+ species classification (Figure 49).



1. Eastern Highlands Element
1.1. Mont Aux Sources Subelement
1.2. Widespread Subelement

2. Cape Element
2.1. West Coast Subelement
2.2. Boland Subelement

3. Afromontane Grassland Element
3.1. Disjunct Cape Peninsula Subelement
3.2. Drakensberg Subelement

4. Afromontane Forest Element
4.1. Widespread Afromontane Subelement
4.2. Tropical Afromontane Subelement

Figure 64. .Hierarchical classification of the **bryofloristic Elements and Subelements** of southern Africa.

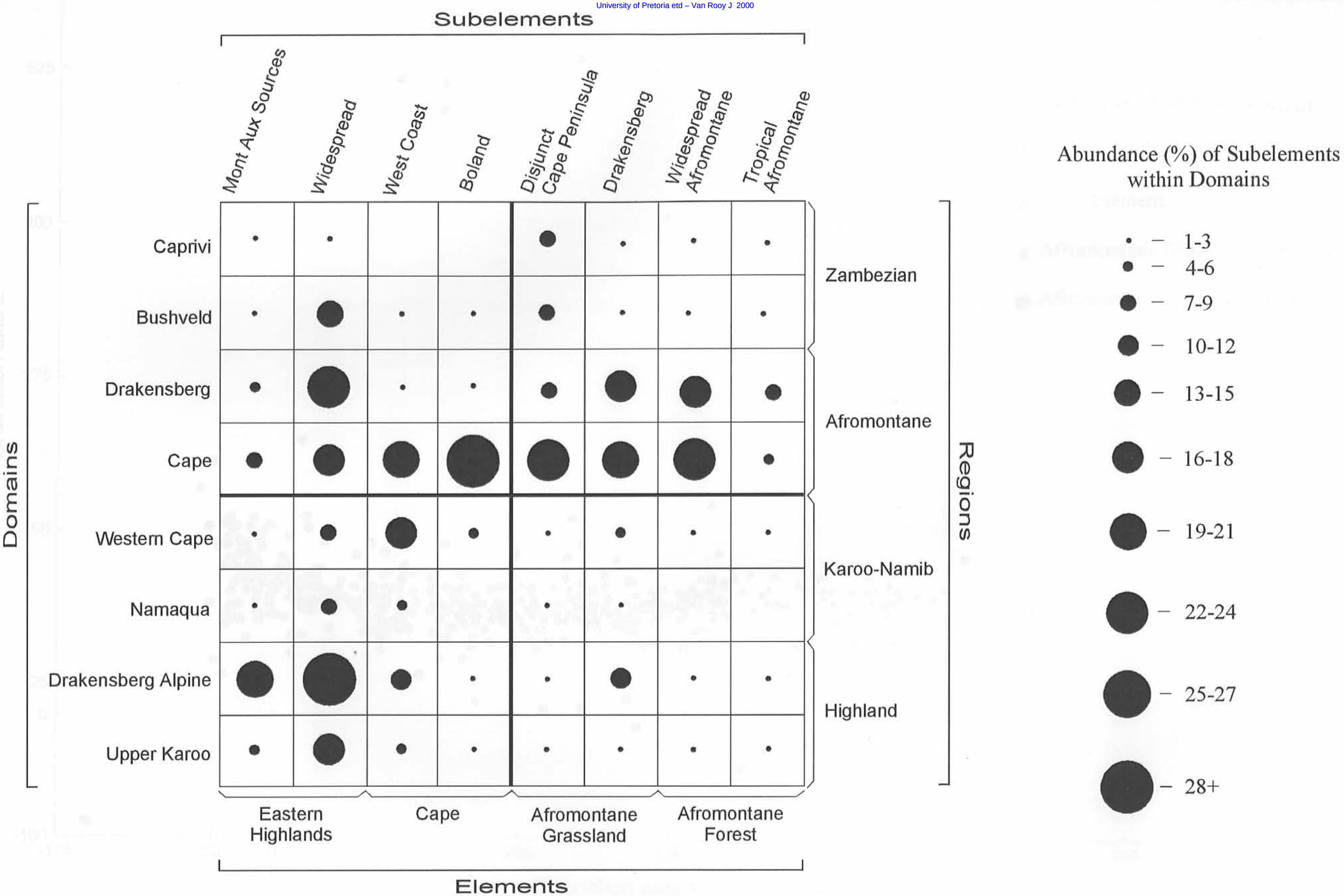


Figure 65. Summarized two-way table of the TWINSPAN 3+ results. The abundance of the eight bryofloristic Subelements in the eight bryofloristic Domains is indicated by different sized dots.

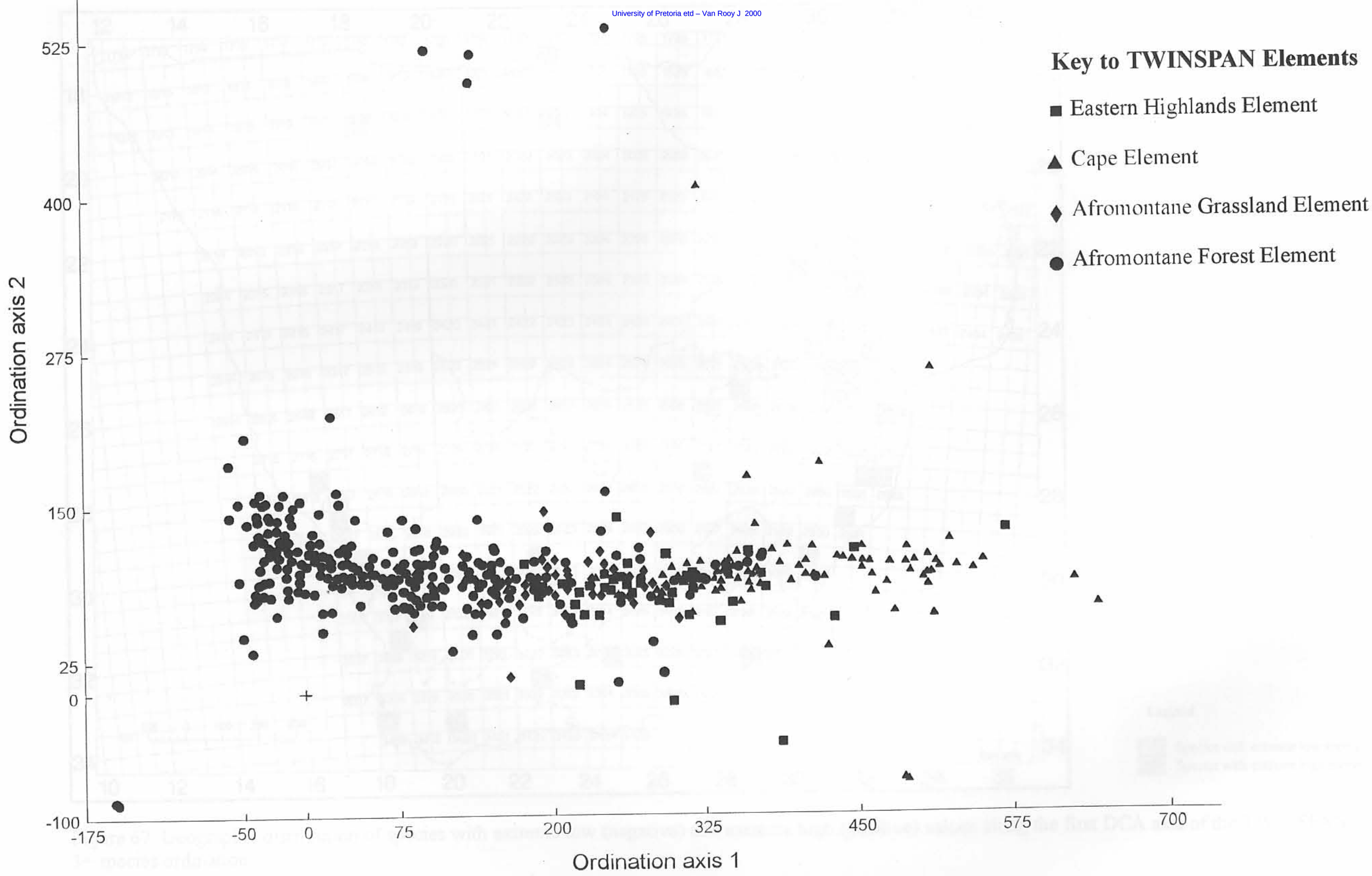


Figure 66. Distribution of **TWINSPAN 3+ Elements** along the first two axes of a **DCA ordination** of TWINSPAN 3+ species. Scale marks are in standard deviation (SD) units.

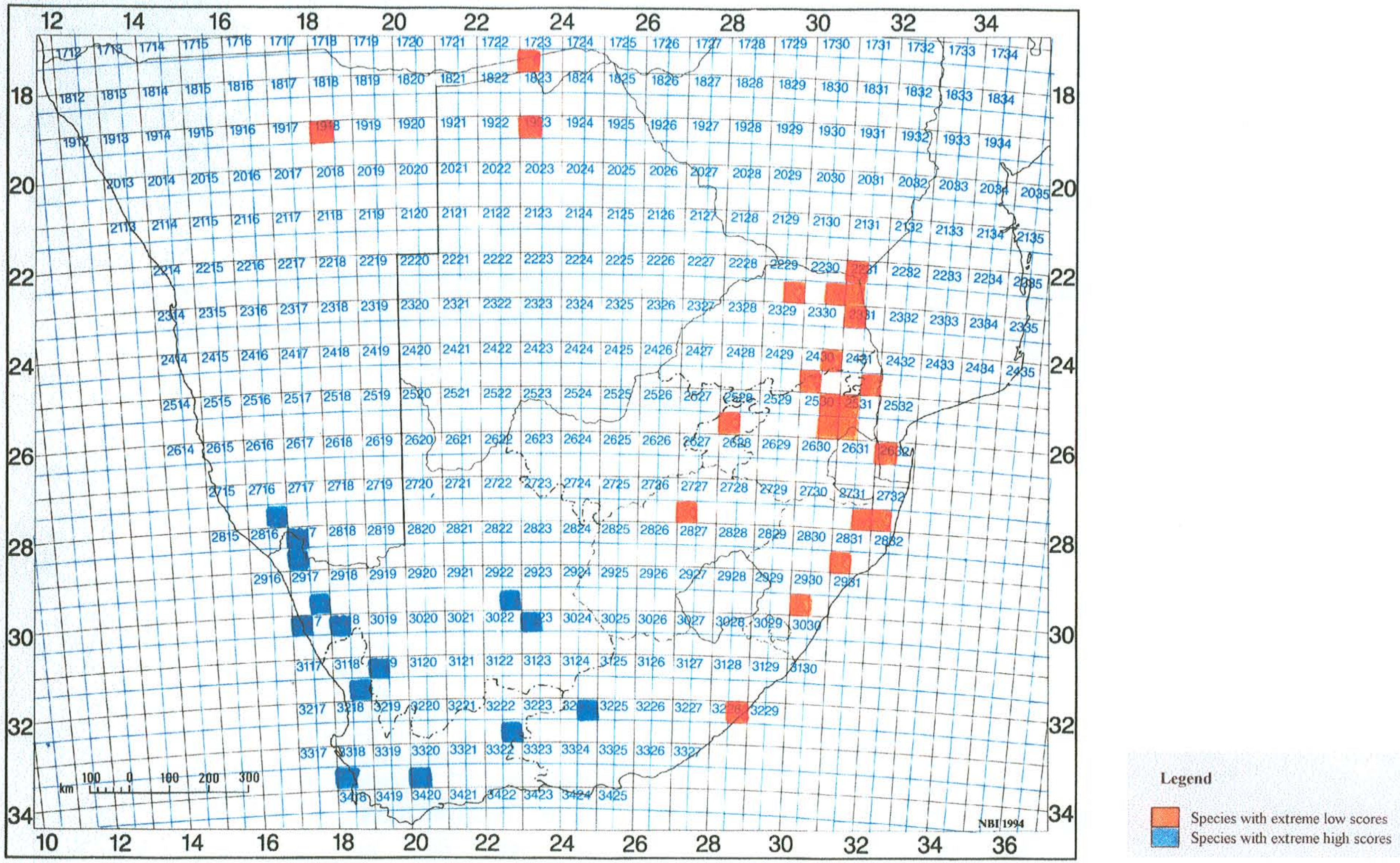


Figure 67. Geographic distribution of species with extreme low (negative) and extreme high (positive) values along the first DCA axis of the TWINSPAN 3+ species ordination.

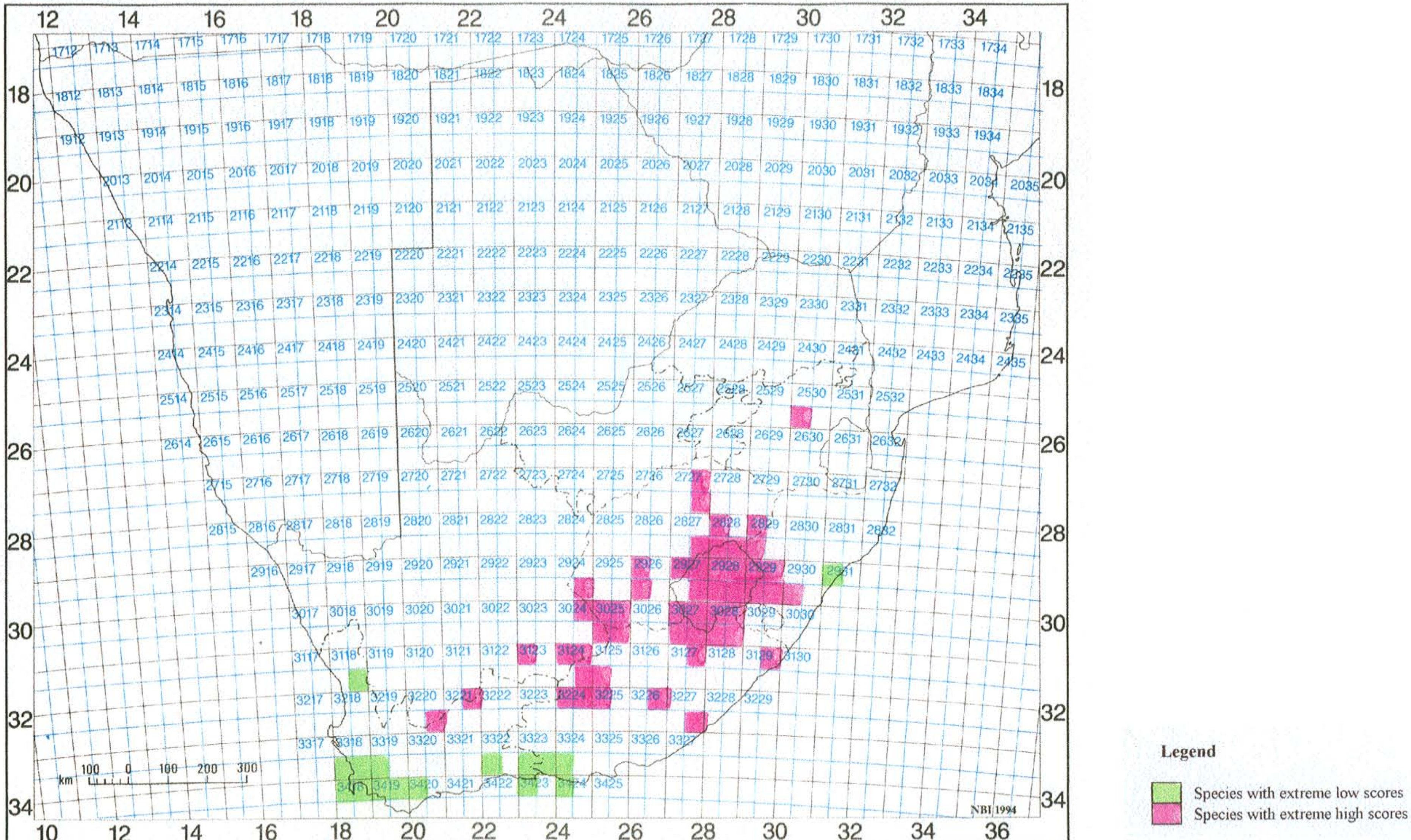


Figure 68. Geographic distribution of species with extreme low (negative) and extreme high (positive) values along the 3rd DCA axis of the TWINSPAN 3+ species ordination.

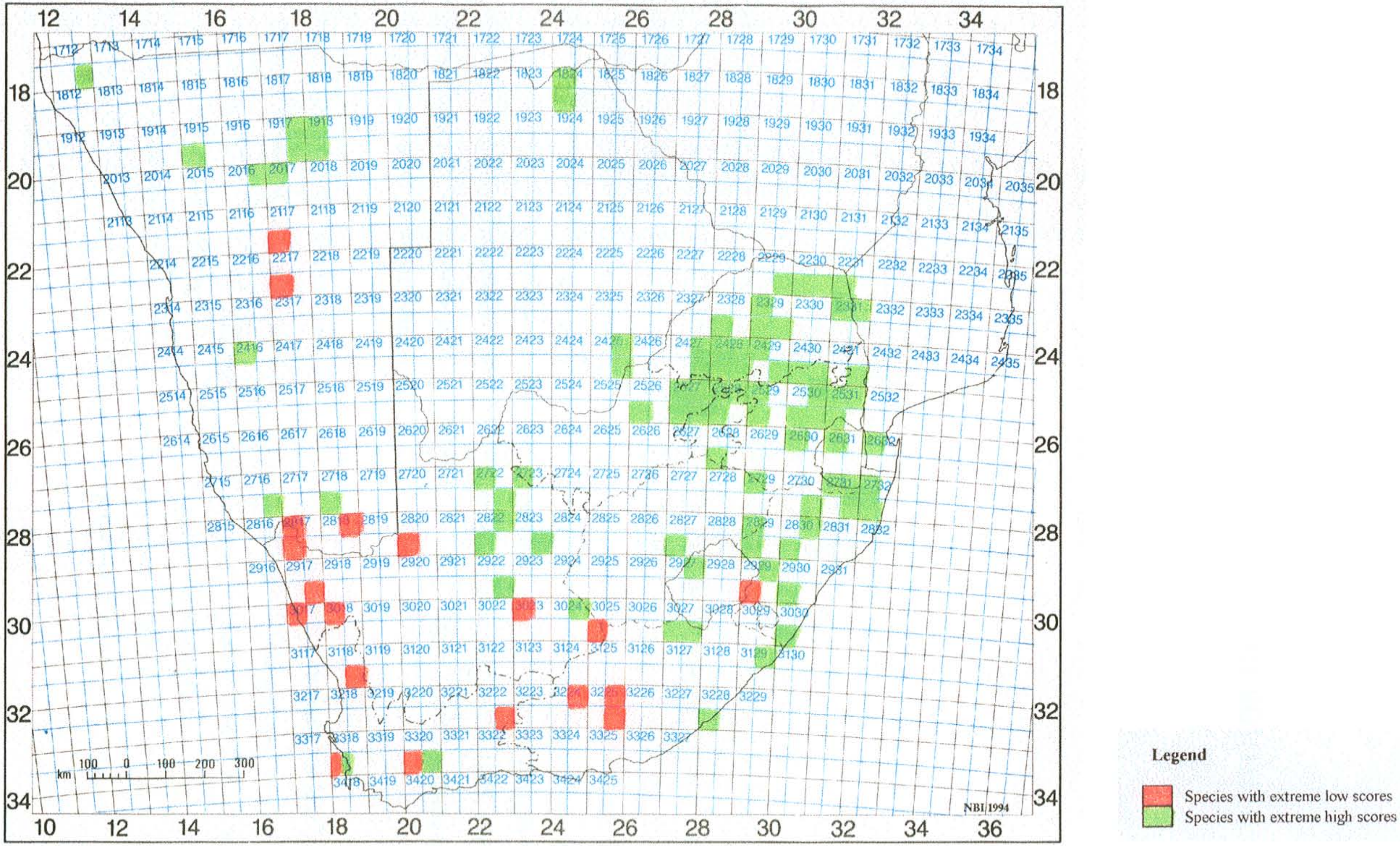


Figure 69. Geographic distribution of species with extreme low (negative) and extreme high (positive) values along the 4th DCA axis of the TWINSPAN 3+ species ordination.

APPENDIX I

A REVISED CHECKLIST OF THE MOSSES OF SOUTHERN AFRICA

Outline of Contents

A. Introduction

This new checklist of the mosses of southern Africa lists all the mosses included in this study and not necessarily the most up to date and complete list of mosses recorded and accepted for the region. Some published taxonomic name changes and new records had to be omitted as the geographic distributions of the taxa concerned, needed for the numerical analyses, are inadequately known, frequently because the specimens in PRE, the largest collection of southern African bryophytes, were not studied by the authors. Examples are taxa in *Campylopus* (Frahm 1985, 1988, 1998), *Hypnum cupressiforme* group (Ando 1993, 1993a), *Tortula* (Kramer 1988), and the family Polytrichaceae (De Sloover 1986, Hyvonen 1989).

Some publications containing name changes or new records were received too late for inclusion or appeared after the compilation of this checklist, for example the descriptions of new species of *Grimmia* (Greven 1996) and *Astomiopsis* (Snider *et al.* 1999), the revision of Anomodontaceae by Granzow-de la Cerda (1997), new synonymy in the genus *Fissidens* (Bruggeman-Nannenga 1997), and new African and southern African records reported by O'Shea *et al.* (1997), Arts (1995, 1998), Sollman (1998), Hodgetts *et al.* (1999) and Ochyra (personal communication).

The taxonomic positions of some taxa are uncertain or have recently changed. For example *Hygroamblystegium caudicaule*, here treated as a synonym of *Pseudoleskea chilensis*, but probably a distinct species under *Drepanophyllaria* (as *Drepanophyllaria caudicaulis* C.Müll., R. Ochyra, personal communication). *Pseudoleskea chilensis* has since been moved to *Orthotheciella varia* (Hedw.) Ochyra (Ochyra 1998) and *Conostomum pentastichum* is no longer considered conspecific with *C. tetragonum* (Virtanen, 1999; Ochyra, personal communication). *Campyliadelphus polygamus* should rather be treated as *Campylium polygamum* (Schimp.) C.E.O. Jensen (Isoviita & Hedenäs 1997). The monotypic, endemic *Wardia hygrometrica* should probably be moved to the family Seligeriaceae (Hedderson *et al.* 1999).

The checklist consists of three parts: 1) an alphabetical list of genera and species with names accepted for this study in **bold,** including references to literature followed and recent synonymy, 2) a systematic arrangement of southern African moss families and genera, and 3) a list of literature references cited in this appendix. For a comprehensive list of recent taxonomic literature on the mosses of southern Africa see Van Rooy (1997).

B. Alphabetical List of Genera and Species

ABIETINELLA C.Müll.
1. Magill & Schelpe. 1979.

A. abietina (Hedw.) M.Fleisch.

ACAULON C.Müll.
1. Magill. 1981.
2. Zander, 1993.

A. leucochaete I.G.Stone
A. recurvatum Magill
A. rufochaete Magill = Microbryum rufochaete

AEROBRYOPSIS Fleischm.
1. Magill & Van Rooy 1998.

A. capensis (C.Müll.) M.Fleisch.

ALOINA (C.Müll.) Kindb.
1. Magill. 1981.

A. bifrons (De Not.) Delgad.

AMPHIDIUM Schimp.
1. Van Rooy. 1992.

A. lapponicum (Hedw.) Schimp.
A. tortuosum (Hornsch.) Cufod.

ANACOLIA Schimp.
1. Magill. 1987.

A. breutelii (C.Müll.) Magill

ANDREAEA Hedw.
1. Magill. 1981.

A. bistratosa Magill

A. nitida Hook.f. & Wilson
A. rupestris Hedw.
A. subulata Harv. ex Hook.

ANOECTANGIUM Schwägr.
1. Magill. 1981.
A. wilmsianum (C.Müll.) Paris
ANOMOBRYUM Schimp.
1. Van Rooy & Magill. 1987.
A. drakensbergense Van Rooy
A. filiforme (Dicks.) Solms
AONGSTROEMIA Bruch, Schimp. & W.Gümbel
1. Magill. 1981.
A. filiformis (P.Beauv.) Wijk & Margad.
A. julacea (Hook.) Mitt.

AONGSTROEMIOPSIS Fleischm.
1. Magill. 1987a.
A. julacea (Dozy & Molk.) M.Fleisch.

ARCHIDIUM Brid.
1. Van Rooy. 1981.
A. acanthophyllum Snider
A. amplexicaule C.Müll.
A. andersonianum Snider
A. capense Hornsch.
A. dinteri (Irmsch.) Snider
A. julicaule C.Müll.
A. microthecium Dixon & P.de la Varde
A. muelleranum Snider
A. ohioense Schimp. ex C.Müll.
A. rehmannii Mitt.
A. subulatum C.Müll.

ASTOMIOPSIS C.Müll.
1. Magill. 1987a.
A. amblyocalyx C.Müll.

ATRICHUM P.Beauv.
1. Magill & Schelpe. 1979.
A. androgynum (C.Müll.) A.Jaeger

AULACOPILUM Wilson
1. Magill & Schelpe 1979.
2. Magill & Van Rooy 1998.
A. trichophyllum Ångstr.

BARBULA Hedw.
1. Magill. 1981.
2. Zander. 1993..
3. Sollman. 1993.
4. Frahm, Lindlar, Sollman & Fischer 1996.
B. acutata C.Müll. = Pseudocrossidium replicatum
B. afrofontana (C.Müll.) Broth. = B. bolleana 3,4
B. bolleana (C.Müll.) Broth.
B. calycina Schwägr.
B. crinita Schultz = Pseudocrossidium crinitum
B.ehrenbergii (Lor.) Fleischer = B. bolleana 4
B. eubryum C.Müll.
B. hornschuchiana Schultz = Pseudocrossidium hornschuchianum
B. indica (Hook.) Spreng.
B. microcalycina Magill
B. rehmannii C.Müll.

BARTRAMIA Hedw.
1. Magill. 1987.
B. aristaria C.Müll.
B. capensis (R.Br.) Wijk & Margad.
B. compacta Hornsch. var. **compacta**
B. compacta Hornsch. var. **macowaniana** (C.Müll.) Magill
B. hampeana C.Müll.

BARTRAMIDULA Bruch, Schimp. & W.Gümbel
B. comosa Broth. = Philonotis comosa
B. globosa (C.Müll.) Broth. = Philonotis globosa

BLINDIA Bruch, Schimp. & W.Gümbel
1. Magill. 1981.
B. magellanica Schimp. ex C.Müll.

BRACHYMENIUM Schwägr.
1. Van Rooy & Magill. 1987. FSA Bryoph. 1,2.
2. Ochi 1985.
B. acuminatum Harv. in Hook.
B. angolense (Welw. & Duby) A.Jaeger = B.systylium 2
B. dicranoides (Hornsch.) A.Jaeger
B. leptophyllum (C.Müll.) A.Jaeger
B. nepalense Hook. in Schwägr.
B. pulchrum Hook.
B. systylium (C.Müll.) A.Jaeger

BRACHYTHECIUM Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
B. implicatum (Hornsch.) A.Jaeger
B. pinnatum Dixon
B. plumosum (Hedw.) Bruch, Schimp. & W.Gümbel
B. populeum (Hedw.) Bruch, Schimp. & W.Gümbel
B. pseudopopuleum (C.Müll.) Schimp.
B. pseudovelutinum (C.Müll.) A.Jaeger
B. salebrosum (F.Weber & Mohr) Bruch, Schimp. & W.Gümbel
B. subrutabulum (C.Müll.) A.Jaeger

BRAUNIA Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
2. Magill & Van Rooy 1998.
B. secunda (Hook.) Bruch, Schimp. & W.Gümbel

BREUTELIA (Bruch, Schimp. & W.Gümbel) Schimp.
1. Magill. 1987.
2. Griffin. 1992.
B. afroscoparia (C.Müll.) Paris = B. substricta
B. angustifolia Rehmann ex Sim = B. microdonta
B. diffracta Mitt.
B. elliptica Magill
B. microdonta (Mitt.) Broth.
B. substricta (C.Müll.) Magill
B. tabularis Dixon ex Sim

BRUCHIA Schwägr.
1. Magill. 1981
2. Rushing. 1986.
B. brevipes Harv. ex Hook.
B. eckloniana C.Müll.
B. foveolata Magill = B. queenslandica
B. queenslandica I.G.Stone

BRYOBARTRAMIA Sainsbury
1. Magill. 1981.
B. novae-valesiae (Broth.) I.G.Stone & G.A.M.Scott

BRYOERYTHROPHYLLUM Ekimov
1. Magill, 1981.
2. Zander. 1986, 1993.
B. campylocarpum (C.Müll.) H.A.Crum
B. jamesonii (Taylor) H.A.Crum - excluded
B. recurvirostrum (Hedw.) P.C.Chen

BRYUM Hedw.
1. Ochi. 1980.
2. Van Rooy & Magill. 1987.
3. Ochyra. 1989.
B. alpinum Huds. ex With.
B. andicola Hook.
B. apiculatum Schwägr.
B. argenteum Hedw.
B. aubertii (Schwägr.) Brid.
B. bicolor Dicks. = B. dichotonun
B. caespiticium Hedw.
B. canariense Brid.
B. capillare Hedw.
B. cellulare Hook.
B dichotomum Hedw.
B. donianum Grev.
B. erythrocaulon (Schwägr.) Brid.
B. micro-erythrocarpum C.Müll. & Kindb. = B. subapiculatum
B. nitens Hook. = B. apiculatum
B. perlimbatum Card. - excluded
B. pseudotriquetrum (Hedw.) Gaertn., B.Mey & Scherb.
B. pycnophyllum (Dixon) Mohamed
B. radiculosum Brid.

B subapiculatum Hampe
B. torquescens Bruch ex De Not.
B. turbinatum (Hedw.) Turner
B. viridescens Welw. & Duby

CALLICOSTELLA (C.Müll.) Mitt.
1. Magill & Schelpe. 1979.
2. Magill & Van Rooy 1998..
C. applanata Broth. & Bryhn = C. tristis
C. tristis (C.Müll.) Broth.

CALYMPERES Sw. in F.Weber
1. Magill. 1981.
2. Reese & Mohamed 1985
3. Ellis 1988.
C. levyanum Besch.
C. pallidum Mitt.
C. rabenhorstii Hampe & C.Müll. = C. pallidum
C. tenerum C.Müll.
C. tenerum C.Müll. var. edamense M.Fleisch. = C. tenerum

CALYPTOTHECIUM Mitt.
1. Magill & Schelpe. 1979
2. Magill & Van Rooy 1998
C. acutifolium (Brid.) Broth.= Pterobryopsis acutifolium 2.
C. hoehnelii (C.Müll.) Argent = Pterobryopsis hoehnelii 2.

CALYPTROCHAETA Desv.
1. Magill & Van Rooy 1998.
C. asplenioides (Brid.) Crosby

CAMPYLIADELPHUS (Kindb.) R.S.Chopra
1. Ochyra & Pócs. 1992.
C. polygamus (Bruch, Schimp.& W.Gümbel) Kanda

CAMPYLOPUS Brid.
1. Magill. 1981.
2. Corley & Frahm. 1982.
3. Frahm. 1984..
4. Vital, 1984.
5. Frahm. 1985
C. ampliretis (C.Müll.) Paris = C. flaccidus
C. atroluteus (C.Müll.) Paris
C. aureonitens (C.Müll.) A.Jaeger
C. bequaertii Thér. & Naveau = C. savannarum
C. bicolor (C.Müll.) Wilson
C. cambouei Renauld & Cardot
C. catarractilis (C.Müll.) Paris
C. delagoae (C.Müll.) Paris = C. savannarum
C. flaccidus Renauld & Cardot
C. fragilis (Brid.) Bruch, Schimp. & W.Gümbel
C. hensii Renauld & Cardot
C. hildebrandtii (C.Müll.) A.Jaeger
C. inchangae (C.Müll.) Paris = C. robillardei
C. introflexus (Hedw.) Brid.
C. jamesonii (Hook.) A.Jaeger
C. julaceus A.Jaeger subsp. **arbogastii** (Renauld & Cardot) A.Jaeger
C. lonchoclados C.Müll. in Geh.
C. nanophyllus C.Müll. ex Broth.
C. pallidus Hook.f. & Wilson = C. pyriformis
C. perpusillus Mitt.
C. pilifer Brid.
C. procerus (C.Müll.) Paris = C. jamesonii
C. pyriformis (Schultz) Brid.
C. robillardei Besch.
C. savannarum (C.Müll.) Mitt.
C. simii Schelpe = C. julaceus subsp. arbogastii
C. stenopelma (C.Müll.) Paris
C. subchlorophyllosus C.Müll. ex Rabenh. = Sphaerothecium subchlorophyllosum
C. symonsii Sim

CARDOTIELLA Vitt
1. Van Rooy & Van Wyk. 1992.
2. Magill & Van Rooy 1998.
C. secunda (C.Müll.) Vitt

CATAGONIUM C.Müll. ex Broth.
1. Lin. 1984.
C. mucronatum (A.Jaeger) Broth. = C. nitens subsp. maritimum

C. nitens (Brid.) Cardot subsp. **maritimum** (Hook.) S.H.Lin

CERATODON Brid.
1. Magill. 1981.
2. Burley & Pritchard. 1990.
C. purpureus (Hedw.) Brid. subsp. **stenocarpus** (Bruch, Schimp. & W.Gümbel)
C. stenocarpus Bruch & Schimp. ex C.Müll. = C. purpureus subsp. stenocarpus

CHAMAEBRYUM Thér. & Dixon
1. Magill. 1987.
C. pottioides Thér. & Dixon
CHEILOTHELA Lindb.
1. Magill 1987a.
C. chilensis (Mont.) Broth.

CHENIA R.H.Zander
1. Zander. 1989, 1993.
C. leptophylla (C.Müll.) R.H.Zander

CHORISODONTIUM (Mitt.) Broth.
1. Magill, R.E. 1981.
2. Frahm, J-.P. 1989. Tropical Bryology 1: 11-24.
3. Ochyra, R. & Bednarek-Ochyra, H. 1997.
C. falcatum Magill = Platyneurum praealtum 2, 3

CHRYSOHYPNUM Hampe
1. Ochyra & Sharp. 1988.
C. cavifolium (Dixon) Ochyra & Sharp
CLADOPHASCUM Dixon
1. Magill. 1981.
C. gymnomitrioides (Dixon) Dixon ex Sim

CONOSTOMUM Sw. in F.Weber & Mohr
1. Magill. 1987.
2. Frahm, J.-P., Borner, H., Streiber, N., Wallau, B. & Weitkus, S. 1996.
C. pentastichum (Brid.) Lindb. = C. tetragonum 2

C. tetragonum (Hedw.) Lindb.

CRATONEURON (Sull.) Spruce
1. Magill & Schelpe. 1979.
C. filicinum (Hedw.) Spruce
CROSSIDIUM Jur.
1. Magill. 1981.
2. Cano, Guerra & Ros. 1993.
C. apiculatum Magill = Microcrossidium apiculatum
C. spiralifolium Magill
CRYPHAEA Mohr in F.Weber
1. Magill & Van Rooy 1998.
C. exigua (C.Müll.) A.Jaeger
CYCLODICTYON Mitt.
1. Magill & Van Rooy 1998..
C. borbonicum (Besch.) Broth. - excluded
C. vallis-gratiae (Hampe) Kuntze

CYGNICOLLUM Fife & Magill
1. Magill. 1987.
C. immersum Fife & Magill

CYRTO-HYPNUM (Hampe) Hampe & Lor.in Hampe
1. Buck & Crum 1990.
C. ramusculosum (Mitt.) Buck & Crum
C. varians (Welw.& Duby) Buck & Crum
C. versicolor (C.Müll.) Buck & Crum

DESMATODON Brid.
1. Zander. 1993.
D. bogosicus C.Müll. = Tortula bogosica
D. convolutus (Brid.) Grout = Tortula atrovirens
D. longipedunculata (C.Müll.) Magill = Hennediella longipedunculata

DICRANELLA (C.Müll.) Schimp.
1. Magill. 1981.
2. Ochyra & Newton, 1986.
D.cardotii (R.Br.) Dixon
D. rigida Dixon ex Sim

D. subsubulata (C.Müll.) A.Jaeger
D. symonsii Dixon = D cardotii

DICRANOLOMA (Renauld) Renauld
1. Magill. 1981.
D. billardieri (Brid.) Paris
D. entabeniense Magill

DIDYMODON Hedw.
1. Zander. 1978.
2. Magill. 1981.
3. Guerra & Ros. 1987.
4. Zander. 1993.
D. australasii (Hook. & Grev.) R.H.Zander
D. ceratodonteus (C.Müll.) Dixon
D. jackvancei R.H.Zander
D. tophaceopsis R.H.Zander
D. trivialis (C.Müll.) Guerra
D. xanthocarpus (C.Müll.) Magill

DIMERODONTIUM Mitt.
1. Magill & Schelpe. 1979.
D. africanum C.Müll.

DISTICHIUM Bruch, Schimp. & W.Gümbel
1. Magill. 1981.
D. capillaceum (Hedw.) Bruch, Schimp. & W.Gümbel

DISTICHOPHYLLUM Dozy & Molk.
1. Magill & Van Rooy 1998.
D. mniifolium (Hornsch.) Sim var. **mniifolium**
D. mniifolium (Hornsch.) Sim var. **taylorii** Magill
D. taylorii Sim = D. mniifolium var. taylorii

DITRICHUM Hampe
1. Magill. 1981.
D. brachypodum (C.Müll.) Broth.
D. difficile (Duby) M.Fleisch.
D. punctulatum Mitt.
D. strictum (Hook.f. & Wilson) Hampe

DREPANOCLADUS (C.Müll.) G.Roth
1. O'Shea 1995.
2. PRE herbarium use following R. Ochyra (pers. comm.)
D. aduncus (Hedw.) Warnst.
D. hallii Broth. & Dixon = D.sendtneri 1, 2
D. sendtneri (Schimp.) Warnst. 2
D. sparsus C.Müll. = Leptodictyum riparium 1, 2
D. uncinatus (Hedw.) Warnst. = Sanionia uncinata

ECCREMIDIUM Hook.f. & Wilson
1. Magill. 1981.
E. exiguum (Hook.f. & Wilson) Wilson ex E.S.Salmon

ECTROPOTHECIUM Mitt.
1. Magill & Schelpe. 1979.
E. brachycarpum (Dixon) Magill
E. perrotii Renauld & Cardot
E. regulare (Brid.) A.Jaeger

ENCALYPTA Hedw.
1. Magill. 1981.
E. ciliata Hedw.
E. vulgaris Hedw.

ENTODON C.Müll.
1. Magill & Schelpe.
2. Townsend. 1991.
E. cymbifolius Wager & Dixon
E. dregeanus (Hornsch.) C.Müll. = E. macropodus
E. geminidens (Besch.) Paris
E. macropodus (Hedw.) C.Müll.
E. natalensis Rehmann ex C.Müll.

EPHEMERUM Hampe
1. Magill. 1987.
E. capense C.Müll.
E. diversifolium Mitt. in Harv.
E. namaquense Magill
E. rehmannii (C.Müll.) Broth.

ERPODIUM (Brid.) C.Müll.
1. Magill & Van Rooy 1998.
E. beccarii C.Müll.

E. coronatum (Hook & Wilson) Mitt. subsp. **transvaaliense** (Broth & Wager) Magill
E. distichum Wager & Dixon
E. grossirete C.Müll.
E. transvaaliense Broth. & Wager ex Dixon = E. coronatum subsp. transvaaliense

ERYTHRODONTIUM Hampe
1. Magill & Schelpe. 1979.
E. julaceum (Schwägr.) Paris - species insufficiently known
E. subjulaceum (C.Müll.) Paris

EUSTICHIA (Brid.) Brid.
1. Magill. 1987.
E. longirostris (Brid.) Brid.

FABRONIA Raddi
1. Magill & Schelpe. 1979.
F. abyssinica C.Müll.
F. breutelii Hampe in C.Müll.
F. eckloniana Hampe in C.Müll.
F. gueinzii Hampe
F. leikipiae C.Müll.
F. perciliata C.Müll.
F. pilifera Hornsch.
F. rehmannii C.Müll.
F. victoriae Dixon
F. wageri Dixon

FISSIDENS Hedw.
1. Pursell & Reese. 1980.
2. Magill. 1981.
3. Pursell. 1987.
4. Bruggeman-Nannenga. 1993.
F. aciphyllus Dixon
F. asplenioides Hedw.
F. borgenii Hampe
F. bryoides Hedw.
F. capriviensis Magill
F. curvatus Hornsch.
F. enervis Sim
F. erosulus (C.Müll.) Paris
F. fasciculatus Hornsch.
F. fontanus (B. Pyl.) Steud. - excluded
F. gladiolus Mitt.
F. glaucescens Hornsch.
F. hoeegii P.de la Varde
F. marginatus Schimp. ex C.Müll.
F. microandrogynus Dixon
F. nitens Rehmann ex E.S.Salmon = F. porrectus
F. palmifolius (P.Beauv.) Broth.
F. parvilimbatus Sim
F. plumosus Hornsch.
F. porrectus Mitt.
F. pseudoserratus (C.Müll.) A.Jaeger
F. pygmaeus Hornsch.
F. rufescens Hornsch.
F. scleromitrius (Besch.) Broth.
F. simii Schelpe
F. splachnifolius Hornsch.
F. stellenboschianus Dixon ex Sim
F. submarginatus Bruch ex C.Krauss
F. subobtusatus C.Müll.
F. usambaricus Broth.
F. wageri Dixon ex Wager

FLORIBUNDARIA Fleischm.
1. Magill & Van Rooy 1998.
F. floribunda (Dozy & Molk.) M.Fleisch.

FONTINALIS Hedw.
1 Magill & Van Rooy 1998.
F. antipyretica Hedw. var. **gracilis** (Lindb.) Schimp.
F. squamosa Hedw.

FORSSTROEMIA Lindb.
1 Magill & Van Rooy 1998.
F. producta (Hornsch.) Paris

FUNARIA Hedw.
1. Magill. 1987.
F. bergiana (Hornsch.) Broth.
F. clavata (Mitt.) Magill
F. hygrometrica Hedw.
F. limbata (C.Müll.) Broth.
F. longicollis Dixon
F. rhomboidea Shaw
F. rottleri (Schwägr.) Broth.
F. spathulata Schimp. ex C.Müll.

F. succuleata (Wager & C.H.Wright) Magill
F. urceolata (Mitt.) Magill

GIGASPERMUM Lindb.
1. Magill. 1987.
G. repens (Hook.) Lindb.

GONIOMITRIUM Hook. & Wilson
1. Magill. 1987.
G. africanum (C.Müll.) Broth.

GRIMMIA Hedw.
1. Magill. 1981.
G. apocarpa Hedw. = Schistidium apocarpum
G. laevigata (Brid.) Brid.
G. ovalis (Hedw.) Lindb.
G. pulvinata (Hedw.) Sm.

GYMNOSTOMUM Nees & Hornsch.
1. Magill. 1981.
G. aeruginosum Sm.
G. bewsii Dixon
G. lingulatum Rehmann ex Sim

HAPLOCLADIUM (C.Müll.) C.Müll.
1. Magill & Schelpe. 1979.
H. angustifolium (Hampe & C.Müll.) Broth.

HAPLOHYMENIUM Dozy & Molk.
1. Magill & Schelpe. 1979.
H. pseudo-triste (C.Müll.) Broth.

HEDWIGIA P.Beauv.
1 Magill & Van Rooy 1998.
H. ciliata (Hedw.) P.Beauv.

HEDWIGIDIUM Bruch, Schimp. & W.Gümbel
1 Magill & Van Rooy 1998.
H. integrifolium (P.Beauv.) Dixon

HELICODONTIUM Schwägr.
1. Magill & Schelpe. 1979.
H. lanceolatum (Hampe & C.Müll.) A.Jaeger

HENNEDIELLA Paris
1. Magill, 1981.
1. Zander. 1993.
H. longipedunculata (C.Müll.) R.H.Zander

HERPETINEURON (C.Müll.) Cardot
1. Magill & Schelpe. 1979.
H. toccoae (Sull. & Lesq.) Cardot

HETEROPHYLLIUM (Schimp.) Kindb. in M.Fleisch.
1. Buck 1993.
H. flexile (Renauld & Cardot) Thér. & P.de la Varde = Rhacopilopsis flexilis
H. transvaalense (Thér. & Dixon) Thér. & P.de la Varde = Rhacopilopsis transvaaliensis

HOLOMITRIUM Brid.
1. Magill. 1981.
H. cylindraceum P.Beauv. var. **cucullatum** (Besch.) Wijk & Margad.

HOMALOTHECIUM Bruch, Schimp. & W.Gümbel
1. Ochyra & Pócs. 1982.
2. Hofmann 1997.
H. afrostriatum (C.Müll.) Ochyra = Palamocladium leskeoides 1.

HOOKERIOPSIS (Besch.) A.Jaeger
1. Magill & Van Rooy 1998.
H. pappeana (Hampe) A.Jaeger

HUSNOTIELLA Cardot
H. latifolia (Dixon) R.H.Zander & Magill = Didymodon tophaceopsis
H. plicata Magill = Didymodon jackvancei

HYGROAMBLYSTEGIUM Loeske
1. Magill & Schelpe. 1979.
2. PRE herbarium use following R. Ochyra (pers. comm.)
H. caudicaulis (C.Müll.) Broth. = Pseudoleskea chilensis 2.

HYMENOSTYLIUM Brid.
1. Magill. 1981.
H. recurvirostrum (Hedw.) Dixon

HYOPHILA Brid.
1. Magill. 1981.
H. baginsensis C.Müll.
H. involuta (Hook.) A.Jaeger

HYPNUM Hedw.
1. Magill & Schelpe. 1979.
2. Ando 1995
H. aduncoides sensu Sim = H. macrogynum 2
H. cupressiforme Hedw.
H. macrogynum Besch.

HYPODONTIUM C.Müll.
1. Magill. 1981.
H. dregei (Hornsch.) C.Müll.
H. pomiforme (Hook.) C.Müll.

HYPOPTERYGIUM Brid.
1. Magill & Van Rooy. 1998
H. laricinum (Hook.) Brid.
H. polythrix Dixon = Lopidium pennaeforme

ISCHYRODON C.Müll.
1. Magill & Schelpe. 1979.
I. lepturus (Taylor) Schelpe

ISOPTERYGIUM Mitt.
1. Magill & Schelpe. 1979.
I. aquaticum Dixon - excluded
I. leucophanes (C.Müll.) A.Jaeger
I. leucopsis (C.Müll.) Paris
I. punctulatum Broth. & Wager
I. strangulatum (C.Müll.) Broth.
I. taxithellioides Broth. & Bryhn
I. taylorii Sim

JAEGERINA C.Müll.
1 Magill & Van Rooy 1998.
J. stolonifera (C.Müll.) C.Müll.

LEPIDOPILIDIUM (C.Müll.) Broth.
1 Magill & Van Rooy 1998.

L. hanningtonii (Mitt.) Broth.

LEPTOBRYUM (Bruch, Schimp. & W.Gümbel) Wilson
1. Van Rooy & Magill. 1987
L. pyriforme (Hedw.) Wilson

LEPTODICTYUM (Schimp.) Warnst.
1. Magill & Schelpe. 1979.
L. riparium (Hedw.) Warnst.

LEPTODON Mohr
1. Magill & Van Rooy 1998.
L. smithii (Hedw.) F.Weber & Mohr

LEPTODONTIUM (C.Müll.) Hampe ex Lindb.
1. Magill. 1981.
L. brachyphyllum Broth. & Thér.
L. longicaule Mitt.
L. viticulosoides (P.Beauv.) Wijk & Margad.

LEPTOHYMENIUM Schwägr.
1. Magill & Schelpe. 1979.
L. breutelii (C.Müll.) Schimp. - species insufficiently known
L. dentatum Schwägr. - species insufficiently known

LEPTOISCHYRODON Dixon
1. Magill & Schelpe. 1979.
L. congoanus Dixon

LEPTOSTOMUM R.Br.
1. Crum. 1992.
L. gerrardii Shaw - species insufficiently known

LEPTOTERIGYNANDRUM C.Müll.
1. Magill. 1987a.
L. austroalpinum C.Müll.

LEPTOTHECA Schwägr.
1. Magill. 1987.
L. gaudichaudii Schwägr.

LEPTOTRICHELLA (Müll. Ha.)Lindb.
1. Ochyra 1998.
L. minuta (Hampe) Ochyra

LESKEELLA (Limpr.) Loeske
1. Magill & Schelpe. 1979.
L. zuluensis Broth. & Bryhn

LEUCOBRYUM Hampe
1. Magill. 1981.
L. acutifolium (Mitt.) Cardot
L. madagassum Besch.
L. rehmannii C.Müll.

LEUCODON Schwägr.
1. Magill & Van Rooy 1998.
L. assimilis (C.Müll.) A.Jaeger
L. capensis Schimp. in Renauld = L. assimilis
L. maritimus (Hook.) Wijk.& Margad. = Catagonium nitens subsp. maritimum

LEUCOLOMA Brid.
1. Magill. 1981.
L. chrysobasilare (C.Müll.) A.Jaeger
L. rehmannii (C.Müll.) Rehmann ex Paris
L. sprengelianum (C.Müll.) A.Jaeger
L. syrrhopodontioides Broth.

LEUCOPERICHAETIUM Magill
1. Magill. 1981.
L. eremophilum Magill

LEVIERELLA C.Müll.
2. Bizot & Pócs. 1982.
L. fabroniacea C.Müll. var. abyssinica Dixon = L. perserrata
L. perserrata P.de la Varde & J.-F.Leroy

LINDBERGIA Kindb.
1. Magill & Schelpe. 1979.
L. haplocladioides Dixon
L. patentifolia Dixon
L. pseudoleskeoides Dixon
L. viridis Dixon

LOPIDIUM Hook.f. & Wilson
1 Magill & Van Rooy 1998.
L. pennaeforme (Brid.) M.Fleisch.

MACROCOMA (C.Müll.) Grout
1 Magill & Van Rooy 1998.
M. lycopodioides (Schwägr.) Vitt
M. pulchella (Hornsch.) Vitt
M. tenue (Hook. & Grev.) Vitt subsp **tenue**

MACROMITRIUM Brid.
2. Van Rooy & Van Wyk. 1992.
M. lebomboense Van Rooy
M. levatum Mitt.
M. macropelma C.Müll.
M. richardii Schwägr.
M. schlotheimiaeforme Paris = Cardotiella secunda
M. secundum C.Müll. = Cardotiella secunda
M. serpens (Hook. & Grev.) Brid.
M. tristratosum Dixon = M. serpens

MEIOTHECIUM Mitt.
1. Magill & Schelpe. 1979.
M. fuscescens (A.Jaeger) Broth.

MICROBRYUM Schimp.
1. Zander. 1993.
M. davallianum (Sm.) R.H.Zander var. **conicum** (Schleich. ex Schwägr.) R.H. Zander
M. rufochaete (Magill) R.H.Zander
M. subplanomarginatum (Dixon) R.H.Zander

MICROCAMPYLOPUS (C.Müll.) M.Fleisch.
M. perpusillus (Mitt.) Broth. = Campylopus perpusillus

MICROCROSSIDIUM Guerra & Cano
1. Cano, Guerra & Ros. 1993.
M. apiculatum (Magill) Guerra & Cano

MICRODUS Schimp. ex Besch. = Leptotrichella
1. Magill. 1981.
2. Ochyra 1997.

M. minutus (Hampe) Besch. = Leptotrichella minuta 2.

MICROPOMA Lindb.
1. Magill. 1987.
M. niloticum (Delile) Lindb.

MIELICHHOFERIA Nees & Hornsch.
1. Van Rooy & Magill. 1987.
M. bryoides (Harv.) Wijk & Margad.
M. subnuda Sim

MITTENOTHAMNIUM Henn.
1. Magill & Schelpe. 1979.
M. cavifolium (Dixon) Wijk & Margad. = Chrysohypnum cavifolium
M. ctenidioides (Dixon) Schelpe
M. cygnicollum (Dixon) Wijk & Margad.
M. diminutivum (Hampe) Britten - species insufficiently known
M. horridulum (Broth.) Cardot
M. patens (Hampe) Cardot
M. pseudo-reptans (C.Müll.) Cardot

NANOBRYUM Dixon
N. dummeri Dixon = Fissidens gladiolus

NECKERA Hedw.
1 Magill & Van Rooy 1998.
N. valentiniana Besch.

OCTOBLEPHARUM Hedw.
1. Magill. 1981.
O. albidum Hedw.

OEDIPODIELLA Dixon
1. Magill. 1987.
O. australis (Wager & Dixon) Dixon

OLIGOTRICHUM Lam. & DC.
1. Fanshawe. 1980.
O. afrolaevigatum (Dixon) G.L.Sm.
O. capense Schelpe & Fanshawe
O. tetragonum Schelpe & Fanshawe
O. wageri (Broth.) G.L.Sm.

OREOWEISIA (Bruch, Schimp. & W.Gümbel) De Not.
1. Magill. 1981.
O. erosa (C.Müll.) Kindb.

ORTHODONTIUM Schwägr.
1. Van Rooy & Magill. 1987.
O. lineare Schwägr.

ORTHOSTICHOPSIS Broth.
2. Magill & Van Rooy 1998.
O. pinnatella (Broth.) Broth.
O. subimbricata (Hampe) Broth.

ORTHOTRICHUM Hedw.
1 Magill & Van Rooy 1998.
O. afro-fastigiatum C.Müll. - species insufficiently known)
O. armatum Lewinsky & Van Rooy
O. diaphanum Brid.
O. firmum Vent.
O. incurvomarginatum Lewinsky & Van Rooy
O. mirum Lewinsky = Stoneobryum mirum
O. oreophilum Lewinsky & Van Rooy
O. rupestre Schwägr.
O. subexsertum Schimp. ex C.Müll.
O. transvaalense Rehmann ex Sim

OXYRRHYNCHIUM (Bruch, Schimp. & W.Gümbel) Warnst.
1. Magill & Schelpe. 1979.
O. confervoideum Sim
O. subasperum Sim

OXYSTEGUS (Limpr.) Hilp.
O. cylindricus (Brid.) Hilp. = Trichostomum tenuirostre

PALAMOCLADIUM C.Müll.
1. Hofmann 1997.
P. leskeoides (Hook.) Britt.
P. sericeum (A.Jaeger) C.Müll. = P. leskeoides 1.
P. sericeum (A.Jaeger) C.Müll. var afrostriatum C.Müll. = P. leskeoides 1.

PAPILLARIA (C.Müll.) C.Müll.
1 Magill & Van Rooy 1998.
P. africana (C.Müll.) A.Jaeger

PHASCONICA C.Müll.
P. tisserantii P.de la Varde = Trichostomum unguiculatum

PHASCUM Hedw.
1. Magill. 1981.
2. Zander, 1993.
P. leptophyllum C.Müll. = Chenia leptophylla
P. peraristatum C.Müll.

PHILONOTIS Brid.
1. Magill. 1987. FSA Bryoph. 1,2.
2. Griffin & Buck. 1989.
P. africana (C.Müll.) Paris
P. comosa (Broth.) D.G.Griffin & W.R.Buck
P. dregeana (C.Müll.) A.Jaeger
P. falcata (Hook.) Mitt.
P. globosa (C.Müll.) D.G.Griffin & W.R.Buck
P. hastata (Duby) Wijk & Margad.
P. scabrifolia (Hook.f. & Wilson) Braithw.
P. vagans (Hook.f. & Wilson) Mitt.

PHYSCOMITRELLOPSIS Broth. & Wager ex Dixon
1. Magill. 1987.
P. africana Wager & Broth. ex Dixon

PHYSCOMITRIUM (Brid.) Brid.
1. Magill. 1987.
P. spathulatum (Hornsch.) C.Müll. var. sessile (Shaw) Magill
P. spathulatum (Hornsch.) C.Müll. var. spathulatum

PILOTRICHELLA (C.Müll.) Besch.
1. Magill & Van Rooy 1998.
P. conferta Renauld & Cardot = P. panduraefolia
P. cuspidata Broth. = P. panduraefolia
P. panduraefolia (C.Müll.) A.Jaeger

PINNATELLA Fleischm.
1. Enroth 1994.
2. Magill & Van Rooy 1998.
P. flagellacea (Mitt.) Broth. ex Paris - excluded.
P. minuta (Mitt.) Broth.
P. oblongifrondea (Broth.) Broth. = P. minuta

PLAGIOBRYUM Lindb.
1. Van Rooy & Magill. 1987.
P. zierii (Hedw.) Lindb.

PLAGIOMNIUM Pic.Serm.
1. Magill. 1987.
P. rhynchophorum (Hook.) Kop. var. **reidii** (Dixon) Kop.

PLAGIOPUS Brid.
1. Magill. 1987.
P. oederianus (Sw.) H.A.Crum & L.E.Anderson

PLAGIOTHECIUM Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
P. membranosulum C.Müll.
P. rhynchostegioides C.Müll.

PLATYHYPNIDIUM Fleischm.
1. Magill & Schelpe. 1979
2. PRE herbarium practise.
P. aquaticum (A.Jaeger) M.Fleisch.
P. macowanianum (Paris) M.Fleisch.

PLATYNEURUM (Cardot) Broth.
1. Frahm 1989.
2. Ochyra & Bednarek-Ochyra 1997.
P. laticostatum (Card.) Broth. = P. praealtum 2.
P. praealtum (Mitt.) Ochyra & Bednarek-Ochyra

PLAUBELIA Brid.
1. Zander. 1993.
P. involuta (Magill) R.H.Zander

PLEURIDIUM Rabenh.
1. Magill. 1981.
P. ecklonii (C.Müll.) Snider
P. nervosum (Hook.) Mitt.
P. papillosum Magill
P. pappeanum (C.Müll.) A.Jaeger

POGONATUM P.Beauv.
1. Fanshawe. 1980.
P. borgenii (Hampe) A.Jaeger
P. capense (Hampe) A.Jaeger
P. nanum (Hedw.) P.Beauv. - excluded
P. oligodus (C.Müll.) Mitt.

POHLIA Hedw.
1. Van Rooy & Magill. 1987.
P. baronii Wijk & Margad.
P. cruda (Hedw.) Lindb.
P. elongata Hedw.
P. nutans (Hedw.) Lindb.

POLYTRICHASTRUM G.L.Sm.
1. Fanshawe. 1980.
P. formosum (Hedw.) G.L.Sm.

POLYTRICHUM Hedw.
1. Fanshawe. 1980.
P. commune Hedw.
P. formosum Hedw. = Polytrichastrum formosum
P. juniperinum Willd. ex Hedw.
P. longisetum Sw.ex Brid. - excluded
P. natalense Sim = Pogonatum oligodus
P. piliferum Schreb. ex Hedw.
P. subformosum Besch.

POROTHAMNIUM Fleischm.
1 Magill & Van Rooy 1998.
P. capense (Broth. & Dixon) Sim - species insufficiently known
P. hildebrandtii (C.Müll.) M.Fleisch. = P. stipitatum
P. natalense (C.Müll.) M.Fleisch. = Porotrichum usagarum
P. pennaefrondeum (C.Müll.) Cardot = Porotrichum madagassum
P. stipitatum (Mitt.) Touw ex De Sloover

POROTRICHUM (Brid.) Hampe
1 Magill & Van Rooy 1998.
P. elongatum (Welw. & Duby) A.Gepp
P. madagassum Kiaer ex Besch.
P. molliculum Broth. = P. usagarum
P. usagarum Mitt.

POTTIA (Rchb.) Fürnr.
1. Magill. 1981.
2. Zander, 1993.
P. macowaniana C.Müll. = Microbryum davallianum var. conicum
P. namaquensis Magill
P. splachnoides (Hornsch.) Broth. = Tortula splachnoides
P. subplanomarginata Dixon = Microbryum subplanomarginatum

PRIONODON C.Müll.
1 Magill & Van Rooy 1998.
P. densus (Hedw.) C.Müll.

PSEUDOCROSSIDIUM Williams
1. Zander. 1979.
2 . Frey & Kurschner. 1988.
3. Sollman, 1991.
4. Zander. 1993.
P. crinitum (Schultz) R.H.Zander
P. hornschuchianum (Schultz) R.H.Zander
P. porphyreoneurum (C.Müll. ex Venturi) R.H.Zander
P. replicatum (Taylor) R.H.Zander

PSEUDOLESKEA Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
2. PRE herbarium use following R. Ochyra (pers. comm.)
P. chilensis (Lor.) Ochyra 2.
P. leskeoides (Paris) C.Müll.

PSEUDOLESKEOPSIS Broth.
1. Magill & Schelpe. 1979.
P. claviramea (C.Müll.) Thér.
P. pseudoattenuata (C.Müll.) Thér.
P. unilateralis Dixon

PSILOPILUM Brid.
1. Fanshawe. 1980.
P. afrolaevigatum Dixon = Oligotrichum afrolaevigatum
P. trichodon (Hook.f. & Wilson) Mitt. - excluded
P. wageri Broth. in Dixon = Oligotrichum wageri

PTEROBRYOPSIS Fleischm.
1. Magill & Van Rooy 1998
Pterobryopsis acutifolium (Brid.) Magill
Pterobryopsis hoenelii (C.Müll.) Magill
P. rehmannii Magill

PTEROGONIUM Sw.
1 Magill & Van Rooy 1998.
P. gracile (Hedw.) Sm.

PTERYGONEURUM Jur.
1. Magill. 1981.
P. macleanum Warnst.

PTYCHOMITRIOPSIS Dixon
1 Magill & Van Rooy 1998.
P. africana Dixon
P. aloinoides Magill

PTYCHOMITRIUM Fürnr.
1 Magill & Van Rooy 1998.
P. crassinervium (C.Müll.) Schimp. ex Paris
P. crispatum (Hedw.) A.Jaeger
P. cucullatifolium (C.Müll.) A.Jaeger
P. depressum (C.Müll.) Paris
P. diexaratum Magill ex Magill & Schelpe
P. eurybasis Dixon
P. exaratifolium H.Rob.
P. godfreyi H.Rob. = Ptychomitriopsis africana
P. marginatum (Wager ex Dixon) Dixon = P. subcrispatum
P. obtusatum (C.Müll.) Paris = P. cucullatifolium
P. subcrispatum Thér. & P.de la Varde

PYRRHOBRYUM Mitt.
1. Magill. 1987.
P. spiniforme (Hedw.) Mitt.
P. vallis-gratiae (Hampe) Manuel

QUATHLAMBA Magill
1. Magill. 1987.
Q. debilicostata Magill

RACOMITRIUM Brid.
1. Magill. 1981.
2. Ochyra et al. 1988.
R. crispulum (Hook.f. & Wilson) Hook.f. & Wilson
R. lamprocarpum (C.Müll.) A.Jaeger
R. lanuginosum (Hedw.) Brid.
R. nigro-viride (C.Müll.) Paris = R. lamprocarpum

RACOPILUM P.Beauv.
1 Magill & Van Rooy 1998.
R. capense C.Müll.

RAUIELLA Reimers
1. Buck & Crum. 1990.
R. praelonga (Besch.) Wijk & Margad.
R. subfilamentosa (Besch.) Wijk & Margad. = R. praelonga

RHABDOWEISIA Bruch, Schimp. & W.Gümbel
1 Magill & Van Rooy 1998.
. Van Rooy. 1991.
R. crispata (With.) Lindb.
R. fugax (Hedw.) Bruch, Schimp. & W.Gümbel

RHACHITHECIUM Broth. ex Le'Jol.
1 Magill & Van Rooy 1998.
R. perpusillum (Thwaites & Mitt.) Broth.

RHACOCARPUS Lindb.
1. Magill & Van Rooy 1998.
R. purpurascens (Brid.) Paris
R. rehmannianus (C.Müll.) Wijk & Margad. = R. purpurascens 1

RHACOPILOPSIS Renauld & Cardot
1. Buck. 1993.
R. flexilis (Renauld & Cardot) Buck
R. transvaaliensis Thér.& Dixon

RHODOBRYUM (Schimp.) Limpr.
1. Van Rooy & Magill. 1987.
R. commersonii (Schwägr.) Paris
R. keniae (C.Müll.) Broth.
R. roseum (Hedw.) Limpr.
R. umbraculum (Hook.) Schimp. ex Paris

RHYNCHOSTEGIELLA (Bruch, Schimp. & W.Gümbel) Limpr.
1. Magill & Schelpe. 1979.
R. holstii (Broth.) Broth.
R. sublaevipes Broth. & Bryhn
R. zeyheri (C.Müll.) Broth.

RHYNCHOSTEGIUM Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
R. brachypterum (Hornsch.) A.Jaeger
R. raphidorrhynchum (C.Müll.) A.Jaeger
R. subbrachypterum Broth. & Bryhn

RIGODIUM Kunze ex Schwägr.
1. Zomlefer. 1993.
R. kilimandscharicum (Broth.) Paris = R. toxarion
R. toxarion (Schwägr.) A.Jaeger

SAELANIA Lindb.
1. Magill. 1981.
S. glaucescens (Hedw.) Broth.

SANIONIA Loeske
1. Tuomikoski & Koponen. 1979.
S. uncinata (Hedw.) Loeske

SCHISTIDIUM Brid.
1. Bremer. 1980.
S. apocarpum (Hedw.) Bruch & Schimp.

SCHLOTHEIMIA Brid.
1. Magill & Van Rooy 1998.
S. ferruginea (Hook. & Grev.) Brid.
S. grevilleana Mitt. - excluded.
S. percuspidata C.Müll.
S. rufo-aeruginosa C.Müll. - species insufficiently known
S. rufopallens C.Müll.
S. ventrosa C.Müll. - species insufficiently known

SCIAROMIUM (Mitt.) Mitt.
S. capense Mitt. ex Dixon = Vittia pachyloma

SEMATOPHYLLUM Mitt.
1. Magill & Schelpe. 1979.
2. Buck. 1983.
S. brachycarpum (Hampe) Broth.
S. caespitosum (Hedw.) Mitt. = S. subpinnatum
S. dregei (C.Müll.) Magill
S. gueinzii (Hampe) Magill
S. sphaeropyxis (C.Müll.) Broth.
S. subpinnatum (Brid.) Britten
S. wagerii C.H.Wright ex Wager
S. zuluense (Sim) Magill

SPHAEROTHECIUM Hampe
1. Frahm. 1986.
S. subchlorophyllosum (C.Müll. ex Rabenh.) Frahm

SPHAGNUM L.
1. Magill. 1981..
2. Eddy. 1985..
S. africanum Wew. & Duby - excluded
S. capense Hornsch.
S. fimbriatum Wilson in Hook.
S. obtusiusculum Lindenb. ex Warnst. = S. violascens
S. perichaetiale Hampe

S. pycnocladulum C.Müll.
S. strictum Sull. subsp. **pappeanum** (C.Müll.) Eddy
S. truncatum Hornsch.
S. violascens C.Müll.

SQUAMIDIUM (C.Müll.) Broth.
1. Magill & Schelpe. 1979.
2. Allen & Crosby. 1986.
S. biforme (Hampe) Broth. = S. brasiliense
S. brasiliense (Hornsch.) Broth.

STEREOPHYLLUM Mitt.
1. Magill & Schelpe. 1979.
S. natalense Sim
S. odontocalyx (C.Müll.) A.Jaeger
S. woodii (Sim) Magill

STONEOBRYUM D.H.Norris & H.Rob.
1 Magill & Van Rooy 1998.
S. mirum (Lewinsky) D.H.Norris & H.Rob.

STREPTOCALYPTA C.Müll.
2. Zander. 1993.
S. pulchriretis (Dixon) R.H.Zander

SYNTRICHIA Brid.
1. Kramer. 1988.
2 . Magill, Delgadillo & Stark. 1983.
3. Ochyra. 1992.
4. Zander. 1993.
S. ammonsiana (H.A.Crum & L.E.Anderson) Ochyra
S. austroafricana (W.A.Kramer) R.H.Zander
S. chisosa (Magill, Delgad. & L.R.Stark) R.H.Zander
S. fragilis (Taylor) Ochyra
S. pagorum (Milde) J.J.Amann
S. papillosa (Wilson in Spruce) Jur.
S. princeps (De Not.) Mitt.
S. ruralis (Hedw.) F.Weber & Mohr

SYRRHOPODON Schwägr.
1. Orban. 1981.
S. asper Mitt.
S. gaudichaudii Mont.
S. gomesii P.de la Varde = S. asper
S. obliquirostris C.Müll. = S. gaudichaudii
S. uncinifolius C.Müll. = S. gaudichaudii

TAYLORIA Hook.
1. Magill. 1987.
T. isleana (Besch.) Broth.
T. orthodonta (P.Beauv.) Wijk & Margad.

TETRAPTERUM Hampe ex A.Jaeger
1. Magill. 1981
T. tetragonum (Hook.) Andrews

THUIDIUM Bruch, Schimp. & W.Gümbel
1. Magill & Schelpe. 1979.
2. Buck & Crum 1990.
T. chenagonii C.Müll. ex Renauld & Cardot - excluded
T. matarumense Besch.
T. ramusculosum (Mitt.) A.Jaeger = Cyrtohypnum ramusculosum
T. varians Welw. & Duby = Cyrtohypnum varians
T. versicolor (C.Müll.) A.Jaeger = Cyrtohypnum versicolor

TIMMIELLA (De Not.) Limpr.
1. Magill. 1981.
T. pelindaba Magill

TORTELLA (Lindb.) Limpr.
1. Magill. 1981.
T. fragilis (Hook. & Wilson) Limpr.
T. humilis (Hedw.) Jenn.
T. xanthocarpa (C.Müll.) Broth.

TORTULA Hedw.
1. Kramer. 1980.
2. Magill. 1981.
3. Townsend, 1987.
4. Zander. 1993.
T. ammonsiana Crum & Anderson = Syntrichia ammonsiana
T. atrovirens (Sm.) Lindb.
T. austroafricana W.A.Kramer = Syntrichia austroafricana

T. bogosica (C.Müll.) R.H.Zander
T. chisosa Magill, Delgad. & L.R.Stark = Syntrichia chisosa
T. muralis Hedw.
T. pagorum (Milde) De Not. = Syntrichia pagorum
T. papillosa Wilson ex Spruce = Syntrichia papillosa
T. porphyreoneura (C.Müll.) Towns. = Pseudocrossidium porphyreoneurum
T. princeps De Not. = Syntrichia princeps
T. schmidii (C.Müll.) Broth. = Syntrichia fragilis
T. splachnoides (Hornsch.) R.H.Zander

TRACHYPHYLLUM A.Gepp in Hiern
1. Buck. 1979.
T. fabronioides (Besch.) A.Gepp - species insufficiently known
T. gastrodes (Welw. & Duby) A.Gepp
T. maximum Dixon = T. gastrodes

TRACHYPODOPSIS Fleischm.
1 Magill & Van Rooy 1998.
T. serrulata (P.Beauv.) M.Fleisch.

TRACHYPUS Reinw. & Hornsch.
1 Magill & Van Rooy 1998.
T. bicolor Reinw. & Hornsch. var. **viridulus** (Mitt.) Zanten

TREMATODON Michx.
1. Magill. 1981.
T. divaricatus Bruch ex C.Krauss
T. intermedius Welw. & Duby
T. longicollis Michx.
T. mayottensis Besch.
T. paradoxus Hornsch.
T. pillansii Dixon ex Sim

TRICHOSTELEUM Mitt.
1. Magill & Schelpe. 1979.
T. perchlorosum Broth. & Bryhn

TRICHOSTOMOPSIS Cardot
T. australasiae (Hook. & Grev.) H.Rob. = Didymodon australasii
T. trivialis (C.Müll.) H.Rob. = Didymodon trivialis

TRICHOSTOMUM Bruch
1. Smith. 1977.
2. Magill. 1981.
3. Zander. 1993.
T. brachydontium Bruch ex F.A.Müll.
T. tenuirostre (Hook.& Taylor) lindb.
T. unguiculatum (Mitt.) R.H.Zander

TRIQUETRELLA C.Müll.
1. Magill. 1981.
T. tristicha (C.Müll.) C.Müll.

TRISTICHIUM C.Müll.
1. Magill. 1981.
T. mirabile (C.Müll.) Herzog

ULOTA Mohr
1 Magill & Van Rooy 1998.
U. ecklonii (Hornsch.) A.Jaeger

VESICULARIA (C.Müll.) C.Müll.
1. Magill & Schelpe. 1979.
V. galerulata (Duby) Broth.

VITTIA Ochyra
1. Ochyra. 1987.
V. pachyloma (Mont.) Ochyra

WARDIA Harv. & Hook.
1 Magill & Van Rooy 1998.
W. hygrometrica Harv. & Hook.

WEISIOPSIS Broth.
1. Magill. 1981.
2. Zander. 1993.
W. involuta Magill = Plaubelia involuta
W. plicata (Mitt.) Broth.
W. pulchriretis Dixon = Streptocalypta pulchriretis

WEISSIA Hedw.
1. Magill. 1981.
W. controversa Hedw.
W. cucullata C.Müll.
W. dieterlenii Thér.
W. humicola C.Müll.
W. latiuscula C.Müll.

WIJKIA Crum
1. Magill & Schelpe. 1979.
W. trichocolea (C.Müll.) H.A.Crum

ZYGODON Hook. & Taylor
1 Magill & Van Rooy 1998.
Z. cernuus C.Müll. - species insufficiently known
Z. dixonii Sim
Z. erosus Mitt.
Z. intermedius Bruch, Schimp.& W.Gümbel
Z. leptobolax C.Müll.
Z. runcinatus C.Müll.
Z. trichomitrius Hook. & Wilson

C. Systematic Arrangement of Southern African Moss Families and Genera

The systematic arrangement of the families and the generic placement generally follow the (*Moss) Flora of Southern Africa* (Magill 1981, 1987; Magill & Van Rooy 1998) or the *Checklist* (Magill & Schelpe 1979). Where changes have occured in the arrangement of families or the placement of genera, or where new families or genera have been added since the publication of Magill & Schelpe's *Checklist* or the first two fascicles of the *Moss Flora,* the literature reference is given under the family name. The numbers after the family names are those of Magill & Schelpe (1979), adapted for use in the PRE Bryophyte Herbarium.

SPHAGNACEAE (1)
Sphagnum

ANDREAEACEAE (2)
Andreaea

FISSIDENTACEAE (3)
1. Pursell & Reese, 1980.
Fissidens

ARCHIDIACEAE (4)
Archidium

DITRICHACEAE (5)
Astomiopsis
Ceratodon
Cheilothela
Distichium
Ditrichum
Eccremidium
Pleuridium
Saelania
Tristichium

SELIGERIACEAE (7)
Blindia

DICRANACEAE (8)
Aongstroemia
Aongstroemiopsis
Bruchia
Campylopus
Chorisodontium
Cladophascum
Dicranella
Dicranoloma

Holomitrium
Leucobryum
Leucoloma
Microdus
Oreoweisia
Sphaerothecium
Trematodon

CALYMPERACEAE (12)
Calymperes
Hypodontium
Octoblepharum
Syrrhopodon

ENCALYPTACEAE (13)
Encalypta

POTTIACEAE (14)
1. Cano, Guerra & Ros 1993.
2. Zander 1993.

Acaulon
Aloina
Anoectangium
Barbula
Bryoerythrophyllum
Chenia
Crossidium
Didymodon
Gymnostomum
Hennediella
Hymenostylium
Hyophila
Leptodontium
Microbryum
Microcrossidium
Phascum
Plaubelia
Pottia
Pseudocrossidium
Pterygoneurum
Streptocalypta
Syntrichia
Tetrapterum
Timmiella
Tortella
Tortula
Trichostomum
Triquetrella
Weisiopsis
Weissia

BRYOBARTRAMIACEAE (14A)
Bryobartramia

GRIMMIACEAE (15)
Grimmia
Leucoperichaetium
Racomitrium
Schistidium

GIGASPERMACEAE (16)
Chamaebryum
Gigaspermum
Oedipodiella

EPHEMERACEAE (18)
Ephemerum

FUNARIACEAE (19)
Cygnicollum
Funaria
Goniomitrium
Micropoma
Physcomitrellopsis
Physcomitrium

SPLACHNACEAE (21)
Tayloria

BRYACEAE (24)
1. Crum, 1992.

Anomobryum
Brachymenium
Bryum
Leptobryum
Mielichhoferia
Orthodontium
Plagiobryum
Pohlia
Rhodobryum

MNIACEAE (26)
Plagiomnium

EUSTICHIACEAE (28)
Eustichia

RHIZOGONIACEAE (32)
Pyrrhobryum

AULACOMNIACEAE (34)
Leptotheca

BARTRAMIACEAE (37)
Anacolia
Bartramia
Breutelia
Conostomum
Philonotis
Plagiopus
Quathlamba

ERPODIACEAE (40)
Aulacopilum
Erpodium

RHACHITHECIACEAE (40A)
Rhachithecium

PTYCHOMITRIACEAE (41)
Ptychomitriopsis
Ptychomitrium

ORTHOTRICHACEAE (42)
1. Norris & Robinson, 1981.
2. Vitt, 1981.
3. Van Rooy & Van Wyk, 1992.
Amphidium
Cardotiella
Macrocoma
Macromitrium
Orthotrichum
Schlotheimia
Stoneobryum
Ulota
Zygodon

RHABDOWEISIACEAE (42A)
Rhabdoweisia

RACOPILACEAE (44)
Racopilum

FONTINALACEAE (45)
Fontinalis

WARDIACEAE (45A)
Wardia

HEDWIGIACEAE (47)
Braunia
Hedwigia
Hedwigidium
Rhacocarpus

CRYPHAEACEAE (48)
Cryphaea

LEUCODONTACEAE (49)
Leucodon
Pterogonium

PRIONODONTACEAE (53)
Prionodon

TRACHYPODACEAE (55)
Trachypodopsis
Trachypus

PTEROBRYACEAE (57)
Jaegerina
Orthostichopsis
Pterobryopsis

METEORIACEAE (58)
Aerobryopsis
Floribundaria
Papillaria
Pilotrichella
Squamidium

LEPTODONTACEAE (58A)
1. Buck, 1981.
Forsstroemia
Leptodon

NECKERACEAE (60)
Neckera

THAMNOBRYACEAE (60A)
1. Buck & Vitt, 1986.
Pinnatella
Porothamnium
Porotrichum

HOOKERIACEAE (65)
Callicostella
Calyptrochaeta
Cyclodictyon
Distichophyllum
Hookeriopsis
Hypopterygium
Lepidopilidium
Lopidium

FABRONIACEAE (70)
Dimerodontium
Fabronia
Helicodontium
Ischyrodon
Leptoischyrodon

STEREOPHYLLACEAE (70A)
1. Buck & Ireland, 1985.
Entodontopsis
Stereophyllum

LESKEACEAE (71)
1. Vitt, 1984.
1. Buck & Crum, 1990.
2. Enroth, 1991.
Haplocladium
Herpetineuron
Leptoterigynandrum
Leskeella
Lindbergia
Pseudoleskea
Pseudoleskeopsis

THUIDIACEAE (72)
1. Buck & Crum, 1990
Abietinella
Cyrtohypnum
Haplohymenium
Rauiella
Thuidium

RIGODIACEAE (72B)
1. Crum, 1981.
Rigodium

AMBLYSTEGIACEAE (73)
1. Tuomikoski & Koponen, 1979.
2. Ochyra, 1987.
3. Ochyra & Pócs, 1992.
Campyliadelphus
Cratoneuron
Drepanocladus
Leptodictyum
Platyhypnidium
Sanionia
Vittia

BRACHYTHECIACEAE (74)
1. Ochyra & Pócs, 1982.
Brachythecium
Oxyrrhynchium
Palamocladium
Rhynchostegiella
Rhynchostegium

ENTODONTACEAE (75)
Entodon
Erythrodontium
Levierella
Trachyphyllum

PLAGIOTHECIACEAE (76)
1. Buck & Ireland, 1985.
Plagiothecium

CATAGONIACEAE (76A)
1. Buck & Ireland, 1985.
Catagonium

SEMATOPHYLLACEAE (77)
1. Buck, 1993.
Rhacopilopsis
Sematophyllum
Trichosteleum
Wijkia

HYPNACEAE (78)
1. Ochyra & Sharp, 1988.
Chrysohypnum
Ectropothecium
Hypnum
Isopterygium
Mittenothamnium
Vesicularia

POLYTRICHACEAE (83)
1. Fanshawe, 1980.
Atrichum
Oligotrichum
Pogonatum
Polytrichastrum
Polytrichum

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APPENDIX II

THE MOSS FLORAS OF THE BRYOGEOGRAPHIC REGIONS (TWINSPAN 5+) OF SOUTHERN AFRICA

Appendix II,1. The moss flora of the Zambezian Region

1. Sphagnaceae
   - Sphagnum capense
   - Sphagnum truncatum
3. Fissidentaceae
   - Fissidens asplenioides
   - Fissidns borgenii
   - Fissidens bryoides
   - Fissidens capriviensis
   - Fissidens erosulus
   - Fissidens glaucescens
   - Fissidens microandrogynus
   - Fissidens palmifolius
   - Fissidens pseudoserratus
   - Fissidens rufescens
   - Fissidens submarginatus
   - Fissidens subobtusatus
   - Fissidens wageri
4. Archidiaceae
   - Archidium acanthophyllum
   - Archidium microthecium
   - Archidium ohioense
5. Ditrichaceae
   - Ceratodon purpureus *subsb.* stenocarpus
   - Ditrichum difficile
   - Eccremidium exiguum
8. Dicranaceae
   - Campylopus atroluteus
   - Campylopus cambouei
   - Campylopus catarractilis
   - Campylopus flaccidus
   - Campylopus introflexus
   - Campylopus perpusillus
   - Campylopus pilifer
   - Campylopus pyriformis
   - Campylopus robillardei
   - Campylopus savannarum
   - Campylopus stenopelma
   - Cladophascum gymnomitrioides
   - Leptotrichella minuta
   - Leucobryum acutifolium
   - Trematodon intermedius
12. Calymperaceae
    - Calymperes rabenhorstii
    - Calymperes tenerum
    - Hypodontium dregei
    - Octoblepharum albidum
14. Pottiaceae
    - Barbula eubryum
    - Barbula indica
    - Bryoerythrophyllum campylocarpum
    - Didymodon ceratodonteus
    - Gymnostomum bewsii
    - Hyophila baginsensis
    - Hyophila involuta
    - Pseudocrossidium crinitum
    - Pseudocrossidium porphyreoneurum
    - Pseudocrossidium replicatum
    - Syntrichia chisosa
    - Syntrichia fragilis
    - Syntrichia pagorum
    - Tortella xanthocarpa
    - Trichostomum brachydontium
    - Weissia controversa
    - Weissia latiuscula
15. Grimmiaceae
    - Schistidium apocarpum
16. Gigaspermaceae
    - Oedipodiella australis
19. Funariaceae
    - Funaria hygrometrica
    - Funaria longicollis
    - Funaria rottleri
    - Goniomitrium africanum
    - Physcomitrium spathulatum *var.* spathulatum

24. Bryaceae
   Anomobryum filiforme
   Brachymenium acuminatum
   Brachymenium pulchrum
   Brachymenium systylium
   Bryum alpinum
   Bryum apiculatum
   Bryum argenteum
   Bryum aubertii
   Bryum canariense
   Bryum capillare
   Bryum cellulare
   Bryum dichotomum
   Bryum erythrocaulon
   Bryum pseudotriquetrum
   Bryum pycnophyllum
   Bryum viridescens
   Mielichhoferia bryoides
   Orthodontium lineare
   Pohlia baronii
   Pohlia elongata
   Rhodobryum commersonii
37. Bartramiaceae
   Bartramia hampeana
   Breutelia microdonta
   Philonotis africana
   Philonotis dregeana
   Philonotis falcata
   Philonotis hastata
40. Erpodiaceae
   Aulacopilum trichophyllum
   Erpodium beccarii
   Erpodium coronatum *subsp.* transvaaliense
   Erpodium grossirete
41. Ptychomitriaceae
   Ptychomitriopsis aloinoides
   Ptychomitrium crispatum
   Ptychomitrium eurybasis
   Ptychomitrium exaratifolium
42. Orthotrichaceae
   Macrocoma lycopodioides
   Macrocoma tenue *subsb.* tenue
   Macromitrium lebomboense
   Schlotheimia ferruginea
   Schlotheimia rufopallens
44. Racopilaceae
   Racopilum capense
47. Hedwigiaceae
   Braunia secunda
49. Leucodontaceae
   Leucodon assimilis
58. Meteoriaceae
   Aerobryopsis capensis
   Papillaria africana
   Pilotrichella panduraefolia
   Squamidium brasiliense
58A. Leptodontaceae
   Forsstroemia producta
65. Hookeriaceae
   Hookeriopsis pappeana
   Hypopterygium laricinum
70. Fabroniaceae
   Fabronia pilifera
   Fabronia rehmannii
70A. Stereophyllaceae
   Stereophyllum radiculosum
71. Leskeaceae
   Lindbergia patentifolia
   Lindbergia pseudoleskeoides
   Pseudoleskeopsis claviramea
   Pseudoleskea leskeoides
72. Thuidiaceae
   Haplohymenium pseudotriste
73. Amblystegiaceae
   Drepanocladus aduncus
   Leptodictyum riparium
74. Brachytheciaceae
   Brachythecium implicatum
75. Entodontaceae
   Entodon cymbifolius
   Erythrodontium subjulaceum
   Trachyphyllum gastrodes
77. Sematophyllaceae
   Sematophyllum brachycarpum
   Sematophyllum sphaeropyxis
78. Hypnaceae
   Hypnum cupressiforme
   Hypnum macrogynum
   Isopterygium leucopsis
83. Polytrichaceae
   Atrichum androgynum
   Pogonatum capense
   Polytrichum commune

Appendix II,1a. The moss flora of the Caprivi Domain

1. Sphagnaceae
   Sphagnum capense

3. Fissidentaceae
    Fissidens capriviensis
    Fissidens submarginatus
4. Archidiaceae
    Archidium acanthophyllum
    Archidium microthecium
8. Dicranaceae
    Campylopus atroluteus
    Campylopus flaccidus
    Campylopus pyriformis
12. Calymperaceae
    Octoblepharum albidum
14. Pottiaceae
    Didymodon ceratodonteus
    Pseudocrossidium porphyreoneurum
    Weissia controversa
24. Bryaceae
    Brachymenium systylium
    Bryum capillare
37. Bartramiaceae
    Philonotis dregeana
    Philonotis falcata
    Philonotis hastata
40. Erpodiaceae
    Erpodium beccarii
    Erpodium grossirete
47. Hedwigiaceae
    Braunia secunda
58. Meteoriaceae
    Aerobryopsis capensis
70. Fabroniaceae
    Fabronia pilifera

Appendix II, 1b. The moss flora of the Bushveld Domain

1. Sphagnaceae
    Sphagnum capense
    Sphagnum truncatum
3. Fissidentaceae
    Fissidens asplenioides
    Fissidens borgenii
    Fissidens bryoides
    Fissidens erosulus
    Fissidens glaucescens
    Fissidens microandrogynus
    Fissidens palmifolius
    Fissidens pseudoserratus
    Fissidens rufescens
    Fissidens submarginatus
    Fissidens subobtusatus
    Fissidens wageri
4. Archidiaceae
    Archidium acanthophyllum
    Archidium microthecium
    Archidium ohioense
5. Ditrichaceae
    Ceratodon purpureus *subsb.* stenocarpus
    Ditrichum difficile
    Eccremidium exiguum
8. Dicranaceae
    Campylopus atroluteus
    Campylopus cambouei
    Campylopus catarractilis
    Campylopus introflexus
    Campylopus perpusillus
    Campylopus pilifer
    Campylopus pyriformis
    Campylopus robillardei.
    Campylopus savannarum
    Campylopus stenopelma
    Cladophascum gymnomitrioides
    Leptotrichella minuta
    Leucobryum acutifolium
    Trematodon intermedius
12. Calymperaceae
    Calymperes rabenhorstii
    Calymperes tenerum
    Hypodontium dregei
14. Pottiaceae
    Barbula eubryum
    Barbula indica
    Bryoerythrophyllum campylocarpum
    Didymodon ceratodonteus
    Gymnostomum bewsii
    Hyophila baginsensis
    Hyophila involuta
    Pseudocrossidium crinitum
    Pseudocrossidium porphyreoneurum
    Pseudocrossidium replicatum
    Syntrichia chisosa
    Syntrichia fragilis
    Syntrichia pagorum
    Tortella xanthocarpa
    Trichostomum brachydontium
    Weissia controversa

Weissia latiuscula
15. Grimmiaceae
Schistidium apocarpum
16. Gigaspermaceae
Oedipodiella australis
19. Funariaceae
Funaria hygrometrica
Funaria longicollis
Funaria rottleri
Goniomitrium africanum
Physcomitrium spathulatum *var.* spathulatum
24. Bryaceae
Anomobryum filiforme
Brachymenium acuminatum
Brachymenium pulchrum
Bryum alpinum
Bryum apiculatum
Bryum argenteum
Bryum aubertii
Bryum canariense
Bryum capillare
Bryum cellulare
Bryum dichotomum
Bryum erythrocaulon
Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum viridescens
Mielichhoferia bryoides
Orthodontium lineare
Pohlia baronii
Pohlia elongata
Rhodobryum commersonii
37. Bartramiaceae
Bartramia hampeana
Breutelia microdonta
Philonotis africana
Philonotis dregeana
Philonotis falcata
Philonotis hastata
40. Erpodiaceae
Aulacopilum trichophyllum
Erpodium beccarii
Erpodium coronatum *subsb.* transvaaliense
41. Ptychomitriaceae
Ptychomitriopsis aloinoides
Ptychomitrium crispatum
Ptychomitrium eurybasis
Ptychomitrium exaratifolium
42. Orthotrichaceae
Macrocoma lycopodioides
Macrocoma tenue *subsb.* tenue
Macromitrium lebomboense
Schlotheimia ferruginea
Schlotheimia rufopallens
44. Racopilaceae
Racopilum capense
47. Hedwigiaceae
Braunia secunda
49. Leucodontaceae
Leucodon assimilis
58. Meteoriaceae
Aerobryopsis capensis
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense
58A. Leptodontaceae
Forsstroemia producta
65. Hookeriaceae
Hookeriopsis pappeana
Hypopterygium laricinum
70. Fabroniaceae
Fabronia pilifera
Fabronia rehmannii
70A. Stereophyllaceae
Stereophyllum radiculosum
71. Leskeaceae
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
72. Thuidiaceae
Haplohymenium pseudotriste
73. Amblystegiaceae
Drepanocladus aduncus
Leptodictyum riparium
74. Brachytheciaceae
Brachythecium implicatum
75. Entodontaceae
Entodon cymbifolius
Erythrodontium subjulaceum
Trachyphyllum gastrodes
77. Sematophyllaceae
Sematophyllum brachycarpum
Sematophyllum sphaeropyxis
78. Hypnaceae
Hypnum cupressiforme
Hypnum macrogynum
Isopterygium leucopsis

83. Polytrichaceae
    Atrichum androgynum
    Pogonatum capense
    Polytrichum commune

Appendix II,2 The moss flora of the Afromontane Region

1. Sphagnaceae
    Sphagnum capense
    Sphagnum fimbriatum
    Sphagnum perichaetiale
    Sphagnum pycnocladulum
    Sphagnum strictum *subsb.* pappeanum
    Sphagnum truncatum
    Sphagnum violascens
2. Andreaeaceae
    Andreaea nitida
    Andreaea rupestris
    Andreaea subulata
3. Fissidentaceae
    Fissidens aciphyllus
    Fissidens asplenioides
    Fissidens borgenii
    Fissidens bryoides
    Fissidens curvatus
    Fissidens enervis
    Fissidens erosulus
    Fissidens fasciculatus
    Fissidens gladiolus
    Fissidens glaucescens
    Fissidens hoegii
    Fissidens marginatus
    Fissidens microandrogynus
    Fissidens palmifolius
    Fissidens parvilimbatus
    Fissidens plumosus
    Fissidens porrectus
    Fissidens pseudoserratus
    Fissidens pygmaeus
    Fissidens rufescens
    Fissidens scleromitrius
    Fissidens simii
    Fissidens splachnifolius
    Fissidens stellenboschianus
    Fissidens submarginatus
    Fissidens subobtusatus
    Fissidens usambaricus
    Fissidens wageri
4. Archidiaceae
    Archidium acanthophyllum
    Archidium andersonianum
    Archidium capense
    Archidium julicaule
    Archidium microthecium
    Archidium muelleranum
    Archidium ohioense
    Archidium rehmannii
    Archidium subulatum
5. Ditrichaceae
    Astomiopsis amblyocalyx
    Ceratodon purpureus *subsb.* Stenocarpus
    Cheilothela chilensis
    Distichium capillaceum
    Ditrichum brachypodum
    Ditrichum difficile
    Ditrichum punctulatum
    Ditrichum strictum
    Eccremidium exiguum
    Pleuridium ecklonii
    Pleuridium nervosum
    Pleuridium pappeanum
    Saelania glaucescens
    Tristichium mirabile
7. Seligeriaceae
    Blindia magellanica
8. Dicranaceae
    Aongstroemia filiformis
    Aongstroemiopsis julacea
    Aongstroemia julacea
    Bruchia brevipes
    Bruchia eckloniana
    Campylopus atroluteus
    Campylopus aureonitens
    Campylopus bicolor
    Campylopus cambouei
    Campylopus catarractilis
    Campylopus flaccidus
    Campylopus fragilis
    Campylopus hensii
    Campylopus hildebrandtii
    Campylopus introflexus
    Campylopus jamesonii
    Campylopus julaceus *subsp.* arbogastii
    Campylopus nanophyllus
    Campylopus perpusillus
    Campylopus pilifer

Campylopus pyriformis
Campylopus robillardei
Campylopus savannarum
Campylopus stenopelma
Platyneurum praealtum
Cladophascum gymnomitrioides
Dicranella cardotii
Dicranella rigida
Dicranella subsubulata
Dicranoloma billardieri
Dicranoloma entabeniense
Holomitrium cylindraceum *var.* cucullatum
Leptotrichella minuta
Leucobryum acutifolium
Leucobryum madagassum
Leucobryum rehmannii
Leucoloma chrysobasilare
Leucoloma rehmannii
Leucoloma sprengelianum
Leucoloma syrrhopodontioides
Oreoweisia erosa
Sphaerothecium subchlorophyllosum
Trematodon divaricatus
Trematodon intermedius
Trematodon longicollis
Trematodon mayottensis
Trematodon paradoxus
Trematodon pillansii

12. Calymperaceae

Calymperes levyanum
Calymperes rabenhorstii
Hypodontium dregei
Hypodontium pomiforme
Octoblepharum albidum
Syrrhopodon asper
Syrrhopodon gaudichaudii

13. Encalyptaceae

Encalypta ciliata
Encalypta vulgaris

14. Pottiaceae

Aloina bifrons
Anoectangium wilmsianum
Barbula bolleana
Barbula calycina
Barbula eubryum
Barbula indica
Barbula microcalycina
Bryoerythrophyllum campylocarpum
Bryoerythrophyllum recurvirostrum
Chenia leptophylla
Didymodon australasiae
Didymodon ceratodonteus
Didymodon jackvancei
Didymodon tophaceopsis
Didymodon trivialis
Didymodon xanthocarpus
Gymnostomum aeruginosum
Gymnostomum bewsii
Gymnostomum lingulatum
Hennediella longipedunculata
Hymenostylium recurvirostrum
Hyophila baginsensis
Hyophila involuta
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Microbryum davallianum *var.* conicum
Microbryum rufochaete
Microbryum subplanomarginatum
Phascum pearistatum
Pseudocrossidium crinitum
Pseudocrossidium hornschuchianum
Pseudocrossidium porphyreoneurum
Pseudocrossidium replicatum
Streptocalypta pulchiretis
Syntrichia ammonsiana
Syntrichia chisosa
Syntrichia fragilis
Syntrichia pagorum
Syntrichia papillosa
Syntrichia princeps
Syntrichia ruralis
Tetrapterum tetragonum
Timmiella pelindaba
Tortella fragilis
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Tortula bogosica
Tortula muralis
Tortula splachnoides
Trichostomum brachydontium

Trichostomum tenuirostre
Trichostomum unguiculatum
Triquetrella tristicha
Weisiopsis plicata
Weissia controversa
Weissia cucullata
Weissia dieterleniae
Weissia humicola
Weissia latiuscula

14A. Bryobartramiaceae
Bryobartramia novaevalesiae

15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Racomitrium crispulum
Racomitrium lamprocarpum
Racomitrium lanuginosum
Schistidium apocarpum

16. Gigaspermaceae
Chamaebryum pottioides
Gigaspermum repens
Oedipodiella australis

18. Ephemeraceae
Ephemerum capense
Ephemerum diversifolium
Ephemerum namaquense
Ephemerum rehmannii

19. Funariaceae
Funaria bergiana
Funaria clavata
Funaria hygrometrica
Funaria limbata
Funaria longicollis
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Funaria succuleata
Funaria urceolata
Goniomitrium africanum
Micropoma niloticum
Physcomitrellopsis africana
Physcomitrium spathulatum *var.* spathulatum

21. Splachnaceae
Tayloria isleana
Tayloria orthodonta

24. Bryaceae
Anomobryum drakensbergense
Anomobryum filiforme
Brachymenium acuminatum
Brachymenium dicranoides
Brachymenium leptophyllum
Brachymenium nepalense
Brachymenium pulchrum
Brachymenium systylium
Bryum alpinum
Bryum andicola
Bryum apiculatum
Bryum argenteum
Bryum aubertii
Bryum caespiticium
Bryum canariense
Bryum capillare
Bryum cellulare
Bryum dichotomum
Bryum donianum
Bryum erythrocaulon
Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum radiculosum
Bryum subapiculatum
Bryum torquescens
Bryum turbinatum
Bryum viridescens
Leptobryum pyriforme
Mielichhoferia bryoides
Mielichhoferia subnuda
Orthodontium lineare
Plagiobryum zierii
Pohlia baronii
Pohlia cruda
Pohlia elongata
Pohlia nutans
Rhodobryum commersonii
Rhodobryum keniae
Rhodobryum roseum
Rhodobryum umbraculum

26. Mniaceae
Plagiomnium rhynchophorum *var.* reidii

28. Eustichiaceae
Eustichia longirostris

32. Rhizogoniaceae
Pyrrhobryum spiniforme
Pyrrhobryum vallisgratiae

34. Aulacomniaceae
Leptotheca gaudichaudii

37. Bartramiaceae
Anacolia breutelii

Bartramia aristaria
Bartramia capensis
Bartramia compacta *var.* compacta
Bartramia compacta *var.* macowaniana
Bartramia hampeana
Breutelia diffracta
Breutelia elliptica
Breutelia microdonta
Breutelia substricta
Breutelia tabularis
Conostomum tetragonum
Philonotis africana
Philonotis comosa
Philonotis dregeana
Philonotis falcata
Philonotis globosa
Philonotis hastata
Philonotis scabrifolia
Philonotis vagans
Plagiopus oederianus
Quathlamba debilicostata

40. Erpodiaceae
Aulacopilum trichophyllum
Erpodium beccarii
Erpodium coronatum *subsb.* transvaaliense
Erpodium distichum

40A. Rhachitheciaceae
Rhachithecium perpusillum

41. Ptychomitriaceae
Ptychomitriopsis africana
Ptychomitriopsis aloinoides
Ptychomitrium crassinervium
Ptychomitrium crispatum
Ptychomitrium cucullatifolium
Ptychomitrium depressum
Ptychomitrium diexaratum
Ptychomitrium eurybasis
Ptychomitrium exaratifolium
Ptychomitrium subcrispatum

42. Orthotrichaceae
Amphidium lapponicum
Amphidium tortuosum
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma pulchella
Macrocoma tenue *subsb.* tenue
Macromitrium lebomboense
Macromitrium levatum
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Orthotrichum armatum
Orthotrichum diaphanum
Orthotrichum firmum
Orthotrichum incurvomarginatum
Orthotrichum oreophilum
Orthotrichum rupestre
Orthotrichum subexsertum
Orthotrichum transvaalense
Schlotheimia ferruginea
Schlotheimia percuspidata
Schlotheimia rufopallens
Stoneobryum mirum
Ulota ecklonii
Zygodon dixonii
Zygodon erosus
Zygodon intermedius
Zygodon leptobolax
Zygodon runcinatus
Zygodon trichomitrius

42A Rhabdoweisiaceae
Rhabdoweisia crispata
Rhabdoweisia fugax

44. Racopilaceae
Racopilum capense

45. Fontinalaceae
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa

45A. Wardiaceae
Wardia hygrometrica

47. Hedwigiaceae
Braunia secunda
Hedwigia ciliata
Hedwigidium integrifolium
Rhacocarpus purpurascens

48. Cryphaeaceae
Cryphaea exigua

49. Leucodontaceae
Leucodon assimilis
Pterogonium gracile

53. Prionodontaceae
Prionodon densus

55. Trachypodaceae
Trachypodopsis serrulata
Trachypus bicolor *var.* viridulus

57. Pterobryaceae
Calyptothecium acutifolium
Calyptothecium hoehnelii

Jaegerina stolonifera
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Pterobryopsis rehmannii

58. Meteoriaceae
Aerobryopsis capensis
Floribundaria floribunda
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense

58A. Leptodontaceae
Forsstroemia producta
Leptodon smithii

60. Neckeraceae
Neckera valentiniana

60A. Thamnobryaceae
Pinnatella minuta
Porothamnium stipitatum
Porotrichum elongatum
Porotrichum madagassum
Porotrichum usagarum

65. Hookeriaceae
Callicostella tristis
Calyptrochaeta asplenioides
Cyclodictyon vallisgratiae
Distichophyllum mniifolium *var.* mniifolium
Distichophyllum mniifolium *var.* taylorii
Hookeriopsis pappeana
Hypopterygium laricinum
Lepidopilidium hanningtonii
Lopidium pennaeforme

70. Fabroniaceae
Dimerodontium africanum
Fabronia abyssinica
Fabronia eckloniana
Fabronia gueinzii
Fabronia leikipiae
Fabronia perciliata
Fabronia pilifera
Fabronia rehmannii
Fabronia victoriae
Fabronia wageri
Helicodontium lanceolatum
Ischyrodon lepturus
Leptoischyrodon congoanus

70A. Stereophyllaceae
Entodontopsis nitens
Stereophyllum radiculosum
Stereophyllum woodii

71. Leskeaceae
Haplocladium angustifolium
Herpetineuron toccoae
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Lindbergia haplocladioides
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Lindbergia viridis
Pseudoleskea chilensis
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
Pseudoleskeopsis pseudoattenuata

72. Thuidiaceae
Abietinella abietina
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Haplohymenium pseudotriste
Rauiella praelonga
Thuidium matarumense

72B. Rigodiaceae
Rigodium toxarion

73. Amblystegiaceae
Campyliadelphus polygamus
Cratoneuron filicinum
Drepanocladus aduncus
Drepanocladus sendtneri
Leptodictyum riparium
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Sanionia uncinata
Vittia pachyloma

74. Brachytheciaceae
Brachythecium implicatum
Brachythecium pinnatum
Brachythecium plumosum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Brachythecium salebrosum
Brachythecium subrutabulum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Palamocladium leskeoides
Rhynchostegiella holstii
Rhynchostegiella sublaevipes
Rhynchostegiella zeyheri
Rhynchostegium brachypterum

Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum

75. Entodontaceae
    Entodon cymbifolius
    Entodon geminidens
    Entodon macropodus
    Entodon natalensis
    Erythrodontium subjulaceum
    Levierella perserrata
    Trachyphyllum gastrodes

76. Plagiotheciaceae
    Plagiothecium membranosulum
    Plagiothecium rhynchostegioides

76A. Catagoniaceae
    Catagonium nitens *subsb.* maritimum

77. Sematophyllaceae
    Meiothecium fuscescens
    Rhacopilopsis flexilis
    Rhacopilopsis transvaaliensis
    Sematophyllum brachycarpum
    Sematophyllum dregei
    Sematophyllum gueinzii
    Sematophyllum sphaeropyxis
    Sematophyllum subpinnatum
    Sematophyllum wageri
    Sematophyllum zuluense
    Trichosteleum perchlorosum
    Wijkia trichocolea

78. Hypnaceae
    Chrysohypnum cavifolium
    Ectropothecium brachycarpum
    Ectropothecium perrotii
    Ectropothecium regulare
    Hypnum cupressiforme
    Hypnum macrogynum
    Isopterygium leucophanes
    Isopterygium leucopsis
    Isopterygium punctulatum
    Isopterygium strangulatum
    Isopterygium taxithelioides
    Isopterygium taylorii
    Mittenothamnium ctenidioides
    Mittenothamnium horridulum
    Mittenothamnium patens
    Mittenothamnium pseudoreptans
    Mittenothamnium reptans
    Vesicularia galerulata

83. Polytrichaceae
    Atrichum androgynum
    Oligotrichum afrolaevigatum
    Oligotrichum capense
    Oligotrichum wageri
    Pogonatum borgenii
    Pogonatum capense
    Pogonatum oligodus
    Polytrichastrum formosum
    Polytrichum commune
    Polytrichum juniperinum
    Polytrichum piliferum
    Polytrichum subformosum

Appendix II,2a. The moss flora of the Drakensberg Domain

1. Sphagnaceae
    Sphagnum capense
    Sphagnum fimbriatum
    Sphagnum perichaetiale
    Sphagnum strictum *subsb.* pappeanum
    Sphagnum truncatum

2. Andreaeaceae
    Andreaea rupestris

3. Fissidentaceae
    Fissidens aciphyllus
    Fissidens asplenioides
    Fissidens borgenii
    Fissidens bryoides
    Fissidens curvatus
    Fissidens enervis
    Fissidens erosulus
    Fissidens fasciculatus
    Fissidens gladiolus
    Fissidens glaucescens
    Fissidens hoegii
    Fissidens microandrogynus
    Fissidens palmifolius
    Fissidens parvilimbatus
    Fissidens plumosus
    Fissidens porrectus
    Fissidens pseudoserratus
    Fissidens rufescens
    Fissidens scleromitrius
    Fissidens simii
    Fissidens submarginatus
    Fissidens subobtusatus
    Fissidens usambaricus
    Fissidens wageri

4. Archidiaceae
   Archidium acanthophyllum
   Archidium capense
   Archidium julicaule
   Archidium microthecium
   Archidium ohioense
5. Ditrichaceae
   Astomiopsis amblyocalyx
   Ceratodon purpureus *subsp.* stenocarpus
   Distichium capillaceum
   Ditrichum brachypodum
   Ditrichum difficile
   Ditrichum punctulatum
   Ditrichum strictum
   Eccremidium exiguum
   Pleuridium ecklonii
   Pleuridium nervosum
   Pleuridium pappeanum
   Saelania glaucescens
   Tristichium mirabile
7. Seligeriaceae
   Blindia magellanica
8. Dicranaceae
   Aongstroemia filiformis
   Aongstroemiopsis julacea
   Aongstroemia julacea
   Campylopus atroluteus
   Campylopus aureonitens
   Campylopus cambouei ren. & card.
   Campylopus flaccidus
   Campylopus fragilis
   Campylopus hensii
   Campylopus hildebrandtii
   Campylopus introflexus
   Campylopus jamesonii
   Campylopus julaceus *subsb.* arbogastii
   Campylopus nanophyllus
   Campylopus perpusillus
   Campylopus pilifer
   Campylopus pyriformis
   Campylopus robillardei
   Campylopus savannarum
   Campylopus stenopelma
   Cladophascum gymnomitrioides
   Dicranella cardotii
   Dicranella subsubulata
   Dicranoloma billardieri
   Dicranoloma entabeniense
   Holomitrium cylindraceum *var.* cucullatum
   Leptotrichella minuta
   Leucobryum acutifolium
   Leucobryum madagassum
   Leucoloma chrysobasilare
   Leucoloma rehmannii
   Leucoloma sprengelianum
   Leucoloma syrrhopodontioides
   Oreoweisia erosa
   Sphaerothecium subchlorophyllosum
   Trematodon divaricatus
   Trematodon intermedius
   Trematodon longicollis
   Trematodon mayottensis
   Trematodon paradoxus
12. Calymperaceae
   Calymperes rabenhorstii
   Hypodontium dregei
   Hypodontium pomiforme
   Octoblepharum albidum
   Syrrhopodon asper
   Syrrhopodon gaudichaudii
13. Encalyptaceae
   Encalypta ciliata
   Encalypta vulgaris
14. Pottiaceae
   Anoectangium wilmsianum
   Barbula bolleana
   Barbula eubryum
   Barbula indica
   Barbula microcalycina
   Bryoerythrophyllum campylocarpum
   Bryoerythrophyllum recurvirostrum
   Chenia leptophylla
   Didymodon australasiae
   Didymodon ceratodonteus
   Didymodon jackvancei
   Didymodon tophaceopsis
   Didymodon trivialis
   Didymodon xanthocarpus
   Gymnostomum aeruginosum
   Gymnostomum bewsii
   Gymnostomum lingulatum
   Hymenostylium recurvirostrum
   Hyophila baginsensis
   Hyophila involuta

Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Microbryum davallianum *var.* conicum
Microbryum rufochaete
Microbryum subplanomarginatum
Phascum peraristatum
Pseudocrossidium crinitum
Pseudocrossidium porphyreoneurum
Pseudocrossidium replicatum
Streptocalypta pulchiretis
Syntrichia ammonsiana
Syntrichia chisosa
Syntrichia fragilis
Syntrichia pagorum
Syntrichia papillosa
Syntrichia princeps
Syntrichia ruralis
Timmiella pelindaba
Tortella fragilis
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Tortula bogosica
Tortula muralis
Trichostomum brachydontium
Trichostomum tenuirostre
Triquetrella tristicha
Weisiopsis plicata
Weissia controversa
Weissia dieterleniae
Weissia humicola
Weissia latiuscula

15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Racomitrium crispulum
Schistidium apocarpum

16. Gigaspermaceae
Oedipodiella australis

18. Ephemeraceae
Ephemerum capense
Ephemerum rehmannii

19. Funariaceae
Funaria bergiana
Funaria hygrometrica
Funaria limbata
Funaria longicollis
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Funaria succuleata
Funaria urceolata
Goniomitrium africanum
Micropoma niloticum
Physcomitrellopsis africana
Physcomitrium spathulatum *var.* spathulatum

21. Splachnaceae
Tayloria isleana
Tayloria orthodonta

24. Bryaceae
Anomobryum drakensbergense
Anomobryum filiforme
Brachymenium acuminatum
Brachymenium leptophyllum
Brachymenium nepalense
Brachymenium pulchrum
Brachymenium systylium
Bryum alpinum
Bryum andicola
Bryum apiculatum
Bryum argenteum
Bryum aubertii
Bryum caespiticium
Bryum canariense
Bryum capillare
Bryum cellulare
Bryum dichotomum
Bryum erythrocaulon
Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum radiculosum
Bryum subapiculatum
Bryum torquescens
Bryum turbinatum
Bryum viridescens
Leptobryum pyriforme
Mielichhoferia bryoides
Mielichhoferia subnuda
Plagiobryum zierii
Pohlia baronii
Pohlia cruda
Pohlia elongata
Rhodobryum commersonii
Rhodobryum keniae
Rhodobryum roseum

Rhodobryum umbraculum

26. Mniaceae
    Plagiomnium rhynchophorum *var.* reidii
28. Eustichiaceae
    Eustichia longirostris
32. Rhizogoniaceae
    Pyrrhobryum spiniforme
37. Bartramiaceae
    Anacolia breutelii
    Bartramia aristaria
    Bartramia capensis
    Bartramia compacta *var.* compacta
    Bartramia compacta *var.* macowaniana
    Bartramia hampeana
    Breutelia diffracta
    Breutelia microdonta
    Breutelia substricta
    Conostomum tetragonum
    Philonotis africana
    Philonotis dregeana
    Philonotis falcata
    Philonotis globosa
    Philonotis hastata
    Philonotis scabrifolia
    Plagiopus oederianus
    Quathlamba debilicostata
40. Erpodiaceae
    Aulacopilum trichophyllum
    Erpodium beccarii
    Erpodium coronatum *subsp.* transvaaliense
    Erpodium distichum

40A. Rhachitheciaceae
    Rhachithecium perpusillum
41. Ptychomitriaceae
    Ptychomitriopsis africana
    Ptychomitriopsis aloinoides magill
    Ptychomitrium crispatum
    Ptychomitrium cucullatifolium
    Ptychomitrium depressum
    Ptychomitrium diexaratum
    Ptychomitrium eurybasis
    Ptychomitrium exaratifolium
    Ptychomitrium subcrispatum
42. Orthotrichaceae
    Amphidium lapponicum
    Amphidium tortuosum
    Cardotiella secunda
    Macrocoma lycopodioides
    Macrocoma tenue *subsb.* tenue
    Macromitrium lebomboense
    Macromitrium levatum
    Macromitrium richardii
    Macromitrium serpens
    Orthotrichum armatum
    Orthotrichum diaphanum
    Orthotrichum firmum
    Orthotrichum oreophilum
    Orthotrichum rupestre
    Orthotrichum subexsertum
    Orthotrichum transvaalense
    Schlotheimia ferruginea
    Schlotheimia percuspidata
    Schlotheimia rufopallens
    Stoneobryum mirum
    Zygodon dixonii
    Zygodon erosus
    Zygodon intermedius
    Zygodon trichomitrius

42A Rhabdoweisiaceae
    Rhabdoweisia crispata
    Rhabdoweisia fugax
44. Racopilaceae
    Racopilum capense
47. Hedwigiaceae
    Braunia secunda
    Hedwigia ciliata
    Hedwigidium integrifolium
    Rhacocarpus purpurascens
48. Cryphaeaceae
    Cryphaea exigua
49. Leucodontaceae
    Leucodon assimilis
    Pterogonium gracile
53. Prionodontaceae
    Prionodon densus
55. Trachypodaceae
    Trachypodopsis serrulata
    Trachypus bicolor *var.* viridulus
57. Pterobryaceae
    Calyptothecium acutifolium
    Calyptothecium hoehnelii
    Jaegerina stolonifera
    Orthostichopsis pinnatella
    Orthostichopsis subimbricata
    Pterobryopsis rehmannii
58. Meteoriaceae
    Aerobryopsis capensis

Floribundaria floribunda
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense

58A. Leptodontaceae
Forsstroemia producta
Leptodon smithii

60. Neckeraceae
Neckera valentiniana

60A. Thamnobryaceae
Pinnatella minuta
Porothamnium stipitatum
Porotrichum elongatum
Porotrichum madagassum
Porotrichum usagarum

65. Hookeriaceae
Callicostella tristis
Cyclodictyon vallisgratiae
Hookeriopsis pappeana
Hypopterygium laricinum
Lepidopilidium hanningtonii
Lopidium pennaeforme

70. Fabroniaceae
Dimerodontium africanum
Fabronia abyssinica
Fabronia eckloniana
Fabronia gueinzii
Fabronia leikipiae
Fabronia perciliata
Fabronia pilifera
Fabronia rehmannii
Fabronia victoriae
Helicodontium lanceolatum
Leptoischyrodon congoanus

70A. Stereophyllaceae
Entodontopsis nitens
Stereophyllum radiculosum
Stereophyllum woodii

71. Leskeaceae
Haplocladium angustifolium
Herpetineuron toccoae
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Lindbergia haplocladioides
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Lindbergia viridis
Pseudoleskea chilensis
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
Pseudoleskeopsis pseudoattenuata

72. Thuidiaceae
Abietinella abietina
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Haplohymenium pseudotriste
Rauiella praelonga
Thuidium matarumense

72B. Rigodiaceae
Rigodium toxarion

73. Amblystegiaceae
Campyliadelphus polygamus
Cratoneuron filicinum
Drepanocladus aduncus
Leptodictyum riparium
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Sanionia uncinata
Vittia pachyloma

74. Brachytheciaceae
Brachythecium implicatum
Brachythecium plumosum
Brachythecium salebrosum
Brachythecium subrutabulum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Palamocladium leskeoides
Rhynchostegium brachypterum
Rhynchostegiella holstii
Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum
Rhynchostegiella sublaevipes
Rhynchostegiella zeyheri

75. Entodontaceae
Entodon cymbifolius
Entodon geminidens
Entodon macropodus
Entodon natalensis
Erythrodontium subjulaceum
Levierella perserrata
Trachyphyllum gastrodes

76. Plagiotheciaceae
Plagiothecium membranosulum
Plagiothecium rhynchostegioides

76A. Catagoniaceae
Catagonium nitens *subsb.* maritimum

77. Sematophyllaceae
    Rhacopilopsis flexilis
    Rhacopilopsis transvaaliensis
    Sematophyllum brachycarpum
    Sematophyllum dregei
    Sematophyllum gueinzii
    Sematophyllum sphaeropyxis
    Sematophyllum subpinnatum
    Sematophyllum wageri
    Sematophyllum zuluense
    Trichosteleum perchlorosum
    Wijkia trichocolea
78. Hypnaceae
    Chrysohypnum cavifolium
    Ectropothecium brachycarpum
    Ectropothecium perrotii
    Ectropothecium regulare
    Hypnum cupressiforme
    Hypnum macrogynum
    Isopterygium leucophanes
    Isopterygium leucopsis
    Isopterygium punctulatum
    Isopterygium taxithelioides
    Mittenothamnium ctenidioides
    Mittenothamnium horridulum
    Mittenothamnium patens
    Mittenothamnium pseudoreptans
    Mittenothamnium reptans
    Vesicularia galerulata
83. Polytrichaceae
    Atrichum androgynum
    Oligotrichum afrolaevigatum
    Oligotrichum capense
    Oligotrichum wageri
    Pogonatum borgenii
    Pogonatum capense
    Pogonatum oligodus
    Polytrichum commune
    Polytrichum juniperinum
    Polytrichum piliferum
    Polytrichum subformosum

Appendix II,2b. The moss flora of the Cape Domain

1. Sphagnaceae
    Sphagnum capense
    Sphagnum perichaetiale
    Sphagnum pycnocladulum
    Sphagnum strictum *subsb.* pappeanum
    Sphagnum truncatum
    Sphagnum violascens
2. Andreaeaceae
    Andreaea nitida
    Andreaea rupestris
    Andreaea subulata
3. Fissidentaceae
    Fissidens asplenioides
    Fissidens borgenii
    Fissidens bryoides
    Fissidens curvatus
    Fissidens fasciculatus
    Fissidens glaucescens
    Fissidens marginatus
    Fissidens parvilimbatus
    Fissidens plumosus
    Fissidens pseudoserratus
    Fissidens pygmaeus
    Fissidens rufescens
    Fissidens splachnifolius
    Fissidens stellenboschianus
4. Archidiaceae
    Archidium andersonianum
    Archidium capense
    Archidium julicaule
    Archidium muelleranum
    Archidium ohioense
    Archidium rehmannii
    Archidium subulatum
5. Ditrichaceae
    Ceratodon purpureus *subsb.* stenocarpus
    Cheilothela chilensis
    Ditrichum brachypodum
    Ditrichum difficile
    Pleuridium ecklonii
    Pleuridium nervosum
    Pleuridium pappeanum
8. Dicranaceae
    Bruchia brevipes
    Bruchia eckloniana
    Campylopus atroluteus
    Campylopus bicolor
    Campylopus camboueí
    Campylopus catarractilis
    Campylopus flaccidus
    Campylopus hildebrandtii
    Campylopus introflexus

Campylopus nanophyllus
Campylopus pilifer
Campylopus pyriformis
Campylopus robillardei
Campylopus savannarum
Campylopus stenopelma
Dicranella rigida
Dicranella subsubulata
Dicranoloma billardieri
Holomitrium cylindraceum *var.* cucullatum
Leptotrichella minuta
Leucobryum acutifolium
Leucobryum rehmannii
Leucoloma rehmannii
Leucoloma sprengelianum
Oreoweisia erosa
Platyneurum praealtum
Trematodon divaricatus
Trematodon paradoxus
Trematodon pillansii

12. Calymperaceae
Calymperes levyanum
Hypodontium dregei
Hypodontium pomiforme
Syrrhopodon gaudichaudii

14. Pottiaceae
Aloina bifrons
Barbula calycina
Barbula indica
Bryoerythrophyllum campylocarpum
Chenia leptophylla
Didymodon australasiae
Didymodon ceratodonteus
Didymodon xanthocarpus
Gymnostomum aeruginosum
Hennediella longipedunculata
Leptodontium brachyphyllum
Microbryum subplanomarginatum
Pseudocrossidium crinitum
Pseudocrossidium hornschuchianum
Pseudocrossidium porphyreoneurum
Syntrichia ammonsiana
Syntrichia fragilis
Syntrichia pagorum
Syntrichia papillosa
Syntrichia princeps
Syntrichia ruralis
Tetrapterum tetragonum
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Tortula muralis
Tortula splachnoides
Trichostomum brachydontium
Trichostomum tenuirostre
Trichostomum unguiculatum
Triquetrella tristicha
Weissia controversa
Weissia cucullata

14a. Bryobartramiaceae
Bryobartramia novaevalesiae

15. Grimmiaceae
Grimmia laevigata
Grimmia pulvinata
Racomitrium crispulum
Racomitrium lamprocarpum
Racomitrium lanuginosum

16. Gigaspermaceae
Chamaebryum pottioides
Gigaspermum repens

18. Ephemeraceae
Ephemerum diversifolium
Ephemerum namaquense
Ephemerum rehmannii

19. Funariaceae
Funaria bergiana
Funaria clavata
Funaria hygrometrica
Funaria limbata
Funaria rottleri
Funaria spathulata
Funaria succuleata
Funaria urceolata
Physcomitrium spathulatum *var.* spathulatum

24. Bryaceae
Brachymenium acuminatum
Brachymenium dicranoides
Brachymenium pulchrum
Bryum alpinum
Bryum andicola
Bryum argenteum
Bryum aubertii
Bryum canariense
Bryum dichotomum
Bryum donianum

Bryum erythrocaulon
Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum radiculosum
Bryum subapiculatum
Bryum torquescens
Leptobryum pyriforme
Mielichhoferia bryoides
Orthodontium lineare
Pohlia elongata
Pohlia nutans
Rhodobryum commersonii
Rhodobryum umbraculum

26. Mniaceae
Plagiomnium rhynchophorum *var.* reidii

32. Rhizogoniaceae
Pyrrhobryum spiniforme
Pyrrhobryum vallisgratiae

34. Aulacomniaceae
Leptotheca gaudichaudii

37. Bartramiaceae
Anacolia breutelii
Bartramia aristaria
Bartramia capensis
Bartramia compacta *var.* compacta
Bartramia hampeana
Breutelia elliptica
Breutelia microdonta
Breutelia substricta
Breutelia tabularis
Philonotis comosa
Philonotis dregeana
Philonotis falcata
Philonotis globosa
Philonotis hastata
Philonotis scabrifolia
Philonotis vagans

41. Ptychomitriaceae
Ptychomitrium crassinervium
Ptychomitrium crispatum
Ptychomitrium depressum
Ptychomitrium subcrispatum

42. Orthotrichaceae
Amphidium tortuosum
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma pulchella
Macrocoma tenue *subsb.* tenue
Macromitrium lebomboense
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Orthotrichum diaphanum
Orthotrichum incurvomarginatum
Orthotrichum rupestre
Orthotrichum subexsertum
Schlotheimia ferruginea
Schlotheimia percuspidata
Schlotheimia rufopallens
Ulota ecklonii
Zygodon leptobolax
Zygodon runcinatus
Zygodon trichomitrius

44. Racopilaceae
Racopilum capense

45. Fontinalaceae
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa

45a. Wardiaceae
Wardia hygrometrica

47. Hedwigiaceae
Braunia secunda
Hedwigidium integrifolium
Rhacocarpus purpurascens

48. Cryphaeaceae
Cryphaea exigua

49. Leucodontaceae
Leucodon assimilis
Pterogonium gracile

57. Pterobryaceae
Calyptothecium hoehnelii

58. Meteoriaceae
Aerobryopsis capensis
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense

58a. Leptodontaceae
Forsstroemia producta
Leptodon smithii

60. Neckeraceae
Neckera valentiniana

60a. Thamnobryaceae
Porothamnium stipitatum
Porotrichum madagassum

65. Hookeriaceae
Calyptrochaeta asplenioides
Cyclodictyon vallisgratiae
Distichophyllum mniifolium *var.* mniifolium

Distichophyllum mniifolium *var.* taylorii
Hookeriopsis pappeana
Hypopterygium laricinum
Lopidium pennaeforme

70. Fabroniaceae
Dimerodontium africanum
Fabronia abyssinica
Fabronia gueinzii
Fabronia leikipiae
Fabronia perciliata
Fabronia pilifera
Fabronia rehmannii
Fabronia victoriae
Fabronia wageri
Helicodontium lanceolatum
Ischyrodon lepturus

70a. Stereophyllaceae
Stereophyllum radiculosum

71. Leskeaceae
Haplocladium angustifolium
Lindbergia haplocladioides
Lindbergia pseudoleskeoides
Pseudoleskea chilensis
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
Pseudoleskeopsis pseudoattenuata

72. Thuidiaceae
Cyrtohypnum versicolor
Haplohymenium pseudotriste

73. Amblystegiaceae
Drepanocladus sendtneri

74.brachytheciaceae
Brachythecium implicatum
Brachythecium pinnatum
Brachythecium plumosum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Brachythecium salebrosum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Palamocladium leskeoides
Rhynchostegium brachypterum
Rhynchostegium raphidorrhynchum
Rhynchostegiella zeyheri

75. Entodontaceae
Entodon macropodus

76. Plagiotheciaceae
Plagiothecium membranosulum
Plagiothecium rhynchostegioides

76a. Catagoniaceae
Catagonium nitens *subsb.* maritimum

77. Sematophyllaceae
Meiothecium fuscescens
Sematophyllum brachycarpum
Sematophyllum dregei
Sematophyllum gueinzii
Sematophyllum sphaeropyxis
Sematophyllum subpinnatum.
Sematophyllum wageri
Sematophyllum zuluense

78. Hypnaceae
Ectropothecium brachycarpum
Ectropothecium regulare
Hypnum cupressiforme
Isopterygium leucophanes
Isopterygium punctulatum
Isopterygium strangulatum
Isopterygium taylorii
Mittenothamnium ctenidioides
Mittenothamnium patens
Mittenothamnium pseudoreptans
Mittenothamnium reptans
Vesicularia galerulata

83. Polytrichaceae
Atrichum androgynum
Oligotrichum capense
Pogonatum capense
Polytrichastrum formosum
Polytrichum commune
Polytrichum juniperinum
Polytrichum piliferum
Polytrichum subformosum

Appendix II,2c. Diagnostic species/infraspecific taxa for the Drakensberg Domain

Abietinella abietina
Amphidium lapponicum
Amphidium tortuosum
Aongstroemia filiformis
Aongstroemiopsis julacea
Archidium julicaule
Astomiopsis amblyocalyx
Blindia magellanica
Brachymenium leptophyllum

Brachymenium nepalense
Brachythecium salebrosum
Breutelia diffracta
Bryum subapiculatum
Callicostella tristis
Calyptothecium acutifolium
Calyptothecium hoehnelii
Campyliadelphus polygamus
Campylopus aureonitens
Campylopus fragilis
Campylopus hensii
Campylopus hildebrandtii
Campylopus jamesonii
Campylopus julaceus *subsp.* arbogastii
Chrysohypnum cavifolium
Conostomum tetragonum
Cratoneuron filicinum
Cryphaea exigua
Cyclodictyon vallisgratiae
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Dicranoloma entabeniense
Dimerodontium africanum
Ditrichum punctulatum
Ditrichum strictum
Ectropothecium brachycarpum
Ectropothecium perrotii
Ectropothecium regulare
Entodon geminidens
Entodontopsis nitens
Ephemerum capense
Erpodium distichum
Eustichia longirostris
Fabronia eckloniana
Fabronia leikipiae
Fabronia perciliata
Fabronia victoriae
Fissidens aciphyllus
Fissidens enervis
Fissidens gladiolus
Fissidens porrectus
Fissidens scleromitrius
Fissidens simii
Fissidens usambaricus
Floribundaria floribunda
Gymnostomum lingulatum
Helicodontium lanceolatum
Herpetineuron toccoae
Holomitrium cylindraceum *var.* cucullatum
Isopterygium leucopsis
Isopterygium taxithelioides
Jaegerina stolonifera
Lepidopilidium hanningtonii
Leptobryum pyriforme
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Leptoischyrodon congoanus
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Leucobryum madagassum
Leucoloma chrysobasilare
Leucoloma rehmannii
Leucoloma syrrhopodontioides
Levierella perserrata
Lindbergia haplocladioides
Lopidium pennaeforme
Macromitrium levatum
Macromitrium richardii
Macromitrium serpens
Micropoma niloticum
Mielichhoferia subnuda
Mittenothamnium ctenidioides
Mittenothamnium horridulum
Mittenothamnium patens
Mittenothamnium pseudoreptans
Mittenothamnium reptans
Oligotrichum afrolaevigatum
Oligotrichum wageri
Oreoweisia erosa
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Orthotrichum armatum
Orthotrichum firmum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Physcomitrellopsis africana
Pinnatella minuta
Plagiobryum zierii
Plagiopus oederianus
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Pogonatum borgenii
Pogonatum oligodus
Porotrichum elongatum
Porotrichum usagarum
Prionodon densus

Pseudoleskea chilensis
Pterobryopsis rehmannii
Pterogonium gracile
Ptychomitriopsis africana
Quathlamba debilicostata
Rauiella praelonga
Rhabdoweisia crispata
Rhabdoweisia fugax
Rhachithecium perpusillum
Rhacopilopsis flexilis
Rhacopilopsis transvaaliensis
Rhodobryum keniae
Rhodobryum roseum
Rhynchostegiella holstii
Rhynchostegiella sublaevipes
Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum
Rigodium toxarion
Saelania glaucescens
Sanionia uncinata
Schlotheimia percuspidata
Sematophyllum subpinnatum
Sematophyllum wageri
Sematophyllum zuluense
Sphagnum fimbriatum
Stereophyllum woodii
Stoneobryum mirum
Streptocalypta pulchiretis
Syrrhopodon asper
Tayloria isleana
Tayloria orthodonta
Tortula bogosica
Trachypodopsis serrulata
Trachypus bicolor *var.* viridulus
Trematodon divaricatus
Trematodon paradoxus
Trichosteleum perchlorosum
Tristichium mirabile
Vesicularia galerulata
Vittia pachyloma
Weisiopsis plicata
Weissia humicola
Zygodon dixonii
Zygodon erosus
Zygodon intermedius

Appendix II,3 The moss flora of the Karoo-Namib Region

1. Sphagnaceae
   - Sphagnum capense
   - Sphagnum perichaetiale
   - Sphagnum pycnocladulum
   - Sphagnum strictum *subsb.*. pappeanum
   - Sphagnum truncatum
   - Sphagnum violascens
2. Andreaeaceae
   - Andreaea bistratosa
   - Andreaea rupestris
   - Andreaea subulata
3. Fissidentaceae
   - Fissidens bryoides
   - Fissidens curvatus
   - Fissidens fasciculatus
   - Fissidens glaucescens
   - Fissidens marginatus
   - Fissidens palmifolius
   - Fissidens parvilimbatus
   - Fissidens plumosus
   - Fissidens pygmaeus
   - Fissidens rufescens
   - Fissidens subobtusatus
4. Archidiaceae
   - Archidium amplexicaule
   - Archidium muelleranum
   - Archidium ohioense
   - Archidium rehmannii
5. Ditrichaceae
   - Ceratodon purpureus *subsb.* stenocarpus
   - Ditrichum brachypodum
   - Ditrichum difficile
   - Pleuridium ecklonii
   - Pleuridium nervosum
   - Pleuridium papillosum
   - Pleuridium pappeanum
8. Dicranaceae
   - Bruchia brevipes
   - Campylopus atroluteus
   - Campylopus hildebrandtii
   - Campylopus introflexus
   - Campylopus pilifer
   - Campylopus pyriformis
   - Campylopus robillardei
   - Campylopus stenopelma

Cladophascum gymnomitrioides
Dicranella cardotii
Dicranella rigida
Dicranella subsubulata
Dicranoloma billardieri
Leucobryum acutifolium
Leucoloma sprengelianum
Platyneurum praealtum
Sphaerothecium subchlorophyllosum
Trematodon intermedius
Trematodon pillansii

12. Calymperaceae
Hypodontium dregei
Hypodontium pomiforme
Syrrhopodon gaudichaudii

13. Encalyptaceae
Encalypta vulgaris

14. Pottiaceae
Acaulon leucochaete
Acaulon recurvatum
Aloina bifrons
Barbula bolleana
Barbula indica
Chenia leptophylla
Crossidium spiralifolium
Didymodon australasiae
Didymodon ceratodonteus
Didymodon trivialis
Didymodon xanthocarpus
Gymnostomum aeruginosum
Hennediella longipedunculata
Microbryum davallianum *var.*. conicum
Microbryum rufochaete
Microbryum subplanomarginatum
Microcrossidium apiculatum
Phascum peraristatum
Pottia namaquensis
Pseudocrossidium crinitum
Pseudocrossidium hornschuchianum
Pseudocrossidium porphyreoneurum
Syntrichia ammonsiana
Syntrichia chisosa
Syntrichia fragilis
Syntrichia pagorum
Syntrichia princeps
Syntrichia ruralis
Tetrapterum tetragonum
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Tortula muralis
Tortula splachnoides
Trichostomum brachydontium
Trichostomum tenuirostre
Trichostomum unguiculatum
Triquetrella tristicha

14A. Bryobartramiaceae
Bryobartramia novaevalesiae

15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Leucoperichaetium eremophilum
Racomitrium crispulum
Racomitrium lamprocarpum
Racomitrium lanuginosum
Schistidium apocarpum

16. Gigaspermaceae
Chamaebryum pottioides
Gigaspermum repens

18. Ephemeraceae
Ephemerum namaquense
Ephemerum rehmannii

19. Funariaceae
Cygnicollum immersum
Funaria bergiana
Funaria clavata
Funaria hygrometrica
Funaria limbata
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Goniomitrium africanum

24. Bryaceae
Brachymenium acuminatum
Brachymenium dicranoides
Bryum alpinum
Bryum argenteum
Bryum canariense
Bryum capillare
Bryum cellulare
Bryum dichotomum
Bryum erythrocaulon
Bryum radiculosum
Bryum torquescens
Bryum turbinatum

Mielichhoferia bryoides
Pohlia elongata
Pohlia nutans
Rhodobryum umbraculum

34. Aulacomniaceae
Leptotheca gaudichaudii

37. Bartramiaceae
Anacolia breutelii
Bartramia aristaria
Bartramia capensis
Bartramia compacta *var.* compacta
Bartramia hampeana
Breutelia substricta
Philonotis africana
Philonotis dregeana
Philonotis falcata
Philonotis globosa
Philonotis scabrifolia

32. Rhizogoniaceae
Pyrrhobryum spiniforme
Pyrrhobryum vallisgratiae

41. Ptychomitriaceae
Ptychomitriopsis aloinoides
Ptychomitrium crassinervium
Ptychomitrium crispatum
Ptychomitrium depressum

42. Orthotrichaceae
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma tenue *subsb.* tenue
Orthotrichum diaphanum
Orthotrichum incurvomarginatum
Orthotrichum rupestre
Orthotrichum subexsertum
Zygodon runcinatus
Zygodon trichomitrius

45A. Wardiaceae
Wardia hygrometrica

47. Hedwigiaceae
Braunia secunda
Hedwigidium integrifolium
Rhacocarpus purpurascens

49. Leucodontaceae
Leucodon assimilis

58. Meteoriaceae
Papillaria africana

58A. Leptodontaceae
Leptodon smithii

60. Neckeraceae
Neckera valentiniana

60A. Thamnobryaceae
Porotrichum madagassum

65. Hookeriaceae
Calyptrochaeta asplenioides
Hookeriopsis pappeana
Hypopterygium laricinum

70. Fabroniaceae
Fabronia breutelii
Fabronia gueinzii
Fabronia rehmannii
Ischyrodon lepturus

71. Leskeaceae
Pseudoleskeopsis claviramea

74 Brachytheciaceae
Brachythecium implicatum
Rhynchostegium brachypterum
Rhynchostegiella zeyheri

75. Entodontaceae
Entodon macropodus

76. Plagiotheciaceae
Plagiothecium membranosulum
Plagiothecium rhynchostegioides

76A. Catagoniaceae
Catagonium nitens *subsb.* maritimum

77. Sematophyllaceae
Sematophyllum brachycarpum
Sematophyllum dregei
Sematophyllum gueinzii

78. Hypnaceae
Hypnum cupressiforme
Isopterygium punctulatum
Isopterygium strangulatum

83. Polytrichaceae
Oligotrichum capense
Oligotrichum tetragonum
Pogonatum capense
Polytrichum commune
Polytrichum juniperinum
Polytrichum piliferum
Polytrichum subformosum

Appendix II,3a The moss flora of the Western Cape Domain

1. Sphagnaceae
Sphagnum capense
Sphagnum perichaetiale
Sphagnum pycnocladulum

Sphagnum strictum *subsp.* pappeanum
Sphagnum truncatum
Sphagnum violascens

2. Andreaeaceae
Andreaea bistratosa
Andreaea rupestris
Andreaea subulata

3. Fissidentaceae
Fissidens bryoides
Fissidens curvatus
Fissidens fasciculatus
Fissidens glaucescens
Fissidens marginatus
Fissidens palmifolius
Fissidens parvilimbatus
Fissidens plumosus
Fissidens pygmaeus
Fissidens rufescens

4. Archidiaceae
Archidium amplexicaule
Archidium muelleranum
Archidium ohioense
Archidium rehmannii

5. Ditrichaceae
Ceratodon purpureus *subsb.* stenocarpus
Ditrichum brachypodum
Ditrichum difficile
Pleuridium ecklonii
Pleuridium nervosum
Pleuridium papillosum
Pleuridium pappeanum

8. Dicranaceae
Bruchia brevipes
Campylopus atroluteus
Campylopus hildebrandtii
Campylopus introflexus
Campylopus pilifer
Campylopus pyriformis
Campylopus robillardei
Campylopus stenopelma
Cladophascum gymnomitrioides
Dicranella cardotii
Dicranella rigida
Dicranella subsubulata
Dicranoloma billardieri
Leucobryum acutifolium
Leucoloma sprengelianum
Platyneurum praealtum
Sphaerothecium subchlorophyllosum
Trematodon intermedius
Trematodon pillansii

12. Calymperaceae
Hypodontium dregei
Hypodontium pomiforme
Syrrhopodon gaudichaudii

13. Encalyptaceae
Encalypta vulgaris

14. Pottiaceae
Acaulon leucochaete
Acaulon recurvatum
Aloina bifrons
Barbula indica
Chenia leptophylla
Crossidium spiralifolium
Didymodon australasiae
Didymodon ceratodonteus
Didymodon trivialis
Didymodon xanthocarpus
Gymnostomum aeruginosum
Hennediella longipedunculata
Microbryum davallianum *var.* conicum
Microbryum rufochaete
Microbryum subplanomarginatum
Microcrossidium apiculatum
Phascum peraristatum
Pottia namaquensis
Pseudocrossidium crinitum
Pseudocrossidium hornschuchianum
Pseudocrossidium porphyreoneurum
Syntrichia ammonsiana
Syntrichia chisosa
Syntrichia fragilis
Syntrichia pagorum
Syntrichia princeps
Syntrichia ruralis
Tetrapterum tetragonum
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Tortula muralis
Tortula splachnoides
Trichostomum brachydontium
Trichostomum tenuirostre
Trichostomum unguiculatum

Triquetrella tristicha
14A. Bryobartramiaceae
Bryobartramia novaevalesiae
15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Leucoperichaetium eremophilum
Racomitrium crispulum
Racomitrium lamprocarpum
Racomitrium lanuginosum
Schistidium apocarpum
16. Gigaspermaceae
Chamaebryum pottioides
Gigaspermum repens
18. Ephemeraceae
Ephemerum namaquense
Ephemerum rehmannii
19. Funariaceae
Cygnicollum immersum
Funaria bergiana
Funaria clavata
Funaria hygrometrica
Funaria limbata
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Goniomitrium africanum
24. Bryaceae
Brachymenium acuminatum
Brachymenium dicranoides
Bryum alpinum
Bryum argenteum
Bryum canariense
Bryum dichotomum
Bryum erythrocaulon
Bryum radiculosum
Bryum torquescens
Bryum turbinatum
Mielichhoferia bryoides
Pohlia elongata
Pohlia nutans
Rhodobryum umbraculum
34. Aulacomniaceae
Leptotheca Gaudichaudii
37. Bartramiaceae
Anacolia breutelii
Bartramia aristaria
Bartramia capensis
Bartramia compacta *var.* compacta
Bartramia hampeana
Breutelia substricta
Philonotis africana
Philonotis dregeana
Philonotis falcata
Philonotis globosa
Philonotis scabrifolia
32. Rhizogoniaceae
Pyrrhobryum spiniforme
Pyrrhobryum vallisgratiae
41. Ptychomitriaceae
Ptychomitrium crassinervium
Ptychomitrium crispatum
Ptychomitrium depressum
42. Orthotrichaceae
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma tenue *subsb.* tenue
Orthotrichum diaphanum
Orthotrichum incurvomarginatum
Orthotrichum rupestre
Orthotrichum subexsertum
Zygodon runcinatus
Zygodon trichomitrius
45A. Wardiaceae
Wardia hygrometrica
47. Hedwigiaceae
Braunia secunda
Hedwigidium integrifolium
Rhacocarpus purpurascens
49. Leucodontaceae
Leucodon assimilis
58. Meteoriaceae
Papillaria africana
58A. Leptodontaceae
Leptodon smithii
60. Neckeraceae
Neckera valentiniana
60A. Thamnobryaceae
Porotrichum madagassum
65. Hookeriaceae
Calyptrochaeta asplenioides
Hookeriopsis pappeana
Hypopterygium laricinum
70. Fabroniaceae
Fabronia breutelii
Fabronia gueinzii
Fabronia rehmannii
Ischyrodon lepturus

71. Leskeaceae
    Pseudoleskeopsis claviramea
74 Brachytheciaceae
    Brachythecium implicatum
    Rhynchostegium brachypterum
    Rhynchostegiella zeyheri
75. Entodontaceae
    Entodon macropodus
76. Plagiotheciaceae
    Plagiothecium membranosulum
    Plagiothecium rhynchostegioides
76A. Catagoniaceae
    Catagonium nitens *subsb.* maritimum
77. Sematophyllaceae
    Sematophyllum brachycarpum
    Sematophyllum dregei
    Sematophyllum gueinzii
78. Hypnaceae
    Hypnum cupressiforme
    Isopterygium punctulatum
    Isopterygium strangulatum
83. Polytrichaceae
    Oligotrichum capense
    Oligotrichum tetragonum
    Pogonatum capense
    Polytrichum commune
    Polytrichum juniperinum
    Polytrichum piliferum
    Polytrichum subformosum

Appendix II,3b The moss flora of the Namaqua Domain

3. Fissidentaceae
    Fissidens subobtusatus
4. Archidiaceae
    Archidium ohioense
8. Dicranaceae
    Campylopus introflexus
14. Pottiaceae
    Barbula bolleana
    Pseudocrossidium crinitum
    Pseudocrossidium porphyreoneurum
    Syntrichia ammonsiana
    Tortula atrovirens
    Trichostomum brachydontium
15. Grimmiaceae
    Grimmia pulvinata
16. Gigaspermaceae
    Chamaebryum pottioides
19. Funariaceae
    Funaria bergiana
    Funaria clavata
    Funaria rhomboidea
24. Bryaceae
    Brachymenium acuminatum
    Bryum argenteum
    Bryum capillare
    Bryum cellulare
37. Bartramiaceae
    Philonotis dregeana
41. Ptychomitriaceae
    Ptychomitriopsis aloinoides

Appendix II,4. The moss flora of the Highlands Region

2. Andreaeaceae
    Andreaea rupestris
3. Fissidentaceae
    Fissidens borgenii
    Fissidens bryoides
    Fissidens curvatus
    Fissidens glaucescens
    Fissidens hoegii
    Fissidens microandrogynus
    Fissidens palmifolius
    Fissidens parvilimbatus
    Fissidens rufescens
4. Archidiaceae
    Archidium capense
5. Ditrichaceae
    Ceratodon purpureus *subsb.* stenocarpus
    Distichium capillaceum
    Pleuridium nervosum
8. Dicranaceae
    Aongstroemia julacea
    Campylopus atroluteus
    Campylopus introflexus
    Campylopus pilifer
    Campylopus pyriformis
    Cladophascum gymnomitrioides
    Dicranella cardotii
    Dicranella subsubulata
    Trematodon intermedius
    Trematodon longicollis
    Trematodon mayottensis

12. Calymperaceae
    - Hypodontium dregei

13. Encalyptaceae
    - Encalypta ciliata
    - Encalypta vulgaris

14.Pottiaceae
    - Anoectangium wilmsianum
    - Barbula bolleana
    - Barbula microcalycina
    - Bryoerythrophyllum campylocarpum
    - Bryoerythrophyllum recurvirostrum
    - Didymodon australasiae
    - Didymodon ceratodonteus
    - Didymodon jackvancei
    - Didymodon tophaceopsis
    - Didymodon trivialis
    - Didymodon xanthocarpus
    - Gymnostomum aeruginosum
    - Gymnostomum bewsii
    - Hymenostylium recurvirostrum
    - Microbryum davallianum *var.* conicum
    - Microbryum subplanomarginatum
    - Pseudocrossidium crinitum
    - Pseudocrossidium hornschuchianum
    - Pseudocrossidium replicatum
    - Pterygoneurum macleanum
    - Syntrichia ammonsiana
    - Syntrichia austroafricana
    - Syntrichia chisosa
    - Syntrichia fragilis
    - Syntrichia pagorum
    - Syntrichia papillosa
    - Syntrichia princeps
    - Syntrichia ruralis
    - Timmiella pelindaba
    - Tortella humilis
    - Tortella xanthocarpa
    - Tortula atrovirens
    - Trichostomum brachydontium
    - Triquetrella tristicha
    - Weissia controversa
    - Weissia dieterleniae
    - Weissia latiuscula

15. Grimmiaceae
    - Grimmia laevigata
    - Grimmia ovalis
    - Grimmia pulvinata
    - Schistidium apocarpum

16. Gigaspermaceae
    - Chamaebryum pottioides
    - Gigaspermum repens
    - Oedipodiella australis

18. Ephemeraceae
    - Ephemerum rehmannii

19. Funariaceae
    - Funaria bergiana
    - Funaria hygrometrica
    - Funaria rhomboidea
    - Funaria rottleri
    - Funaria spathulata
    - Funaria succuleata
    - Funaria urceolata
    - Goniomitrium africanum
    - Physcomitrium spathulatum *var.* sessile
    - Physcomitrium spathulatum *var.* spathulatum

24. Bryaceae
    - Anomobryum drakensbergense
    - Anomobryum filiforme
    - Brachymenium acuminatum
    - Bryum alpinum
    - Bryum andicola
    - Bryum apiculatum
    - Bryum argenteum
    - Bryum aubertii
    - Bryum caespiticium
    - Bryum canariense
    - Bryum capillare
    - Bryum cellulare
    - Bryum dichotomum
    - Bryum pseudotriquetrum
    - Bryum pycnophyllum
    - Bryum radiculosum
    - Bryum torquescens
    - Bryum turbinatum
    - Mielichhoferia bryoides
    - Pohlia cruda
    - Pohlia nutans

26. Mniaceae
    - Plagiòmnium rhynchophorum *var.* reidii

37. Bartramiaceae
    - Anacolia breutelii
    - Bartramia hampeana
    - Philonotis dregeana

Philonotis falcata
Philonotis globosa
Philonotis hastata
Philonotis scabrifolia

41. Ptychomitriaceae
Ptychomitriopsis aloinoides magill
Ptychomitrium crispatum
Ptychomitrium cucullatifolium
Ptychomitrium depressum
Ptychomitrium diexaratum
Ptychomitrium subcrispatum

42. Orthotrichaceae
Macrocoma tenue *subsb.* tenue
Orthotrichum diaphanum
Orthotrichum oreophilum
Orthotrichum rupestre
Orthotrichum transvaalense

47. Hedwigiaceae
Braunia secunda
Hedwigia ciliata
Hedwigidium integrifolium

58. Meteoriaceae
Aerobryopsis capensis

58A. Leptodontaceae
Leptodon smithii

70. Fabroniaceae
Fabronia abyssinica
Fabronia pilifera

71. Leskeaceae
Haplocladium angustifolium
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Lindbergia viridis
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
Pseudoleskeopsis pseudoattenuata

72. Thuidiaceae
Thuidium matarumense

73. Amblystegiaceae
Drepanocladus aduncus

74. Brachytheciaceae
Brachythecium implicatum
Brachythecium plumosum
Brachythecium subrutabulum
Palamocladium leskeoides

75. Entodontaceae
Entodon cymbifolius
Entodon natalensis

76. Sematophyllaceae
Sematophyllum gueinzii
Wijkia trichocolea

77. Hypnaceae
Hypnum cupressiforme
Hypnum macrogynum

83. Polytrichaceae
Atrichum androgynum
Polytrichum juniperinum
Polytrichum piliferum

Appendix II,4a. The moss flora of the Drakensberg Alpine Domain

2. Andreaeaceae
Andreaea rupestris

3. Fissidentaceae
Fissidens bryoides
Fissidens curvatus
Fissidens glaucescens
Fissidens hoegii
Fissidens microandrogynus
Fissidens palmifolius
Fissidens parvilimbatus
Fissidens rufescens

5. Ditrichaceae
Ceratodon purpureus *subsb.* stenocarpus
Distichium capillaceum
Pleuridium nervosum

8. Dicranaceae
Aongstroemia julacea
Campylopus atroluteus
Campylopus introflexus
Campylopus pilifer
Campylopus pyriformis
Cladophascum gymnomitrioides
Dicranella cardotii
Dicranella subsubulata
Trematodon intermedius
Trematodon longicollis
Trematodon mayottensis

12. Calymperaceae
Hypodontium dregei

13. Encalyptaceae
Encalypta ciliata
Encalypta vulgaris

14.Pottiaceae
Anoectangium wilmsianum
Barbula bolleana
Barbula microcalycina

Bryoerythrophyllum campylocarpum
Bryoerythrophyllum recurvirostrum
Didymodon australasiae
Didymodon ceratodonteus
Didymodon jackvancei
Didymodon trivialis
Didymodon xanthocarpus
Gymnostomum aeruginosum
Gymnostomum bewsii
Hymenostylium recurvirostrum
Microbryum davallianum *var.* conicum
Microbryum subplanomarginatum
Pseudocrossidium crinitum
Pseudocrossidium hornschuchianum
Pseudocrossidium replicatum
Pterygoneurum macleanum
Syntrichia austroafricana
Syntrichia chisosa
Syntrichia fragilis
Syntrichia pagorum
Syntrichia papillosa
Syntrichia princeps
Syntrichia ruralis
Timmiella pelindaba
Tortella humilis
Tortella xanthocarpa
Tortula atrovirens
Trichostomum brachydontium
Triquetrella tristicha
Weissia controversa
Weissia dieterleniae
Weissia latiuscula

15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Schistidium apocarpum

16. Gigaspermaceae
Oedipodiella australis

19. Funariaceae
Funaria bergiana
Funaria hygrometrica
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Funaria succuleata
Funaria urceolata
Goniomitrium africanum
Physcomitrium spathulatum *var.* sessile
Physcomitrium spathulatum *var.* spathulatum

24. Bryaceae
Anomobryum drakensbergense
Anomobryum filiforme
Brachymenium acuminatum
Bryum alpinum
Bryum andicola
Bryum apiculatum
Bryum argenteum
Bryum aubertii
Bryum caespiticium
Bryum canariense
Bryum capillare
Bryum cellulare
Bryum dichotomum
Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum torquescens
Bryum turbinatum
Mielichhoferia bryoides
Pohlia cruda
Pohlia nutans

26. Mniaceae
Plagiomnium rhynchophorum *var.* reidii

37. Bartramiaceae
Anacolia breutelii
Bartramia hampeana
Philonotis dregeana
Philonotis falcata
Philonotis globosa
Philonotis hastata
Philonotis scabrifolia

41. Ptychomitriaceae
Ptychomitriopsis aloinoides magill
Ptychomitrium crispatum
Ptychomitrium cucullatifolium
Ptychomitrium depressum
Ptychomitrium diexaratum
Ptychomitrium subcrispatum

42. Orthotrichaceae
Macrocoma tenue *subsb.* tenue
Orthotrichum diaphanum
Orthotrichum oreophilum
Orthotrichum rupestre

Orthotrichum transvaalense

47. Hedwigiaceae
    Braunia secunda
    Hedwigia ciliata
    Hedwigidium integrifolium
58A. Leptodontaceae
    Leptodon smithii
70. Fabroniaceae
    Fabronia abyssinica
    Fabronia pilifera
71. Leskeaceae
    Haplocladium angustifolium
    Lindbergia patentifolia
    Lindbergia pseudoleskeoides
    Pseudoleskeopsis claviramea
    Pseudoleskea leskeoides
    Pseudoleskeopsis pseudoattenuata
72. Thuidiaceae
    Thuidium matarumense
73. Amblystegiaceae
    Drepanocladus aduncus
74. Brachytheciaceae
    Brachythecium implicatum
    Brachythecium plumosum
    Brachythecium subrutabulum
    Palamocladium leskeoides
75. Entodontaceae
    Entodon cymbifolius
    Entodon natalensis
76. Sematophyllaceae
    Sematophyllum gueinzii
    Wijkia trichocolea
77. Hypnaceae
    Hypnum cupressiforme
    Hypnum macrogynum
83. Polytrichaceae
    Atrichum androgynum
    Polytrichum juniperinum
    Polytrichum piliferum

Appendix II,4b. The moss flora of the Upper Karoo Domain

3. Fissidentaceae
    Fissidens borgenii
    Fissidens bryoides
    Fissidens curvatus
    Fissidens microandrogynus
    Fissidens rufescens
4. Archidiaceae
    Archidium capense
8. Dicranaceae
    Cladophascum gymnomitrioides
14. Pottiaceae
    Barbula bolleana
    Didymodon australasiae
    Didymodon ceratodonteus
    Didymodon tophaceopsis
    Didymodon trivialis
    Gymnostomum aeruginosum
    Hymenostylium recurvirostrum
    Microbryum davallianum *var.* conicum
    Pseudocrossidium crinitum
    Pseudocrossidium replicatum
    Syntrichia ammonsiana
    Syntrichia fragilis
    Syntrichia pagorum
    Tortula atrovirens
    Trichostomum brachydontium
    Triquetrella tristicha
    Weissia controversa
    Weissia latiuscula
15. Grimmiaceae
    Grimmia laevigata
    Grimmia pulvinata
    Schistidium apocarpum
16. Gigaspermaceae
    Chamaebryum pottioides
    Gigaspermum repens
18. Ephemeraceae
    Ephemerum rehmannii
19. Funariaceae
    Funaria hygrometrica
    Funaria rhomboidea
    Funaria rottleri
    Funaria spathulata
    Funaria succuleata
    Funaria urceolata
    Goniomitrium africanum
    Physcomitrium spathulatum *var.* sessile
24. Bryaceae
    Brachymenium acuminatum
    Bryum alpinum
    Bryum apiculatum
    Bryum argenteum
    Bryum canariense
    Bryum capillare
    Bryum cellulare

Bryum pseudotriquetrum
Bryum pycnophyllum
Bryum radiculosum
Bryum torquescens
Bryum turbinatum

37. Bartramiaceae
Bartramia hampeana
Philonotis dregeana
Philonotis falcata

41. Ptychomitriaceae
Ptychomitrium cucullatifolium
Ptychomitrium subcrispatum

42. Orthotrichaceae
Orthotrichum diaphanum

58. Meteoriaceae
Aerobryopsis capensis

70. Fabroniaceae
Fabronia pilifera

71. Leskeaceae
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Lindbergia viridis
Pseudoleskeopsis claviramea

Appendix II,5a. Alphabetical list of genera restricted to the Afromontane Region

Abietinella
Amphidium
Aongstroemiopsis
Astomiopsis
Blindia
Callicostella
Calyptothecium
Campyliadelphus
Cheilothela
Chrysohypnum
Conostomum
Cratoneuron
Cryphaea
Cyclodictyon
Cyrtohypnum
Dimerodontium
Distichophyllum
Ectropothecium
Entodontopsis
Eustichia
Fontinalis
Helicodontium
Herpetineuron
Holomitrium
Hyophila
Jaegerina
Lepidopilidium
Leptobryum
Leptodontium
Leptoischyrodon
Leptoterigynandrum
Leskeella
Levierella
Lopidium
Meiothecium
Micropoma
Mittenothamnium
Oreoweisia
Orthostichopsis
Orthostichopsis
Oxyrrhynchium
Physcomitrellopsis
Pinnatella
Plagiobryum
Plagiopus
Platyhypnidium
Polytrichastrum
Porothamnium
Prionodon
Pterobryopsis
Pterogonium
Quathlamba
Rauiella
Rhabdoweisia
Rhachithecium
Rhacopilopsis
Rigodium
Saelania
Sanionia
Stoneobryum
Streptocalypta
Tayloria
Trachypodopsis
Trachypus
Trichosteleum
Tristichium
Ulota
Vesicularia
Vittia
Weisiopsis

Appendix II,5b. Phylogenetic (see Conspectus of classification in Magill & Van Rooy 1998) list of genera restricted to the Afromontane Region

Ditrichaceae
- Astomiopsis
- Cheilothela
- Saelania
- Tristichium

Seligeriaceae
- Blindia

Dicranaceae
- Aongstroemiopsis
- Holomitrium
- Oreoweisia

Pottiaceae
- Hyophila
- Leptodontium
- Streptocalypta
- Weisiopsis

Funariaceae
- Micropoma
- Physcomitrellopsis

Splachnaceae
- Tayloria

Bryaceae
- Leptobryum
- Plagiobryum

Eustichiaceae
- Eustichia

Bartramiaceae
- Conostomum
- Plagiopus
- Quathlamba

Rhachitheciaceae
- Rhachithecium

Orthotrichaceae
- Amphidium
- Stoneobryum
- Ulota

Rhabdoweisiaceae
- Rhabdoweisia

Fontinalaceae
- Fontinalis

Cryphaeaceae
- Cryphaea

Leucodontaceae
- Pterogonium

Prionodontaceae
- Prionodon

Trachypodaceae
- Trachypodopsis
- Trachypus

Pterobryaceae
- Calyptothecium
- Jaegerina
- Orthostichopsis
- Pterobryopsis

Thamnobryaceae
- Pinnatella
- Porothamnium

Hookeriaceae
- Callicostella
- Cyclodictyon
- Distichophyllum
- Lepidopilidium
- Lopidium

Fabroniaceae
- Dimerodontium
- Helicodontium
- Leptoischyrodon

Stereophyllaceae
- Entodontopsis

Leskeaceae
- Herpetineuron
- Leptoterigynandrum
- Leskeella

Thuidiaceae
- Abietinella
- Cyrtohypnum
- Rauiella

Rigodiaceae
- Rigodium

Amblystegiaceae
- Campyliadelphus
- Cratoneuron
- Platyhypnidium
- Sanionia
- Vittia

Brachytheciaceae
- Oxyrrhynchium

Entodontaceae
- Levierella

Sematophyllaceae
- Meiothecium
- Rhacopilopsis
- Trichosteleum

Hypnaceae
- Chrysohypnum

Ectropothecium
Mittenothamnium
Vesicularia
Polytrichaceae
Polytrichastrum

Appendix II,6. List of moss species/infraspecific taxa restricted to the Afromontane Region (diagnostic species)

Abietinella abietina
Amphidium lapponicum
Amphidium tortuosum
Andreaea nitida
Aongstroemia filiformis
Aongstroemiopsis julacea
Archidium andersonianum
Archidium julicaule
Archidium subulatum
Astomiopsis amblyocalyx
Barbula calycina
Blindia magellanica
Brachymenium leptophyllum
Brachymenium nepalense
Brachythecium pinnatum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Brachythecium salebrosum
Breutelia diffracta
Breutelia elliptica
Breutelia tabularis
Bruchia eckloniana
Bryum donianum
Bryum subapiculatum
Callicostella tristis
Calymperes levyanum
Calyptothecium acutifolium
Calyptothecium hoehnelii
Campyliadelphus polygamus
Campylopus aureonitens
Campylopus bicolor
Campylopus fragilis
Campylopus hensii
Campylopus hildebrandtii
Campylopus jamesonii
Campylopus julaceus *subsp.* arbogastii
Cheilothela chilensis
Chrysohypnum cavifolium
Conostomum tetragonum
Cratoneuron filicinum
Cryphaea exigua
Cyclodictyon vallisgratiae
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Dicranoloma entabeniense
Dimerodontium africanum
Distichophyllum mniifolium *var.* mniifolium
Distichophyllum mniifolium *var.* taylorii
Ditrichum punctulatum
Ditrichum strictum
Drepanocladus sendtneri
Ectropothecium brachycarpum
Ectropothecium perrotii
Ectropothecium regulare
Entodon geminidens
Entodontopsis nitens
Ephemerum capense
Ephemerum diversifolium
Erpodium distichum
Eustichia longirostris
Fabronia eckloniana
Fabronia leikipiae
Fabronia perciliata
Fabronia victoriae
Fabronia wageri
Fissidens aciphyllus
Fissidens enervis
Fissidens gladiolus
Fissidens porrectus
Fissidens scleromitrius
Fissidens simii
Fissidens splachnifolius
Fissidens stellenboschianus
Fissidens usambaricus
Floribundaria floribunda
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa
Gymnostomum lingulatum
Helicodontium lanceolatum
Herpetineuron toccoae
Holomitrium cylindraceum *var.* cucullatum
Isopterygium leucopsis
Isopterygium taxithelioides
Isopterygium taylorii
Jaegerina stolonifera

Lepidopilidium hanningtonii
Leptobryum pyriforme
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Leptoischyrodon congoanus
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Leucobryum madagassum
Leucobryum rehmannii
Leucoloma chrysobasilare
Leucoloma rehmannii
Leucoloma syrrhopodontioides
Levierella perserrata
Lindbergia haplocladioides
Lopidium pennaeforme
Macrocoma pulchella
Macromitrium levatum
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Meiothecium fuscescens
Micropoma niloticum
Mielichhoferia subnuda
Mittenothamnium ctenidioides
Mittenothamnium horridulum
Mittenothamnium patens
Mittenothamnium pseudoreptans
Mittenothamnium reptans
Oligotrichum afrolaevigatum
Oligotrichum wageri
Oreoweisia erosa
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Orthotrichum armatum
Orthotrichum firmum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Philonotis comosa
Philonotis vagans
Physcomitrellopsis africana
Pinnatella minuta
Plagiobryum zierii
Plagiopus oederianus
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Pogonatum borgenii
Pogonatum oligodus
Polytrichastrum formosum
Porotrichum elongatum
Porotrichum usagarum
Prionodon densus
Pseudoleskea chilensis
Pterobryopsis rehmannii
Pterogonium gracile
Ptychomitriopsis africana
Quathlamba debilicostata
Rauiella praelonga
Rhabdoweisia crispata
Rhabdoweisia fugax
Rhachithecium perpusillum
Rhacopilopsis flexilis
Rhacopilopsis transvaaliensis
Rhodobryum keniae
Rhodobryum roseum
Rhynchostegiella holstii
Rhynchostegiella sublaevipes
Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum
Rigodium toxarion
Saelania glaucescens
Sanionia uncinata
Schlotheimia percuspidata
Sematophyllum subpinnatum
Sematophyllum wageri
Sematophyllum zuluense
Sphagnum fimbriatum
Stereophyllum woodii
Stoneobryum mirum
Streptocalypta pulchiretis
Syrrhopodon asper
Tayloria isleana
Tayloria orthodonta
Tortula bogosica
Trachypodopsis serrulata
Trachypus bicolor *var.* viridulus
Trematodon divaricatus
Trematodon paradoxus
Trichosteleum perchlorosum
Tristichium mirabile
Ulota ecklonii
Vesicularia galerulata
Vittia pachyloma
Weisiopsis plicata
Weissia cucullata
Weissia humicola
Zygodon dixonii
Zygodon erosus
Zygodon intermedius
Zygodon leptobolax

APPENDIX III

COMPOSITION OF THE BRYOGEOGRAPHIC (FLORISTIC) ELEMENTS (TWINSPAN 3+) OF SOUTHERN AFRICA

Appendix III,1. Composition of bryofloristic element 1/1 (1st level of TWINSPAN 3+ division, group 1)

1. Sphagnaceae
   - Sphagnum perichaetiale
   - Sphagnum violascens
2. Andreaeaceae
   - Andreaea bistatosa
   - Andreaea rupestris
   - Andreaea subulata
3. Fissidentaceae
   - Fissidens curvatus
   - Fissidens fasciculatus
   - Fissidens hoegii
   - Fissidens marginatus
   - Fissidens microandrogynus
   - Fissidens parvilimbatus
   - Fissidens pygmaeus
   - Fissidens rufescens
4. Archidiaceae
   - Archidium amplexicaule
   - Archidium capense
   - Archidium dinteri
   - Archidium microthecium
   - Archidium ohioense
   - Archidium rehmannii
5. Ditrichaceae
   - Pleuridium ecklonii
   - Pleuridium nervosum
   - Pleuridium papillosum
   - Pleuridium pappeanum
8. Dicranaceae
   - Bruchia brevipes
   - Bruchia queenslandica
   - Campylopus hildebrandtii
   - Platyneurum praealtum
   - Cladophascum gymnomitrioides
   - Dicranella rigida
   - Leucoloma sprengelianum
   - Trematodon mayottensis
12. Calymperaceae
   - Hypodontium pomiforme
13. Encalyptaceae
   - Encalypta ciliata
   - Encalypta vulgaris
14. Pottiaceae
   - Aloina bifrons
   - Acaulon recurvatum
   - Acaulon leucochaete
   - Bryoerythrophyllum recurvirostrum
   - Crossidium spiralifolium
   - Didymodon australasiae
   - Didymodon ceratodonteus
   - Didymodon jackvancei
   - Didymodon tophaceopsis
   - Didymodon trivialis
   - Didymodon xanthocarpus
   - Hennediella longipedunculata
   - Microbryum davallianum *var.* conicum
   - Microcrossidium apiculatum
   - Microbryum rufochaete
   - Microbryum subplanomarginatum
   - Phascum peraristatum
   - Pottia namaquensis
   - Pseudocrossidium crinitum
   - Pseudocrossidium hornschuchianum
   - Pseudocrossidium replicatum
   - Pterygoneurum macleanum
   - Syntrichia ammonsiana

Syntrichia austroafricana
Syntrichia chisosa
Syntrichia princeps
Syntrichia ruralis
Tetrapterum tetragonum
Timmiella pelindaba
Tortella fragilis
Tortula atrovirens
Tortula muralis
Tortula splachnoides
Trichostomum brachydontium
Trichostomum unguiculatum
Triquetrella tristicha
Weissia dieterleniae

14A. Bryobartramiaceae
Bryobartramia novaevalesiae

15. Grimmiaceae
Grimmia laevigata
Grimmia ovalis
Grimmia pulvinata
Leucoperichaetium eremophilum
Racomitrium crispulum
Racomitrium lamprocarpum
Racomitrium lanuginosum
Schistidium apocarpum

16. Gigaspermaceae
Chamaebryum pottioides
Gigaspermum repens

18. Ephemeraceae
Ephemerum namaquense
Ephemerum rehmannii

19. Funariaceae
Cygnicollum immersum
Funaria bergiana
Funaria clavata
Funaria hygrometrica
Funaria rhomboidea
Funaria rottleri
Funaria spathulata
Funaria succuleata
Goniomitrium africanum
Physcomitrium spathulatum *var.* sessile

24. Bryaceae
Anomobryum drakensbergense
Brachymenium dicranoides
Bryum alpinum
Bryum argenteum
Bryum canariense
Bryum cellulare
Bryum pycnophyllum
Bryum radiculosum
Bryum torquescens
Bryum turbinatum
Pohlia nutans

32. Rhizogoniaceae
Pyrrhobryum vallisgratiae

34. Aulacomniaceae
Leptotheca gaudichaudii

37. Bartramiaceae
Anacolia breutelii
Bartramia compacta *var.* compacta
Bartramia compacta *var.* macowaniana
Bartramia hampeana
Breutelia substricta
Philonotis globosa

41. Ptychomitriaceae
Ptychomitriopsis aloinoides
Ptychomitrium crassinervium
Ptychomitrium cucullatifolium
Ptychomitrium diexaratum

42. Orthotrichaceae
Orthotrichum diaphanum
Orthotrichum incurvomarginatum
Orthotrichum oreophilum
Orthotrichum rupestre
Orthotrichum subexsertum
Zygodon runcinatus

45A. Wardiaceae
Wardia hygrometrica

47. Hedwigiaceae
Rhacocarpus purpurascens

70. Fabroniaceae
Fabronia abyssinica
Fabronia breutelii
Ischyrodon lepturus

78. Hypnaceae
Isopterygium strangulatum

83. Polytrichaceae
    Polytrichum juniperinum
    Polytrichum piliferum

Appendix III,2. Composition of bryofloristic element 1/2 (1st level of TWINSPAN 3+ division, group 2)

1. Sphagnaceae
    Sphagnum capense
    Sphagnum fimbriatum
    Sphagnum pycnocladulum
    Sphagnum strictum *subsp.* pappeanum
    Sphagnum truncatum
2. Andreaeaceae
    Andreaea nitida
3. Fissidentaceae
    Fissidens aciphyllus
    Fissidens asplenioides
    Fissidens borgenii
    Fissidens bryoides
    Fissidens capriviensis
    Fissidens enervis
    Fissidens erosulus
    Fissidens gladiolus
    Fissidens glaucescens
    Fissidens palmifolius
    Fissidens plumosus
    Fissidens porrectus
    Fissidens pseudoserratus
    Fissidens scleromitrius
    Fissidens simii
    Fissidens splachnifolius
    Fissidens stellenboschianus
    Fissidens submarginatus
    Fissidens subobtusatus
    Fissidens usambaricus
    Fissidens wageri
4. Archidiaceae
    Archidium acanthophyllum
    Archidium andersonianum
    Archidium julicaule
    Archidium muelleranum
    Archidium subulatum
5. Ditrichaceae
    Astomiopsis amblyocalyx
    Ceratodon purpureus *subsb.* stenocarpus
    Cheilothela chilensis
    Distichium capillaceum
    Ditrichum brachypodum
    Ditrichum difficile
    Ditrichum punctulatum
    Ditrichum strictum
    Eccremidium exiguum
    Saelania glaucescens
    Tristichium mirabile
7. Seligeriaceae
    Blindia magellanica
8. Dicranaceae
    Aongstroemia filiformis
    Aongstroemiopsis julacea
    Aongstroemia julacea
    Bruchia eckloniana
    Campylopus atroluteus
    Campylopus aureonitens
    Campylopus bicolor
    Campylopus cambouei
    Campylopus catarractilis
    Campylopus flaccidus
    Campylopus fragilis
    Campylopus hensii
    Campylopus introflexus
    Campylopus jamesonii
    Campylopus julaceus *subsp.* arbogastii
    Campylopus nanophyllus
    Campylopus perpusillus
    Campylopus pilifer
    Campylopus pyriformis
    Campylopus robillardei
    Campylopus savannarum
    Campylopus stenopelma
    Dicranella cardotii
    Dicranella subsubulata
    Dicranoloma billardieri
    Dicranoloma entabeniense
    Holomitrium cylindraceum *var.* cucullatum
    Leptotrichella minuta

Leucobryum acutifolium
Leucobryum madagassum
Leucobryum rehmannii
Leucoloma chrysobasilare
Leucoloma rehmannii
Leucoloma syrrhopodontioides
Oreoweisia erosa
Sphaerothecium subchlorophyllosum
Trematodon divaricatus
Trematodon intermedius
Trematodon longicollis
Trematodon paradoxus
Trematodon pillansii

12. Calymperaceae
Calymperes levyanum
Calymperes rabenhorstii
Calymperes tenerum
Hypodontium dregei
Octoblepharum albidum
Syrrhopodon asper
Syrrhopodon gaudichaudii

14. Pottiaceae
Anoectangium wilmsianum
Barbula bolleana
Barbula calycina
Barbula eubryum
Barbula indica
Barbula microcalycina
Bryoerythrophyllum campylocarpum
Chenia leptophylla
Gymnostomum aeruginosum
Gymnostomum bewsii
Gymnostomum lingulatum
Hymenostylium recurvirostrum
Hyophila baginsensis
Hyophila involuta
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Pseudocrossidium porphyreoneurum
Streptocalypta pulchiretis
Syntrichia fragilis
Syntrichia pagorum
Syntrichia papillosa
Tortella humilis
Tortella xanthocarpa
Tortula bogosica
Trichostomum tenuirostre
Weisiopsis plicata
Weissia controversa
Weissia cucullata
Weissia humicola
Weissia latiuscula

16. Gigaspermaceae
Oedipodiella australis

18. Ephemeraceae
Ephemerum capense
Ephemerum diversifolium

19. Funariaceae
Funaria limbata
Funaria longicollis
Funaria urceolata
Micropoma niloticum
Physcomitrellopsis africana
Physcomitrium spathulatum *var.* spathulatum

21. Splachnaceae
Tayloria isleana
Tayloria orthodonta

24. Bryaceae
Anomobryum filiforme
Brachymenium acuminatum
Brachymenium leptophyllum
Brachymenium nepalense
Brachymenium pulchrum
Brachymenium systylium
Bryum andicola
Bryum apiculatum
Bryum aubertii
Bryum caespiticium
Bryum capillare
Bryum dichotomum
Bryum donianum
Bryum erythrocaulon
Bryum pseudotriquetrum
Bryum subapiculatum
Bryum viridescens
Leptobryum pyriforme
Mielichhoferia bryoides

Mielichhoferia subnuda
Orthodontium lineare
Plagiobryum zierii
Pohlia baronii
Pohlia cruda
Pohlia elongata
Rhodobryum commersonii
Rhodobryum keniae
Rhodobryum roseum
Rhodobryum umbraculum

26. Mniaceae
Plagiomnium rhynchophorum *var.* reidii

28. Eustichiaceae
Eustichia longirostris

32. Rhizogoniaceae
Pyrrhobryum spiniforme

37. Bartramiaceae
Bartramia aristaria
Bartramia capensis
Breutelia diffracta
Breutelia elliptica
Breutelia microdonta
Breutelia tabularis
Conostomum tetragonum
Philonotis africana
Philonotis comosa
Philonotis dregeana
Philonotis falcata
Philonotis hastata
Philonotis scabrifolia
Philonotis vagans
Plagiopus oederianus
Quathlamba debilicostata

40. Erpodiaceae
Aulacopilum trichophyllum
Erpodium beccarii
Erpodium coronatum *subsp.* transvaaliense
Erpodium distichum
Erpodium grossirete

40A. Rhachitheciaceae
Rhachithecium perpusillum

41. Ptychomitriaceae
Ptychomitriopsis africana
Ptychomitrium crispatum
Ptychomitrium depressum
Ptychomitrium eurybasis
Ptychomitrium exaratifolium
Ptychomitrium subcrispatum

42. Orthotrichaceae
Amphidium lapponicum
Amphidium tortuosum
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma pulchella
Macrocoma tenue subsp tenue
Macromitrium lebomboense
Macromitrium levatum
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Orthotrichum armatum
Orthotrichum firmum
Orthotrichum transvaalense
Schlotheimia ferruginea
Schlotheimia percuspidata
Schlotheimia rufopallens
Stoneobryum mirum
Ulota ecklonii
Zygodon dixonii
Zygodon erosus
Zygodon intermedius
Zygodon leptobolax
Zygodon trichomitrius

42A Rhabdoweisiaceae
Rhabdoweisia crispata
Rhabdoweisia fugax

44. Racopilaceae
Racopilum capense

45. Fontinalaceae
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa

47. Hedwigiaceae
Braunia secunda
Hedwigia ciliata
Hedwigidium integrifolium

48. Cryphaeaceae
Cryphaea exigua

49. Leucodontaceae
Leucodon assimilis

Pterogonium gracile
53. Prionodontaceae
Prionodon densus
55. Trachypodaceae
Trachypodopsis serrulata
Trachypus bicolor *var.* viridulus
57. Pterobryaceae
Calyptothecium acutifolium
Calyptothecium hoehnelii
Jaegerina stolonifera
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Pterobryopsis rehmannii
58. Meteoriaceae
Aerobryopsis capensis
Floribundaria floribunda
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense
58A. Leptodontaceae
Forsstroemia producta
Leptodon smithii
60. Neckeraceae
Neckera valentiniana
60A. Thamnobryaceae
Pinnatella minuta
Porothamnium stipitatum
Porotrichum elongatum
Porotrichum madagassum
Porotrichum usagarum
65. Hookeriaceae
Callicostella tristis
Calyptrochaeta asplenioides
Cyclodictyon vallisgratiae
Distichophyllum mniifolium *var.* mniifolium
Distichophyllum mniifolium *var.* taylorii
Hookeriopsis pappeana
Hypopterygium laricinum
Lepidopilidium hanningtonii
Lopidium pennaeforme
70. Fabroniaceae
Dimerodontium africanum
Fabronia eckloniana
Fabronia gueinzii
Fabronia leikipiae
Fabronia perciliata
Fabronia pilifera
Fabronia rehmannii
Fabronia victoriae
Fabronia wageri
Helicodontium lanceolatum
Leptoischyrodon congoanus
70A. Stereophyllaceae
Entodontopsis nitens
Stereophyllum radiculosum
Stereophyllum woodii
71. Leskeaceae
Haplocladium angustifolium
Herpetineuron toccoae
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Lindbergia haplocladioides
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Lindbergia viridis
Pseudoleskea chilensis
Pseudoleskeopsis claviramea
Pseudoleskea leskeoides
Pseudoleskeopsis pseudoattenuata
72. Thuidiaceae
Abietinella abietina
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Haplohymenium pseudotriste
Rauiella praelonga
Thuidium matarumense
72B. Rigodiaceae
Rigodium toxarion
73. Amblystegiaceae
Campyliadelphus polygamus
Cratoneuron filicinum
Drepanocladus aduncus
Drepanocladus sendtneri
Leptodictyum riparium
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Sanionia uncinata

Vittia pachyloma

74. Brachytheciaceae
    - Brachythecium implicatum
    - Brachythecium pinnatum
    - Brachythecium plumosum
    - Brachythecium populeum
    - Brachythecium pseudopopuleum
    - Brachythecium pseudovelutinum
    - Brachythecium salebrosum
    - Brachythecium subrutabulum
    - Oxyrrhynchium confervoideum
    - Oxyrrhynchium subasperum
    - Palamocladium leskeoides
    - Rhynchostegium brachypterum
    - Rhynchostegiella holstii
    - Rhynchostegium raphidorrhynchum
    - Rhynchostegium subbrachypterum
    - Rhynchostegiella sublaevipes
    - Rhynchostegiella zeyheri
75. Entodontaceae
    - Entodon cymbifolius
    - Entodon geminidens
    - Entodon macropodus
    - Entodon natalensis
    - Erythrodontium subjulaceum
    - Levierella perserrata
    - Trachyphyllum gastrodes
76. Plagiotheciaceae
    - Plagiothecium membranosulum
    - Plagiothecium rhynchostegioides

76A. Catagoniaceae
- Catagonium nitens *subsb.* maritimum

77. Sematophyllaceae
    - Meiothecium fuscescens
    - Rhacopilopsis flexilis
    - Rhacopilopsis transvaaliensis
    - Sematophyllum brachycarpum
    - Sematophyllum dregei
    - Sematophyllum gueinzii
    - Sematophyllum sphaeropyxis
    - Sematophyllum subpinnatum
    - Sematophyllum wageri
    - Sematophyllum zuluense
    - Trichosteleum perchlorosum
    - Wijkia trichocolea
78. Hypnaceae
    - Chrysohypnum cavifolium
    - Ectropothecium brachycarpum
    - Ectropothecium perrotii
    - Ectropothecium regulare
    - Hypnum cupressiforme
    - Hypnum macrogynum
    - Isopterygium leucophanes
    - Isopterygium leucopsis
    - Isopterygium punctulatum
    - Isopterygium taxithelioides
    - Isopterygium taylorii
    - Mittenothamnium ctenidioides
    - Mittenothamnium horridulum
    - Mittenothamnium patens
    - Mittenothamnium pseudoreptans
    - Mittenothamnium reptans
    - Vesicularia galerulata
83. Polytrichaceae
    - Atrichum androgynum
    - Oligotrichum afrolaevigatum
    - Oligotrichum capense
    - Oligotrichum tetragonum
    - Oligotrichum wageri
    - Pogonatum borgenii
    - Pogonatum capense
    - Pogonatum oligodus
    - Polytrichastrum formosum
    - Polytrichum commune
    - Polytrichum subformosum

Appendix III,3. Composition of the Eastern Highlands Element or element 2/1 (2nd level of TWINSPAN 3+ division, group 1)

3. Fissidentaceae
    - Fissidens curvatus
    - Fissidens hoegii
    - Fissidens microandrogynus
    - Fissidens parvilimbatus
4. Archidiaceae
    - Archidium microthecium

8. Dicranaceae
 Cladophascum gymnomitrioides
 Trematodon mayottensis
13. Encalyptaceae
 Encalypta ciliata
 Encalypta vulgaris
14. Pottiaceae
 Bryoerythrophyllum recurvirostrum
 Didymodon ceratodonteus
 Didymodon jackvancei
 Didymodon tophaceopsis
 Didymodon trivialis
 Microbryum davallianum *var.* conicum
 Pseudocrossidium replicatum
 Pterygoneurum macleanum
 Syntrichia ammonsiana
 Timmiella pelindaba
 Tortella fragilis
 Trichostomum brachydontium
 Weissia dieterleniae
15. Grimmiaceae
 Grimmia ovalis
 Schistidium apocarpum
18. Ephemeraceae
 Ephemerum rehmannii
19. Funariaceae
 Funaria bergiana
 Funaria hygrometrica
 Funaria rhomboidea
 Funaria rottleri
 Funaria spathulata
 Funaria succuleata
 Physcomitrium spathulatum *var.* sessile
24. Bryaceae
 Anomobryum drakensbergense
 Bryum alpinum
 Bryum argenteum
 Bryum cellulare
 Bryum pycnophyllum
 Bryum turbinatum
37. Bartramiaceae
 Anacolia breutelii
 Bartramia hampeana
 Philonotis globosa
41. Ptychomitriaceae
 Ptychomitriopsis aloinoides
 Ptychomitrium cucullatifolium
 Ptychomitrium diexaratum
42. Orthotrichaceae
 Orthotrichum oreophilum
 Orthotrichum rupestre
70. Fabroniaceae
 Fabronia abyssinica

Appendix III,4. Composition of the Cape Element or element 2/2 (2nd level of TWINSPAN 3+ division, group 2)

1. Sphagnaceae
 Sphagnum perichaetiale
 Sphagnum violascens
2. Andreaeaceae
 Andreaea bistatosa
 Andreaea rupestris
 Andreaea subulata
3. Fissidentaceae
 Fissidens fasciculatus
 Fissidens marginatus
 Fissidens pygmaeus
 Fissidens rufescens
4. Archidiaceae
 Archidium amplexicaule
 Archidium capense
 Archidium dinteri
 Archidium ohioense
 Archidium rehmannii
5. Ditrichaceae
 Pleuridium ecklonii
 Pleuridium nervosum
 Pleuridium papillosum
 Pleuridium pappeanum
8. Dicranaceae
 Bruchia brevipes
 Bruchia queenslandica
 Campylopus hildebrandtii
 Platyneurum praealtum
 Dicranella rigida
 Leucoloma sprengelianum

12. Calymperaceae
    Hypodontium pomiforme
14. Pottiaceae
    Aloina bifrons
    Acaulon recurvatum
    Acaulon leucochaete
    Crossidium spiralifolium
    Didymodon australasiae
    Didymodon xanthocarpus
    Hennediella longipedunculata
    Microcrossidium apiculatum
    Microbryum rufochaete
    Microbryum subplanomarginatum
    Phascum peraristatum
    Pottia namaquensis
    Pseudocrossidium crinitum
    Pseudocrossidium hornschuchianum
    Syntrichia austroafricana
    Syntrichia chisosa
    Syntrichia princeps
    Syntrichia ruralis
    Tetrapterum tetragonum
    Tortula atrovirens
    Tortula muralis
    Tortula splachnoides
    Trichostomum unguiculatum
    Triquetrella tristicha
14A. Bryobartramiaceae
    Bryobartramia novaevalesiae
15. Grimmiaceae
    Grimmia laevigata
    Grimmia pulvinata
    Leucoperichaetium eremophilum
    Racomitrium crispulum
    Racomitrium lamprocarpum
    Racomitrium lanuginosum
16. Gigaspermaceae
    Chamaebryum pottioides
    Gigaspermum repens
18. Ephemeraceae
    Ephemerum namaquense
19. Funariaceae
    Cygnicollum immersum
    Funaria clavata
    Goniomitrium africanum
24. Bryaceae
    Brachymenium dicranoides
    Bryum alpinum
    Bryum canariense
    Bryum radiculosum
    Bryum torquescens
    Pohlia nutans
32. Rhizogoniaceae
    Pyrrhobryum vallisgratiae
34. Aulacomniaceae
    Leptotheca gaudichaudii
37. Bartramiaceae
    Bartramia compacta *var.* compacta
    Bartramia compacta *var.* macowaniana
    Breutelia substricta
41. Ptychomitriaceae
    Ptychomitrium crassinervium
42. Orthotrichaceae
    Orthotrichum diaphanum
    Orthotrichum incurvomarginatum
    Orthotrichum subexsertum
    Zygodon runcinatus
45A. Wardiaceae
    Wardia hygrometrica
47. Hedwigiaceae
    Rhacocarpus purpurascens
70. Fabroniaceae
    Fabronia abyssinica
    Fabronia breutelii
    Ischyrodon lepturus
78. Hypnaceae
    Isopterygium strangulatum
83. Polytrichaceae
    Polytrichum juniperinum
    Polytrichum piliferum

Appendix III,5. Composition of the Afromontane Grassland Element or element 2/3 (2nd level of TWINSPAN 3+ division, group 3)

1. Sphagnaceae
   - Sphagnum pycnocladulum
   - Sphagnum truncatum
2. Fissidentaceae
   - Fissidens bryoides
   - Fissidens plumosus
5. Ditrichaceae
   - Ceratodon purpureus *subsb.* stenocarpus
   - Distichium capillaceum
   - Ditrichum difficile
8. Dicranaceae
   - Aongstroemiopsis julacea
   - Campylopus atroluteus
   - Campylopus introflexus
   - Campylopus pilifer
   - Dicranella cardotii
   - Trematodon intermedius
   - Trematodon longicollis
   - Trematodon pillansii
12. Calymperaceae
   - Hypodontium dregei
14. Pottiaceae
   - Anoectangium wilmsianum
   - Barbula bolleana
   - Barbula microcalycina
   - Chenia leptophylla
   - Gymnostomum aeruginosum
   - Gymnostomum bewsii
   - Hymenostylium recurvirostrum
   - Pseudocrossidium porphyreoneurum
   - Syntrichia fragilis
   - Syntrichia pagorum
   - Syntrichia papillosa
   - Tortella xanthocarpa
   - Trichostomum tenuirostre
   - Weissia controversa
   - Weissia latiuscula
16. Gigaspermaceae
   - Oedipodiella australis
19. Funariaceae
   - Funaria urceolata
24. Bryaceae
   - Brachymenium acuminatum
   - Bryum apiculatum
   - Bryum caespiticium
   - Bryum capillare
   - Bryum dichotomum
   - Bryum pseudotriquetrum
   - Mielichhoferia bryoides
   - Pohlia cruda
   - Pohlia elongata
26. Mniaceae
   - Plagiomnium rhynchophorum *var.* reidii
37. Bartramiaceae
   - Philonotis dregeana
   - Philonotis falcata
   - Philonotis scabrifolia
41. Ptychomitriaceae
   - Ptychomitrium crispatum
   - Ptychomitrium depressum
   - Ptychomitrium subcrispatum
42. Orthotrichaceae
   - Orthotrichum transvaalense
58A. Leptodontaceae
   - Leptodon smithii
65. Hookeriaceae
   - Calyptrochaeta asplenioides
70. Fabroniaceae
   - Fabronia pilifera
71. Leskeaceae
   - Lindbergia patentifolia
   - Lindbergia pseudoleskeoides
   - Pseudoleskeopsis claviramea
   - Pseudoleskeopsis pseudoattenuata
74. Brachytheciaceae
   - Brachythecium subrutabulum
75. Entodontaceae
   - Entodon natalensis
76. Plagiotheciaceae
   - Plagiothecium membranosulum
   - Plagiothecium rhynchostegioides
78. Hypnaceae
   - Hypnum cupressiforme

Isopterygium punctulatum

Appendix III,6. Composition of the Afromontane Forest Element or element 2/4 (2nd level of TWINSPAN 3+ division, group 4)

1. Sphagnaceae
   - Sphagnum capense
   - Sphagnum fimbriatum
   - Sphagnum strictum *subsp.* pappeanum
2. Andreaeaceae
   - Andreaea nitida
3. Fissidentaceae
   - Fissidens aciphyllus
   - Fissidens asplenioides
   - Fissidens borgenii
   - Fissidens capriviensis
   - Fissidens enervis
   - Fissidens erosulus
   - Fissidens gladiolus
   - Fissidens glaucescens
   - Fissidens palmifolius
   - Fissidens porrectus
   - Fissidens pseudoserratus
   - Fissidens scleromitrius
   - Fissidens simii
   - Fissidens splachnifolius
   - Fissidens stellenboschianus
   - Fissidens submarginatus
   - Fissidens subobtusatus
   - Fissidens usambaricus
   - Fissidens wageri
4. Archidiaceae
   - Archidium acanthophyllum
   - Archidium andersonianum
   - Archidium julicaule
   - Archidium muelleranum
   - Archidium subulatum
5. Ditrichaceae
   - Astomiopsis amblyocalyx
   - Cheilothela chilensis
   - Ditrichum brachypodum
   - Ditrichum punctulatum
   - Ditrichum strictum
   - Eccremidium exiguum
   - Saelania glaucescens
   - Tristichium mirabile
7. Seligeriaceae
   - Blindia magellanica
8. Dicranaceae
   - Aongstroemia filiformis
   - Aongstroemia julacea
   - Bruchia eckloniana
   - Campylopus aureonitens
   - Campylopus bicolor
   - Campylopus cambouei
   - Campylopus catarractilis
   - Campylopus flaccidus
   - Campylopus fragilis
   - Campylopus hensii
   - Campylopus jamesonii
   - Campylopus julaceus *subsp.* arbogastii
   - Campylopus nanophyllus
   - Campylopus perpusillus
   - Campylopus pyriformis
   - Campylopus robillardei
   - Campylopus savannarum
   - Campylopus stenopelma
   - Dicranella subsubulata
   - Dicranoloma billardieri
   - Dicranoloma entabeniense
   - Holomitrium cylindraceum *var.* cucullatum
   - Leptotrichella minuta
   - Leucobryum acutifolium
   - Leucobryum madagassum
   - Leucobryum rehmannii
   - Leucoloma chrysobasilare
   - Leucoloma rehmannii
   - Leucoloma syrrhopodontioides
   - Oreoweisia erosa
   - Sphaerothecium subchlorophyllosum
   - Trematodon divaricatus
   - Trematodon paradoxus
12. Calymperaceae
   - Calymperes levyanum
   - Calymperes rabenhorstii
   - Calymperes tenerum

Octoblepharum albidum
Syrrhopodon asper
Syrrhopodon gaudichaudii
14. Pottiaceae
Barbula calycina
Barbula eubryum
Barbula indica
Bryoerythrophyllum campylocarpum
Gymnostomum lingulatum
Hyophila baginsensis
Hyophila involuta
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Streptocalypta pulchiretis
Tortella humilis
Tortula bogosica
Weisiopsis plicata
Weissia cucullata
Weissia humicola
18. Ephemeraceae
Ephemerum capense
Ephemerum diversifolium
19. Funariaceae
Funaria limbata
Funaria longicollis
Micropoma niloticum
Physcomitrellopsis africana
Physcomitrium spathulatum *var.* spathulatum
21. Splachnaceae
Tayloria isleana
Tayloria orthodonta
24. Bryaceae
Anomobryum filiforme
Brachymenium leptophyllum
Brachymenium nepalense
Brachymenium pulchrum
Brachymenium systylium
Bryum andicola
Bryum aubertii
Bryum donianum
Bryum erythrocaulon
Bryum subapiculatum
Bryum viridescens
Leptobryum pyriforme
Mielichhoferia subnuda
Orthodontium lineare
Plagiobryum zierii
Pohlia baronii
Rhodobryum commersonii
Rhodobryum keniae
Rhodobryum roseum
Rhodobryum umbraculum
28. Eustichiaceae
Eustichia longirostris
32. Rhizogoniaceae
Pyrrhobryum spiniforme
37. Bartramiaceae
Bartramia aristaria
Bartramia capensis
Breutelia diffracta
Breutelia elliptica
Breutelia microdonta
Breutelia tabularis
Conostomum tetragonum
Philonotis africana
Philonotis comosa
Philonotis hastata
Philonotis vagans
Plagiopus oederianus
Quathlamba debilicostata
40. Erpodiaceae
Aulacopilum trichophyllum
Erpodium beccarii
Erpodium coronatum *subsp.* transvaaliense
Erpodium distichum
Erpodium grossirete
40A. Rhachitheciaceae
Rhachithecium perpusillum
41. Ptychomitriaceae
Ptychomitriopsis africana
Ptychomitrium eurybasis
Ptychomitrium exaratifolium
42. Orthotrichaceae
Amphidium lapponicum
Amphidium tortuosum
Cardotiella secunda
Macrocoma lycopodioides
Macrocoma pulchella

Macrocoma tenue *subsp*. tenue
Macromitrium lebomboense
Macromitrium levatum
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Orthotrichum armatum
Orthotrichum firmum
Schlotheimia ferruginea
Schlotheimia percuspidata
Schlotheimia rufopallens
Stoneobryum mirum
Ulota ecklonii
Zygodon dixonii
Zygodon erosus
Zygodon intermedius
Zygodon leptobolax
Zygodon trichomitrius

42A Rhabdoweisiaceae
Rhabdoweisia crispata
Rhabdoweisia fugax

44. Racopilaceae
Racopilum capense

45. Fontinalaceae
Fontinalis antipyretica var gracilis
Fontinalis squamosa

47. Hedwigiaceae
Braunia secunda
Hedwigia ciliata
Hedwigidium integrifolium

48. Cryphaeaceae
Cryphaea exigua

49. Leucodontaceae
Leucodon assimilis
Pterogonium gracile

53. Prionodontaceae
Prionodon densus

55. Trachypodaceae
Trachypodopsis serrulata
Trachypus bicolor *var*. viridulus

57. Pterobryaceae
Calyptothecium acutifolium
Calyptothecium hoehnelii
Jaegerina stolonifera
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Pterobryopsis rehmannii

58. Meteoriaceae
Aerobryopsis capensis
Floribundaria floribunda
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense

58A. Leptodontaceae
Forsstroemia producta

60. Neckeraceae
Neckera valentiniana

60A. Thamnobryaceae
Pinnatella minuta
Porothamnium stipitatum
Porotrichum elongatum
Porotrichum madagassum
Porotrichum usagarum

65. Hookeriaceae
Callicostella tristis
Cyclodictyon vallisgratiae
Distichophyllum mniifolium *var*. mniifolium
Distichophyllum mniifolium *var*. taylorii
Hookeriopsis pappeana
Hypopterygium laricinum
Lepidopilidium hanningtonii
Lopidium pennaeforme

70. Fabroniaceae
Dimerodontium africanum
Fabronia eckloniana
Fabronia gueinzii
Fabronia leikipiae
Fabronia perciliata
Fabronia rehmannii
Fabronia victoriae
Fabronia wageri
Helicodontium lanceolatum
Leptoischyrodon congoanus

70A. Stereophyllaceae
Entodontopsis nitens
Stereophyllum radiculosum
Stereophyllum woodii

71. Leskeaceae
Haplocladium angustifolium

Herpetineuron toccoae
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Lindbergia haplocladioides
Lindbergia viridis
Pseudoleskea chilensis
Pseudoleskea leskeoides

72. Thuidiaceae
Abietinella abietina
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Haplohymenium pseudotriste
Rauiella praelonga
Thuidium matarumense

72B. Rigodiaceae
Rigodium toxarion

73. Amblystegiaceae
Campyliadelphus polygamus
Cratoneuron filicinum
Drepanocladus aduncus
Drepanocladus sendtneri
Leptodictyum riparium
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Sanionia uncinata
Vittia pachyloma

74. Brachytheciaceae
Brachythecium implicatum
Brachythecium pinnatum
Brachythecium plumosum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Brachythecium salebrosum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Palamocladium leskeoides
Rhynchostegiella holstii
Rhynchostegiella sublaevipes
Rhynchostegiella zeyheri
Rhynchostegium brachypterum
Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum

75. Entodontaceae
Entodon cymbifolius
Entodon geminidens
Entodon macropodus
Erythrodontium subjulaceum
Levierella perserrata
Trachyphyllum gastrodes

76A. Catagoniaceae
Catagonium nitens *ssp* maritimum

77. Sematophyllaceae
Meiothecium fuscescens
Rhacopilopsis flexilis
Rhacopilopsis transvaaliensis
Sematophyllum brachycarpum
Sematophyllum dregei
Sematophyllum gueinzii
Sematophyllum sphaeropyxis
Sematophyllum subpinnatum
Sematophyllum wageri
Sematophyllum zuluense
Trichosteleum perchlorosum
Wijkia trichocolea

78. Hypnaceae
Chrysohypnum cavifolium
Ectropothecium brachycarpum
Ectropothecium perrotii
Ectropothecium regulare
Hypnum macrogynum
Isopterygium leucophanes
Isopterygium leucopsis
Isopterygium taxithelioides
Isopterygium taylorii
Mittenothamnium ctenidioides
Mittenothamnium horridulum
Mittenothamnium patens
Mittenothamnium pseudoreptans
Mittenothamnium reptans
Vesicularia galerulata

83. Polytrichaceae
Atrichum androgynum
Oligotrichum afrolaevigatum
Oligotrichum capense
Oligotrichum tetragonum

Oligotrichum wageri
Pogonatum borgenii
Pogonatum capense
Pogonatum oligodus
Polytrichastrum formosum
Polytrichum commune
Polytrichum subformosum

Appendix III,7. Composition of the Mont Aux Sources Subelement, element 3/1 (3rd level of TWINSPAN 3+ division, group 1)

3. Fissidentaceae
Fissidens curvatus
Fissidens hoegii
8. Dicranaceae
Trematodon mayottensis
13. Encalyptaceae
Encalypta ciliata
Encalypta vulgaris
14. Pottiaceae
Bryoerythrophyllum recurvirostrum
Didymodon ceratodonteus
Didymodon jackvancei
Didymodon tophaceopsis
Didymodon trivialis
Microbryum davallianum *var.* conicum
Pseudocrossidium replicatum
Pterygoneurum macleanum
Timmiella pelindaba
Tortella fragilis
Weissia dieterleniae
15. Grimmiaceae
Grimmia ovalis
18. Ephemeraceae
Ephemerum rehmannii
19. Funariaceae
Funaria bergiana
Funaria rottleri
Funaria spathulata
Funaria succuleata
Physcomitrium spathulatum *var.* sessile
24. Bryaceae
Anomobryum drakensbergense
Bryum alpinum
Bryum turbinatum
37. Bartramiaceae
Anacolia breutelii
Bartramia hampeana
Philonotis globosa
41. Ptychomitriaceae
Ptychomitriopsis aloinoides
Ptychomitrium cucullatifolium
Ptychomitrium diexaratum
42. Orthotrichaceae
Orthotrichum oreophilum
Orthotrichum rupestre
70. Fabroniaceae
Fabronia abyssinica

Appendix III,8. Composition of the Widespread Subelement or element 3/2 (3rd level of TWINSPAN 3+ division, group 2)

3. Fissidentaceae
Fissidens microandrogynus
Fissidens parvilimbatus
4. Archidiaceae
Archidium microthecium
8. Dicranaceae
Cladophascum gymnomitrioides
14. Pottiaceae
Syntrichia ammonsiana
Trichostomum brachydontium
15. Grimmiaceae
Schistidium apocarpum
19. Funariaceae
Funaria hygrometrica
Funaria rhomboidea
24. Bryaceae
Bryum argenteum
Bryum cellulare
Bryum pycnophyllum

Appendix III,9. Composition of the West Coast Subelement or element 3/3 (3rd level of TWINSPAN 3+ division, group 3)

2. Andreaeaceae
   Andreaea bistatosa
3. Fissidentaceae
   Fissidens pygmaeus
   Fissidens rufescens
4. Archidiaceae
   Archidium amplexicaule
   Archidium dinteri
5. Ditrichaceae
   Pleuridium nervosum
   Pleuridium papillosum
   Pleuridium pappeanum
8. Dicranaceae
   Bruchia brevipes
   Bruchia queenslandica
   Platyneurum praealtum
12. Calymperaceae
   Hypodontium pomiforme
14. Pottiaceae
   Aloina bifrons
   Acaulon recurvatum
   Acaulon leucochaete
   Crossidium spiralifolium
   Didymodon australasiae
   Didymodon xanthocarpus
   Hennediella longipedunculata
   Microcrossidium apiculatum
   Microbryum rufochaete
   Microbryum subplanomarginatum
   Phascum peraristatum
   Pottia namaquensis
   Pseudocrossidium crinitum
   Pseudocrossidium hornschuchianum
   Syntrichia austroafricana
   Syntrichia chisosa
   Syntrichia princeps
   Syntrichia ruralis
   Tetrapterum tetragonum
   Tortula atrovirens
   Tortula splachnoides
   Trichostomum unguiculatum
   Triquetrella tristicha
14A. Bryobartramiaceae
   Bryobartramia novaevalesiae
15. Grimmiaceae
   Grimmia laevigata
   Grimmia pulvinata
   Leucoperichaetium eremophilum
16. Gigaspermaceae
   Chamaebryum pottioides
   Gigaspermum repens
18. Ephemeraceae
   Ephemerum namaquense
19. Funariaceae
   Cygnicollum immersum
   Funaria clavata
   Goniomitrium africanum
21. Splachnaceae
   Tayloria isleana
   Tayloria orthodonta
24. Bryaceae
   Brachymenium dicranoides
   Bryum alpinum
   Bryum canariense
   Bryum radiculosum
   Bryum torquescens
37. Bartramiaceae
   Bartramia compacta *var.* compacta
   Bartramia compacta *var.* macowaniana
   Breutelia substricta
41. Ptychomitriaceae
   Ptychomitrium crassinervium
42. Orthotrichaceae
   Orthotrichum diaphanum
   Orthotrichum incurvomarginatum
70. Fabroniaceae
   Fabronia abyssinica
   Fabronia breutelii
   Ischyrodon lepturus

Appendix III,10. Composition of the Boland Subelement or element 3/4 (3rd level of TWINSPAN 3+ division, group 4)

1. Sphagnaceae
   Sphagnum perichaetiale
   Sphagnum violascens
2. Andreaeaceae
   Andreaea rupestris
   Andreaea subulata
3. Fissidentaceae
   Fissidens fasciculatus
   Fissidens marginatus
4. Archidiaceae
   Archidium capense
   Archidium ohioense
   Archidium rehmannii
5. Ditrichaceae
   Pleuridium ecklonii
8. Dicranaceae
   Campylopus hildebrandtii
   Dicranella rigida
   Leucoloma sprengelianum
14. Pottiaceae
   Tortula muralis
15. Grimmiaceae
   Racomitrium crispulum
   Racomitrium lamprocarpum
   Racomitrium lanuginosum
24. Bryaceae
   Pohlia nutans
32. Rhizogoniaceae
   Pyrrhobryum vallisgratiae
34. Aulacomniaceae
   Leptotheca gaudichaudii
42. Orthotrichaceae
   Orthotrichum subexsertum
   Zygodon runcinatus
45A. Wardiaceae
   Wardia hygrometrica
47. Hedwigiaceae
   Rhacocarpus purpurascens
78. Hypnaceae
   Isopterygium strangulatum
83. Polytrichaceae
   Polytrichum juniperinum
   Polytrichum piliferum

Appendix III,11. Composition of the Disjunct Cape Peninsula Subelement or element 3/5 (3rd level of TWINSPAN 3+ division, group 5)

1. Sphagnaceae
   Sphagnum truncatum
2. Fissidentaceae
   Fissidens plumosus
8. Dicranaceae
   Trematodon pillansii
14. Pottiaceae
   Pseudocrossidium porphyreoneurum
   Syntrichia pagorum
   Weissia latiuscula
24. Bryaceae
   Bryum capillare
   Pohlia elongata
70. Fabroniaceae
   Fabronia pilifera
76. Plagiotheciaceae
   Plagiothecium membranosulum
78. Hypnaceae
   Isopterygium punctulatum

Appendix III,12. Composition of the Drakensberg Subelement or element 3/6 (3rd level of TWINSPAN 3+ division, group 6)

1. Sphagnaceae
   Sphagnum pycnocladulum
2. Fissidentaceae
   Fissidens bryoides
5. Ditrichaceae
   Ceratodon purpureus *subsb.* stenocarpus
   Distichium capillaceum
   Ditrichum difficile
8. Dicranaceae
   Aongstroemiopsis julacea
   Campylopus atroluteus

Campylopus introflexus
Campylopus pilifer
Dicranella cardotii
Trematodon intermedius
Trematodon longicollis

12. Calymperaceae
Hypodontium dregei

14. Pottiaceae
Anoectangium wilmsianum
Barbula bolleana
Barbula microcalycina
Chenia leptophylla
Gymnostomum aeruginosum
Gymnostomum bewsii
Hymenostylium recurvirostrum
Syntrichia fragilis
Syntrichia papillosa
Tortella xanthocarpa
Trichostomum tenuirostre
Weissia controversa

16. Gigaspermaceae
Oedipodiella australis

19. Funariaceae
Funaria urceolata

24. Bryaceae
Brachymenium acuminatum
Bryum apiculatum
Bryum caespiticium
Bryum dichotomum
Bryum pseudotriquetrum
Mielichhoferia bryoides
Pohlia cruda

26. Mniaceae
Plagiomnium rhynchophorum *var.* reidii

37. Bartramiaceae
Philonotis dregeana
Philonotis falcata
Philonotis scabrifolia

41. Ptychomitriaceae
Ptychomitrium crispatum
Ptychomitrium depressum
Ptychomitrium subcrispatum

42. Orthotrichaceae
Orthotrichum transvaalense

58A. Leptodontaceae
Leptodon smithii

65. Hookeriaceae
Calyptrochaeta asplenioides

71. Leskeaceae
Lindbergia patentifolia
Lindbergia pseudoleskeoides
Pseudoleskeopsis claviramea
Pseudoleskeopsis pseudoattenuata

74. Brachytheciaceae
Brachythecium subrutabulum

75. Entodontaceae
Entodon natalensis

76. Plagiotheciaceae
Plagiothecium rhynchostegioides

78. Hypnaceae
Hypnum cupressiforme

Appendix III,13. Composition of the Widespread Afromontane Subelement or element 3/7 (3rd level of TWINSPAN 3+ division, group 7)

1. Sphagnaceae
Sphagnum capense
Sphagnum strictum *subsp.* pappeanum

3. Fissidentaceae
Fissidens borgenii
Fissidens glaucescens
Fissidens palmifolius

4. Archidiaceae
Archidium acanthophyllum

8. Dicranaceae
Campylopus perpusillus
Campylopus pyriformis
Campylopus robillardei
Campylopus stenopelma
Dicranella subsubulata
Dicranoloma billardieri
Leptotrichella minuta

14. Pottiaceae
Barbula indica
Bryoerythrophyllum campylocarpum
Tortella humilis

19. Funariaceae
    Funaria limbata
    Physcomitrium spathulatum *var.* spathulatum
24. Bryaceae
    Anomobryum filiforme
    Bryum erythrocaulon
    Orthodontium lineare
37. Bartramiaceae
    Bartramia capensis
    Breutelia microdonta
    Philonotis africana
    Philonotis hastata
40. Erpodiaceae
    Erpodium coronatum subsp. transvaaliense
42. Orthotrichaceae
    Macrocoma lycopodioides
    Macrocoma tenue *subsp.* tenue
    Schlotheimia rufopallens
    Zygodon trichomitrius
47. Hedwigiaceae
    Braunia secunda
    Hedwigia ciliata
    Hedwigidium integrifolium
49. Leucodontaceae
    Leucodon assimilis
65. Hookeriaceae
    Hookeriopsis pappeana
70. Fabroniaceae
    Fabronia gueinzii
    Fabronia rehmannii
71. Leskeaceae
    Lindbergia viridis
    Pseudoleskea leskeoides
72. Thuidiaceae
    Thuidium matarumense
73. Amblystegiaceae
    Leptodictyum riparium
74. Brachytheciaceae
    Brachythecium implicatum
    Rhynchostegiella zeyheri
    Rhynchostegium brachypterum
76A. Catagoniaceae
    Catagonium nitens *ssp* maritimum
77. Sematophyllaceae
    Sematophyllum brachycarpum
    Sematophyllum dregei
    Sematophyllum gueinzii
83. Polytrichaceae
    Polytrichum commune

Appendix III,14. Composition of the Tropical Afromontane Subelement or element 3/8 (3rd level of TWINSPAN 3+ division, group 8)

1. Sphagnaceae
    Sphagnum fimbriatum
2. Andreaeaceae
    Andreaea nitida
3. Fissidentaceae
    Fissidens aciphyllus
    Fissidens asplenioides
    Fissidens capriviensis
    Fissidens enervis
    Fissidens erosulus
    Fissidens gladiolus
    Fissidens porrectus
    Fissidens pseudoserratus
    Fissidens scleromitrius
    Fissidens simii
    Fissidens splachnifolius
    Fissidens stellenboschianus
    Fissidens submarginatus
    Fissidens subobtusatus
    Fissidens usambaricus
    Fissidens wageri
4. Archidiaceae
    Archidium andersonianum
    Archidium julicaule
    Archidium muelleranum
    Archidium subulatum
5. Ditrichaceae
    Astomiopsis amblyocalyx
    Cheilothela chilensis
    Ditrichum brachypodum
    Ditrichum punctulatum
    Ditrichum strictum
    Eccremidium exiguum
    Saelania glaucescens

Tristichium mirabile
7. Seligeriaceae
Blindia magellanica
8. Dicranaceae
Aongstroemia filiformis
Aongstroemia julacea
Bruchia eckloniana
Campylopus aureonitens
Campylopus bicolor
Campylopus cambouei
Campylopus catarractilis
Campylopus flaccidus
Campylopus fragilis
Campylopus hensii
Campylopus jamesonii
Campylopus julaceus *subsp.* arbogastii
Campylopus nanophyllus
Campylopus savannarum
Dicranoloma entabeniense
Holomitrium cylindraceum *var.* cucullatum
Leucobryum acutifolium
Leucobryum madagassum
Leucobryum rehmannii
Leucoloma chrysobasilare
Leucoloma rehmannii
Leucoloma syrrhopodontioides
Oreoweisia erosa
Sphaerothecium subchlorophyllosum
Trematodon divaricatus
Trematodon paradoxus
12. Calymperaceae
Calymperes levyanum
Calymperes rabenhorstii
Calymperes tenerum
Octoblepharum albidum
Syrrhopodon asper
Syrrhopodon gaudichaudii
14. Pottiaceae
Barbula calycina
Barbula eubryum
Gymnostomum lingulatum
Hyophila baginsensis
Hyophila involuta
Leptodontium brachyphyllum
Leptodontium longicaule
Leptodontium viticulosoides
Streptocalypta pulchiretis
Tortula bogosica
Weisiopsis plicata
Weissia cucullata
Weissia humicola
18. Ephemeraceae
Ephemerum capense
Ephemerum diversifolium
19. Funariaceae
Funaria longicollis
Micropoma niloticum
Physcomitrellopsis africana
21. Splachnaceae
Tayloria isleana
Tayloria orthodonta
24. Bryaceae
Brachymenium leptophyllum
Brachymenium nepalense
Brachymenium pulchrum
Brachymenium systylium
Bryum andicola
Bryum aubertii
Bryum donianum
Bryum subapiculatum
Bryum viridescens
Leptobryum pyriforme
Mielichhoferia subnuda
Plagiobryum zierii
Pohlia baronii
Rhodobryum commersonii
Rhodobryum keniae
Rhodobryum roseum
Rhodobryum umbraculum
28. Eustichiaceae
Eustichia longirostris
32. Rhizogoniaceae
Pyrrhobryum spiniforme
37. Bartramiaceae
Bartramia aristaria
Breutelia diffracta
Breutelia elliptica
Breutelia tabularis
Conostomum tetragonum

Philonotis comosa
Philonotis vagans
Plagiopus oederianus
Quathlamba debilicostata

40. Erpodiaceae
Aulacopilum trichophyllum
Erpodium beccarii
Erpodium distichum
Erpodium grossirete

40A. Rhachitheciaceae
Rhachithecium perpusillum

41. Ptychomitriaceae
Ptychomitriopsis africana
Ptychomitrium eurybasis
Ptychomitrium exaratifolium

42. Orthotrichaceae
Amphidium lapponicum
Amphidium tortuosum
Cardotiella secunda
Macrocoma pulchella
Macromitrium lebomboense
Macromitrium levatum
Macromitrium macropelma
Macromitrium richardii
Macromitrium serpens
Orthotrichum armatum
Orthotrichum firmum
Schlotheimia ferruginea
Schlotheimia percuspidata
Stoneobryum mirum
Ulota ecklonii
Zygodon dixonii
Zygodon erosus
Zygodon intermedius
Zygodon leptobolax

42A Rhabdoweisiaceae
Rhabdoweisia crispata
Rhabdoweisia fugax

44. Racopilaceae
Racopilum capense

45. Fontinalaceae
Fontinalis antipyretica *var.* gracilis
Fontinalis squamosa

48. Cryphaeaceae
Cryphaea exigua

49. Leucodontaceae
Pterogonium gracile

53. Prionodontaceae
Prionodon densus

55. Trachypodaceae
Trachypodopsis serrulata
Trachypus bicolor *var.* viridulus

57. Pterobryaceae
Calyptothecium acutifolium
Calyptothecium hoehnelii
Jaegerina stolonifera
Orthostichopsis pinnatella
Orthostichopsis subimbricata
Pterobryopsis rehmannii

58. Meteoriaceae
Aerobryopsis capensis
Floribundaria floribunda
Papillaria africana
Pilotrichella panduraefolia
Squamidium brasiliense

58A. Leptodontaceae
Forsstroemia producta

60. Neckeraceae
Neckera valentiniana

60A. Thamnobryaceae
Pinnatella minuta
Porothamnium stipitatum
Porotrichum elongatum
Porotrichum madagassum
Porotrichum usagarum

65. Hookeriaceae
Callicostella tristis
Cyclodictyon vallisgratiae
Distichophyllum mniifolium *var.* mniifolium
Distichophyllum mniifolium *var.* taylorii
Hypopterygium laricinum
Lepidopilidium hanningtonii
Lopidium pennaeforme

70. Fabroniaceae
Dimerodontium africanum
Fabronia eckloniana
Fabronia leikipiae
Fabronia perciliata
Fabronia victoriae

Fabronia wageri
Helicodontium lanceolatum
Leptoischyrodon congoanus

70A. Stereophyllaceae
Entodontopsis nitens
Stereophyllum radiculosum
Stereophyllum woodii

71. Leskeaceae
Haplocladium angustifolium
Herpetineuron toccoae
Leptoterigynandrum austroalpinum
Leskeella zuluensis
Lindbergia haplocladioides
Pseudoleskea chilensis

72. Thuidiaceae
Abietinella abietina
Cyrtohypnum ramuscolosum
Cyrtohypnum varians
Cyrtohypnum versicolor
Haplohymenium pseudotriste
Rauiella praelonga

72B. Rigodiaceae
Rigodium toxarion

73. Amblystegiaceae
Campyliadelphus polygamus
Cratoneuron filicinum
Drepanocladus aduncus
Drepanocladus sendtneri
Platyhypnidium aquaticum
Platyhypnidium macowanianum
Sanionia uncinata
Vittia pachyloma

74. Brachytheciaceae
Brachythecium pinnatum
Brachythecium plumosum
Brachythecium populeum
Brachythecium pseudopopuleum
Brachythecium pseudovelutinum
Brachythecium salebrosum
Oxyrrhynchium confervoideum
Oxyrrhynchium subasperum
Palamocladium leskeoides
Rhynchostegiella holstii
Rhynchostegiella sublaevipes
Rhynchostegium raphidorrhynchum
Rhynchostegium subbrachypterum

75. Entodontaceae
Entodon cymbifolius
Entodon geminidens
Entodon macropodus
Erythrodontium subjulaceum
Levierella perserrata
Trachyphyllum gastrodes

77. Sematophyllaceae
Meiothecium fuscescens
Rhacopilopsis flexilis
Rhacopilopsis transvaaliensis
Sematophyllum sphaeropyxis
Sematophyllum subpinnatum
Sematophyllum wageri
Sematophyllum zuluense
Trichosteleum perchlorosum
Wijkia trichocolea

78. Hypnaceae
Chrysohypnum cavifolium
Ectropothecium brachycarpum
Ectropothecium perrotii
Ectropothecium regulare
Hypnum macrogynum
Isopterygium leucophanes
Isopterygium leucopsis
Isopterygium taxithelioides
Isopterygium taylorii
Mittenothamnium ctenidioides
Mittenothamnium horridulum
Mittenothamnium patens
Mittenothamnium pseudoreptans
Mittenothamnium reptans
Vesicularia galerulata

83. Polytrichaceae
Atrichum androgynum
Oligotrichum afrolaevigatum
Oligotrichum capense
Oligotrichum tetragonum
Oligotrichum wageri
Pogonatum borgenii
Pogonatum capense
Pogonatum oligodus

Polytrichastrum formosum
Polytrichum subformosum