AN ANALYSIS OF THE FLORA OF SOUTHERN AFRICA: ITS CHARACTERISTICS, RELATIONSHIPS, AND ORIGINS[1,2]

PETER GOLDBLATT[3]

ABSTRACT

Southern Africa, including Namibia (South West Africa), South Africa, Lesotho, Swaziland, and Botswana, covers an area of ca. 2.5 million km². The flora comprises ca. 18,500 species in 1,930 genera. There are 10 endemic families, while 80% of the species and 29% of the genera are endemic. Of the five phytogeographic regions recognized, the Cape Floristic Region is the richest and most distinctive, and in this small area there are some 8,550 species in 957 genera. Most of the subcontinent is arid to semiarid. Its rich and diverse flora, contrasting with the relatively depauperate tropical African flora, is believed to have evolved gradually since the early to mid-Tertiary at the southern edge of the tropics as Africa became progressively drier, partly from an ancient southern African temperate flora and partly from a tropical African forest flora. The large number of species in the Cape Region and adjacent arid areas probably evolved recently in the last 1–2 million years as the climate fluctuated violently during the Pleistocene. Peculiarities of the flora include an unusually high proportion of petaloid monocots, a wealth of succulents, mainly in winter rainfall arid areas, large numbers of sclerophyllous to microphyllous shrubs, and very few annuals.

The first major collections of plants from southern Africa began to arrive in Europe in the late seventeenth and early eighteenth century at the time when Linnaeus was formulating his principles of plant classification and nomenclature. These first examples caused great excitement in the scientific community, for many of them were remarkably different from anything known at the time: the first Proteaceae, Restionaceae, Cunoniaceae, and Bruniaceae, to mention a few families, as well great numbers of succulents and geophytic plants which were then and still are greatly sought after in the horticultural world.

Such was the interest stimulated by these plants that southern Africa was one of the first areas outside the European sphere to be explored botanically, Linnaeus's most famous pupil Thunberg being sent there in 1765 for several years. Little did the botanists of northern Europe realize that the source of these amazing plants was entirely unrepresentative of the African flora as a whole. In fact, almost all the early plants were collected in or near the Dutch settlement of Cape Town at the southwestern tip of the continent. It was not until the early nineteenth century that exploring naturalists moving north across the semidesert Karoo, and eastwards, encountered the rolling savanna plains, with both the plants and animals we now associate with Africa generally.

The area where these first southern African plants were found is now known botanically as the Cape Floristic Region, often regarded as one of only six

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[3] B. A. Krukoff Curator of African Botany, Missouri Botanical Garden, 2345 Tower Grove Avenue, St. Louis, Missouri 63110.

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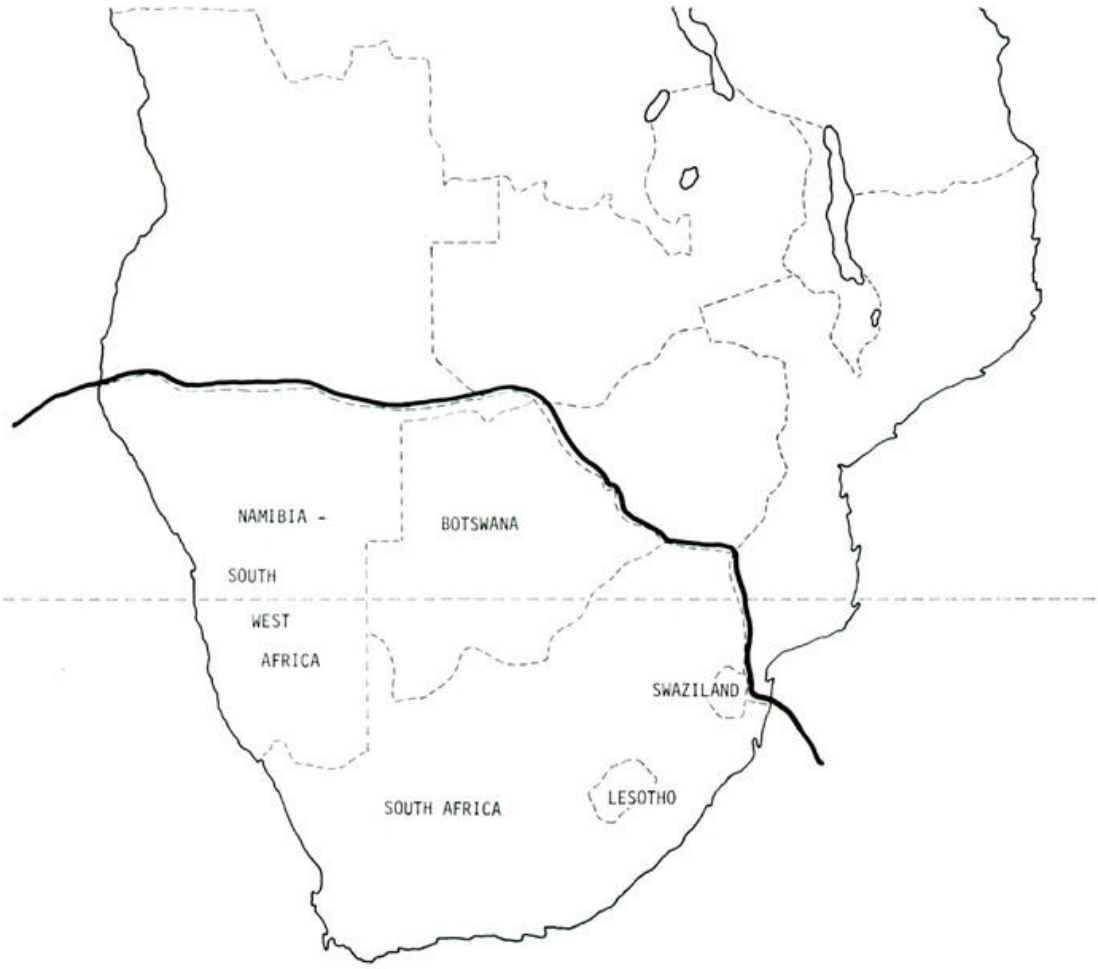

Figure 1. Southern Africa as treated in this paper includes the entire area below the heavy line, with the countries South Africa, Botswana, Lesotho, Swaziland, and Namibia (South West Africa).

Floral Kingdoms in the world (Good, 1974; Takhtajan, 1969). Though small in area, less than 4% of the total land surface of southern Africa as treated here, the flora of this region has come to exemplify in most minds that of southern Africa. The Cape Floristic Region, with its many remarkable and unique characteristics, is analyzed in particular detail in the following pages, with less attention being devoted to the other floristic regions of southern Africa.

Geographical Limits

Southern Africa in this analysis includes the countries of South Africa, Lesotho, Swaziland, Namibia (South West Africa), and Botswana to the north (Fig. 1). This encompasses an area of some 2.5 million km^2, complementing Brenan's delimitation of tropical Africa (this symposium). Ideally we wished to define tropical and southern Africa in phytogeographic or climatic terms, but almost all of the available botanical data are based on political boundaries, and we have found it practical to accept this situation. Perhaps a third of this total

TABLE 1. Comparison of native genera and species of vascular plants of various regions.

Region	Area $10^3 \times km^2$	Genera	Endemic Genera	Species	Endemic Species
Southern Africa	2,573	1,930	560(29.0%)	18,532	14,850(80.3%)
Cape Floristic Region	89	957	198(20.7%)	8,550	6,252(73.1%)
Cape Peninsula[a]	0.47	533	1 (0.2%)	2,256	157 (7.0%)
Natal[b]	91	1,238	?	4,826	?
Namibia[c]	827	910	22 (2.4%)	3,210	?
Australia[d]	7,716	?	?	15,000[g]	85%
Gray's Manual Area[a] (Eastern North America)	3,238	849	6 (0.%7)	4,425	599(13.5%)
Europe[e] (*Flora Europaea*)	10,000	1,340	?	10,500	3,500 (33%)
California Floristic Province[a]	324	795	50 (6.3%)	4,452	2,125(47.7%)
British Isles[a]	308	545	0 (0%)	1,443	17 (1.2%)
New Zealand[a]	268	393	39 (9.9%)	1,996	1,618(81.1%)
Hawaii[a]	16.6	253	31(12.3%)	1,897	1,751(92.3%)
Carolinas[a]	217	819	1 (0.1%)	2,995	23 (0.8%)
Sonoran Desert[a]	310	746	20 (2.7%)	2,441	650(26.6%)
Guatemala[a]	109	1,799	?	7,817	?
West Tropical Africa[f]	4,500	1,742	?	7,500	(ca. 37%)

[a] Data from Raven & Axelrod (1978) who give additional comparative information.
[b] Ross (1973), including introduced species.
[c] Merxmüller (1971 and pers. comm.); data on endemic genera are added by myself.
[d] Specht et al. (1974).
[e] Webb (1978), based on estimates of native genera and species.
[f] Data from Hepper (1971).
[g] Ride (1978) estimates ca. 25,000 species for Australia.

area, including a considerable portion of Namibia and Botswana, as well as a small segment of the South African province of the Transvaal, lies north of the tropic of Capricorn. Nevertheless, as the following pages will show, southern Africa, though floristically heterogeneous, shares few species with tropical Africa and does form a convenient geographic unit so that it can be considered the south temperate element of the African flora.

NUMBERS OF GENERA AND SPECIES

The native flora of southern Africa, including Pteridophytes and Gymnosperms, comprises some 226 families and 1,930 genera with 18,532 species (Table 1). Endemism is relatively high, with 10 families, including the gymnosperm Stangeriaceae and the dicotyledonous Achariaceae, Greyiaceae, Bruniaceae, Penaeaceae, Stilbaceae, Grubbiaceae, Roridulaceae, Retziaceae, and Geissolomataceae (Table 3). The latter six are exclusive to the Cape Region, the Bruniaceae predominantly so, and the three remaining are centered to the east also in mesic conditions.

Of the 1,930 genera, 559 or 29% are endemic and no less than 14,850 or 80.3% of 18,532 species are endemic. These figures indicate even more strongly than the lines limiting phytogeographic zones (Fig. 2) that the southern African flora is remarkably distinct. Much of the richness lies in the Cape Region where there are 8,550 species of which 73%, or 6,252 species, are endemic. This area includes only ca. 89,000 km^2, or less than 4% of the total region under consideration. Excluding the Cape Floristic Region, southern Africa is thus floristically

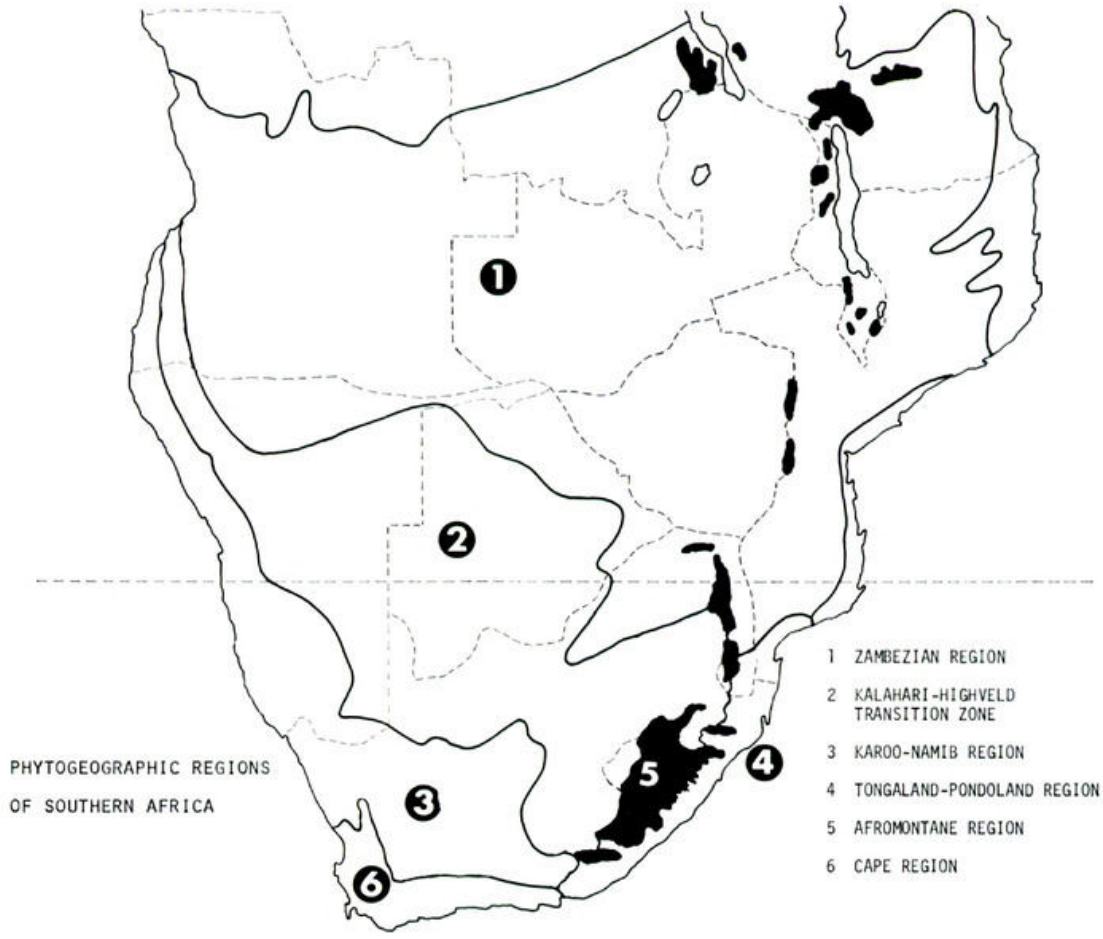

FIGURE 2. Phytogeographic regions of southern Africa following White (1976a, 1976b, 1978), with some changes to the Cape Region.

much poorer although in area barely reduced. Southern Africa, even excluding the Cape, is still rich with some 1,732 genera and 12,280 species occurring outside the Cape Region. This figure is clearly high when compared with that characteristic of the adjacent tropical *Flora Zambeziaca* area (Zambia, Malawi, Mozambique, Rhodesia, and Botswana) of some 2.6 million km², with an estimated 6,000 species (Exell, 1971). It even exceeds the total for Zaïre, Burundi, and Rwanda, an area with about 10,000 species and an estimated 33% endemism in 2.3 million km² (Brenan, this symposium) in a region with a rich tropical flora, and it is far richer than west tropical Africa (Hepper, 1971) which has an estimated 7,500 species in 4.5 million km².

REFERENCES AND SOURCES

Prime sources of the data treated here are firstly *Flora Capensis* (Harvey & Sonder, 1859–1865; Thiselton-Dyer, 1896–1933) produced over the years 1860–1925, a flora treating all temperate South Africa which included some 11,705 species. The flora is now being replaced by the *Flora of Southern Africa* (Codd et al., 1963–), the first volume of which appeared in 1963, but as only a few

families have been treated, *Flora Capensis* and the numerous generic monographs and revisions subsequently published have provided most information. There are in addition five modern regional floras for southern Africa, *Prodromus Einer Flora von Südwestafrika* (Merxmüller, 1966–1972) for Namibia, *The Flora of Natal* (Ross, 1972), *Flora of Lesotho* (Jacot-Guillarmod, 1971), *The Flora of Swaziland* (Compton, 1976) and *Flora of the Cape Peninsula* (Adamson & Salter, 1950).

Most problems were encountered in dealing adequately with families or genera not revised since their treatment in one of the early volumes of *Flora Capensis*, as subsequent changes have often been extensive and the early volumes give little distributional data. In many cases I have had to refer to herbarium collections, mainly in South Africa, and to consult authorities for some groups. In particular the following provided the most up to date information, often not yet in print (which will explain certain conflicts with published data): J. P. Rourke (Proteaceae, Stilbaceae); I. Williams (Rutaceae—Diosmeae); E. Esterhuysen (Restionaceae—some 45 undescribed species are taken into account); E. A. Schelpe (Orchidaceae and Pteridophytes); E. G. Oliver (Ericaceae); B. Bayer (*Gasteria*, *Haworthia*, succulent Asclepidaceae); H. Glen (Mesembryanthemoideae in general, especially *Lampranthus*, *Disphyma*, *Gibbaeum*); L. E. Codd (Labiatae); A. A. (Mauve) Obermeyer (*Ornithogalum*, Juncaceae); H. Tölken (Crassulaceae); R. M. Polhill (Papilionoideae in general, *Crotalaria*); M. Thompson (Hypoxidaceae); B. Nordenstam (Compositae generally, *Helipterum*, *Othonna*, Senecioneae, also Liliaceae—*Wurmbea*, *Ornithoglossum*); A. J. M. Leeuwenberg (Loganiaceae); D. Wiens (Loranthaceae); O. Leistner (Malvaceae); A. Rommel (*Amellus*); L. Leach (Asclepiadaceae—Stapelieae, succulent Euphorbias); T. Norlindh (Arctoteae and *Garuleum*); H. E. Wanntorp (*Microloma*); O. M. Hilliard (*Helichrysum*, Drakensberg Flora); H. Rasmussen (*Knowltonia*). Data for Iridaceae were compiled by myself and also include unpublished information.

The families recognized for this work (Appendix 1) are those currently accepted by the Kew Herbarium with minor exceptions. *Retzia* is not included in Solanaceae, but placed in its own family (Dahlgren, 1975; Goldblatt & Keating, 1976) while *Dracaena* remains in Liliaceae and *Heteropyxis* is included in Myrtaceae. The Pteridophytes are treated following Schelpe's (1969) scheme of families and genera. The families of seed plants are listed in Appendix 1 with numbers of genera, species, and endemics. Genera are those admitted by Dyer (1975, 1976) in his revised edition of *The Genera of Southern African Flowering Plants*, with important exceptions listed below. Aizoaceae—genera synonymized by Friedrich (1970), Hartmann (1976), Poppendieck (1976) and Ihlenfeldt & Jörgensen (1973) are not recognized. Liliaceae—minor changes are made with *Poellnitzia* accorded recognition and revisions by Jessop (1970, 1972, 1977) are followed. Restionaceae—following recommendations by Johnson & Evans (1966), Cutler (1969), and Johnson & Briggs (1975, 1978), Gilg-Benedict's (1930) treatment of *Leptocarpus* and *Hypolaena* as exclusively Australasian (the South African species assigned to *Mastersiella* and *Calopsis*) and *Restio* as exclusively African (and Madagascan) is followed. Thus no genera

of Restionaceae are common to Africa and Australia. Cyperaceae—following the arrangement in the Kew Herbarium (after Kükenthal, 1935), *Cyperus* includes *Pycreus*, *Juncellus* and *Mariscus*, while *Schoenoxiphium* is accorded recognition and not placed in *Kobresia*. Compositae—this is much emended including modifications recently published (Nordenstam, 1975, 1976, and in press; Bremer, 1976a, 1976b; Hilliard, 1977; Grau, in press). Campanulaceae—following Thulin (1974, 1975), *Wahlenbergia* includes *Cephalostigma* and *Lightfootia*, while the genus *Unigenes* (Wimmer, 1953) is admitted. Other minor changes made following recent revisions will not be mentioned in detail.

The data in this paper thus constitute a critical compilation assembled from numerous sources and are the only modern presentation of information of this type for southern Africa. Dyer (1975, 1976) provides estimates of numbers of species, and distributions of genera in his generic flora, but is not critical in this respect, and therefore often misleading. It is also noteworthy that in the most recently published estimate of the flora of southern Africa, Killick (1971, 1976) suggests there are somewhat more than 17,000 species while my data indicate that there are about 18,500 species. The figures are of the same order and as studies continue the number will probably be found to lie somewhere between. Numbers in Aizoaceae particularly, are likely to be considerably reduced as more critical revisions such as those of Hartmann (1976), Poppendieck (1976), Ihlenfeld & Jörgensen (1973) appear. There are, however, many species undescribed in South African herbaria (not all accounted for here), as the 45 in Restionaceae illustrate. Even though southern Africa is relatively well collected, an appreciable number of species are still undiscovered as shown by several recent revisions and articles dealing with the flora.

Vegetation and Phytogeography

Before dealing in more detail with the flora, it is useful to outline some aspects of the vegetation and local phytogeography. There are in fact numerous treatments of the vegetation and its relationships for southern Africa, important works including those of Bolus (1893, 1905), Bews (1925), Pole-Evans (1936), Adamson (1938), and the excellent and detailed work of Acocks (1953). The subject has recently been surveyed in detail by Werger (1978a). Studies relating southern Africa to the continent as a whole are fewer (cf. reviews by Monod [1957] and Werger [1978a]), and of these the recent works of White (Chapman & White, 1970; White, 1976a, 1976b), which have resulted in a revised chorological map of Africa, seem most appropriate in the present context, especially as they are also used by Brenan for tropical Africa (this symposium). White's terminology for phytogeographic zones (Table 2) is followed and, with minor changes in the Cape Floristic Region, also his boundaries for these areas (Fig. 2).

The Cape Region, which forms a major focus in this analysis and is dealt with in great detail, is accordingly defined very closely. While the characteristics of the Cape Flora are generally agreed upon, geographic limits have varied considerably in almost every treatment of note, e.g., Bolus (1905), Pole-Evans (1936), Weimarck (1941), and Taylor (1978). The area here recognized for

TABLE 2. Phytogeographic regions of southern Africa with estimated generic endemism.

Region	Number of Genera
1. Zambezian Region	2
2. Kalahari-Highveld Transition Zone	15
3. Karoo-Namib Region	80 (about 50 Aizoaceae)
4. Tongaland-Pondoland Region	15
5. Afromontane Region	20
6. Cape Region	198

the region is in many ways a compromise, but is based solidly on Acock's definition of the characteristic vegetation type, the fynbos (Fig. 3), and not *primarily* on climate, though it is an area of predominantly winter rainfall.

Some workers have preferred to consider the Cape Flora as the fynbos element only, as this vegetation is the most distinctive and includes the majority of taxa peculiar to the Cape Flora (Oliver, 1977a; Taylor, 1978; White, 1978). Whatever the merits of this position, it is not practical as it prevents simple areal definition with the result that an analysis of the type presented here would be impossible.

Rigid delimitation of White's other phytogeographic zones in southern Africa is very difficult. This is evident in his recognition of the broad Kalahari-Highveld Transition Zone but is also true elsewhere. Definition is difficult in the east between Highveld and Afromontane floras and along the coast between the Tongaland-Pondoland Region and the Afromontane Region. The eastern Cape, a meeting point of four floristic zones, is especially complex and to define this area rigidly without extensive research creates more problems than it solves.

The Cape Region here (Fig. 3) includes all major fynbos areas and extends from Nieuwoudtville in the north, following the eastern slopes of the Cedarberg, and thence east from Karoopoort along the north slope of the Witteberg, Swartberg, Baviaans Kloof, and Groot Winterhoek Mountains, ending at Port Elizabeth. All territory south and west of this line to the coast, containing several other vegetation types, in addition to fynbos, forms the Cape Floristic Region. Simply for convenience a northern limit is drawn at the Olifants River from its mouth to the Giftberg, where it turns south. This specifically excludes small isolated areas of depauperate Cape fynbos north along the west coast of Namaqualand and in the Kamiesberg as well as the western Karoo between Calvinia and Sutherland, i.e., Weimarck's Hantam-Roggeveld subcenter. Also excluded are islands of fynbos in the east on the Groot River Heights and the narrow belt running east–west along the Zuurberg summit in the Albany district, Weimarck's Zuurberg subcenter, which is essentially an area of coastal forest and grassland with a minor fynbos constituent.

FLORISTIC REGIONS

1. *Zambezian Region.*—This region occupies a vast area from southern Zaïre and Tanzania south to Zambia, Angola, Rhodesia and Mozambique to the northern part of Namibia, northeastern Botswana and the northern half of the

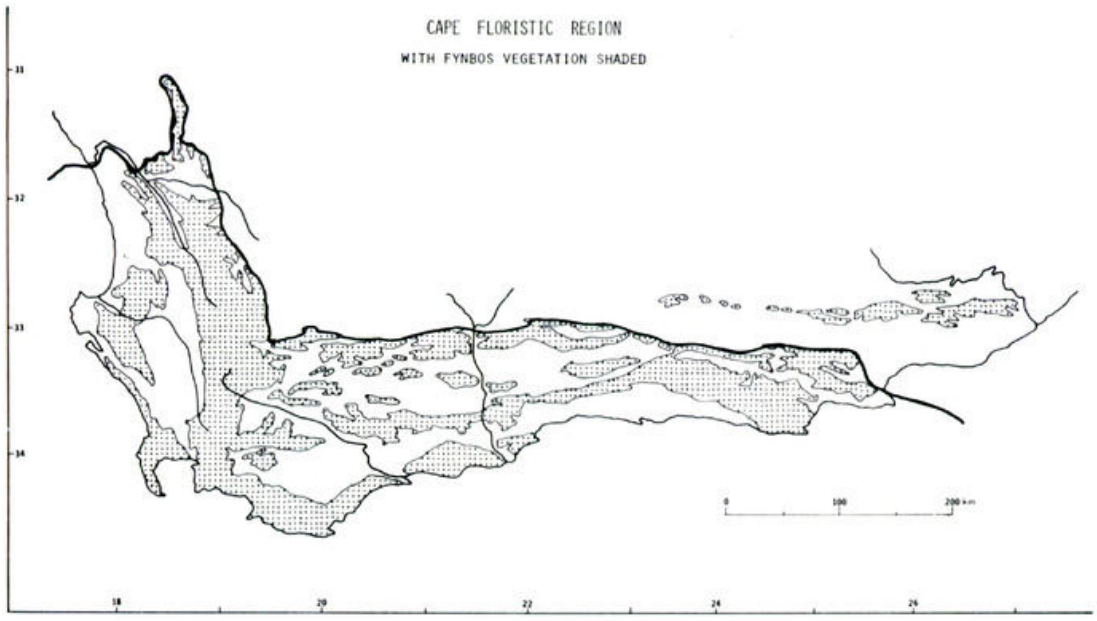

FIGURE 3. The limits of the Cape Floristic Region as defined in this paper. Areas of fynbos type vegetation [Acock's (1953) Macchia, False Macchia, Coastal Macchia and Coastal Renosterbosveld] shaded.

Transvaal. In brief, it is a tropical area of grassland and open woodland, with Gramineae and woody and shrubby Leguminosae very well represented. The southern portion is relatively depauperate and lacks many characteristic elements. In southern Africa there are only two species of the widespread *Brachystegia* and one of *Julbernardia* (both Leguminosae), while *Tamarindus* (Leguminosae), another very typical Zambezian genus, is not recorded. The single record of *Monotes* and of its family Dipterocarpaceae for southern Africa is in northeastern Botswana. There are perhaps only two genera that are clearly endemic in the southern African portion of the Zambezian Region, *Volkiella* (Cyperaceae) and *Mosdenia* (Gramineae), both monotypic (Table 2).

2. *The Kalahari-Highveld Transition Zone.*—Lying south and west of the Zambezian Region, this region is one of transition from the tropical Zambezian to the arid Karoo-Namib Region. This region is essentially grassland with the minor woody element (*Acacia* is notable), mainly of Zambezian species, often very dwarfed by climate or soil. It is almost exclusively southern African (a small segment lies in southern Angola), and it encompasses the relatively well-watered grasslands of the Transvaal and Orange Free State highveld, as well as the lightly wooded but arid grassland of the northern Cape Province, south and central Botswana, and eastern Namibia including the Kalahari Desert. Although the largest phytogeographic region in southern Africa, it is relatively poor in species and has few endemics, exemplifying its transitional nature. An estimated 15 genera, mostly small, are confined to this region, including *Neuradopsis* (Neuradaceae), *Duthieastrum* (Iridaceae), *Psilochloa* and *Tarigidia* (Gramineae), and several Aizoaceae. Werger (1978a, 1978b) prefers to include the southwestern portion of this transitional region, the southern Kalahari, as part

of the Karoo-Namib Region and the remainder as part of the Zambezian Region. This emphasizes the karoid affinities (Werger, 1973) of many of the more characteristic elements of the Kalahari-Highveld Zone.

3. *The Karoo-Namib Region.*—This occupies the interior of the Cape Province and the entire west coast of Namibia as well as Namaqualand (the northwestern part of the Cape Province). Outside southern Africa the region extends into southwestern Angola. It is entirely arid, desert or semidesert, and has a very characteristic flora. The ecology and vegetation of the region are described in detail by Werger (1978b). The region is diverse and Werger recognizes five subregions. In its eastern portion, which has a summer rainfall, the landscape is dominated by small shrubs, mainly Compositae, with grasses well represented. In the west, with predominantly winter rainfall, there is a wealth of succulents of Aizoaceae, Asclepiadaceae, Crassulaceae, Zygophyllaceae, Geraniaceae, Liliaceae, and Compositae that constitute the greatest development of such plants of any arid or desert flora (Compton, 1929). Annuals often appear conspicuous, but except in the Namib Desert, the southern Kalahari (Leistner, 1967)—included in this region by Werger (1978b)—and in disturbed sites, seldom comprise a high proportion of the species present. The region is the center for Aizoaceae—Mesembryanthemoideae, which have radiated extensively along the west coast. As might be expected, endemism is very high both at species and genus level, and at least 80 genera are endemic or centered in the Karoo-Namib of which some 50 belong to Aizoaceae. Restricted to the region but not to southern Africa are such interesting genera as *Welwitschia*, the peculiar relict gymnosperm, and *Adenolobus*, the caesalpinioid legume perhaps related to the Northern Hemisphere *Cercis*.

In the southern part of this region, wherever rainfall is sufficient, there are isolated pockets of Cape Flora. Acocks (1953) has stressed the close relationship of the Cape and Karoo floras, communities of which are in ecotonal balance. Cape elements contribute significantly to the Karoo-Namib flora, while the few woody emergents have tropical affinities, e.g., *Rhigozum* (Bignoniaceae), *Commiphora* (Burseraceae), *Nymania* (Meliaceae), *Erythrophysa* (Sapindaceae), and *Boscia* (Capparaceae).

4. *The Tongaland-Pondoland Region.*—This is a subtropical forest zone, extending along the coast from the eastern Cape Province to extreme southern Mozambique. It is related to the coastal forests of East Africa (Zanzibar-Inhambane Region) and secondarily to the main African tropical rain forest of the Guinea-Congo Region (see detailed survey by Moll & White, 1978). The Tongaland-Pondoland Region is a mosaic of forest and coastal grassland that interfingers with elements of the Afromontane Region bordering it on the west (White, 1976b). There are many endemic species in the region, but perhaps only about 15 endemic genera; the figure of 23 given by Moll & White (1978) seems rather inflated. The endemic genera of the region, though not necessarily of southern Africa as defined here, include *Rhynchocalyx* (Lythraceae), *Jubaeopsis* (Palmae, which is related to the tropical African *Elaeis*), *Pseudosalacia* (Celastraceae), *Mackaya* (Acanthaceae), *Anastrabe* (Scrophulariaceae), *Bachmannia* (Capparaceae), and *Umtiza* (Leguminosae). The cycad *Stangeria*, the

only genus of Stangeriaceae, is restricted to the region, while Achariaceae is centered here though extending southward as far as Knysna. Several more genera such as *Hippobromus* (Sapindaceae), *Loxostylis* (Anacardiaceae), and *Harpephyllum* (Anacardiaceae) have the main part of the range in the region. Many tropical forest elements occurring in southern Africa are virtually restricted to the Tongaland-Pondoland Region, e.g., *Ptaeroxylon* (Ptaeroxylaceae), *Barringtonia* (Lecythidaceae), *Raphia* (Palmae), *Schlecterina* (Passifloraceae), *Xylotheca* (Flacourtiaceae), *Mitriostigma* (Rubiaceae), *Inhambanella* (Sapotaceae), *Cola* (Sterculiaceae), and the few southern African mangroves, e.g., *Avicennia* (Avicenniaceae), *Ceriops*, *Bruguiera*, and *Rhizophora* (Rhizophoraceae), and *Lumnitzera* (Combretaceae).

5. *The Afromontane Region.*—This is not a discrete region but a series of isolated highland areas, mainly along the eastern half of Africa, with its main centers in Ethiopia, East Africa, and eastern South Africa (White, 1978). In southern Africa it is situated around the Drakensberg Mountains, located mainly in Lesotho and western Natal, where high altitude allows development of an alpine flora which has been described in detail by Killick (1978). It extends northward through the eastern Transvaal and southward to the Hogsback area of the eastern Cape Province. There are characteristic forest taxa, but with the Cape forests excluded from the Afromontane Region here, the southern African Afromontane flora is predominantly a grassland, with a rich herbaceous flora. Species endemism is high and there are perhaps as many as 24 genera endemic or strongly centered in the region, including one family, Greyiaceae, and genera such as *Eumorphia* (Compositae), *Rhodohypoxis* (Hypoxidaceae), and *Bowkeria* and *Glumicalyx* (Scrophulariaceae).

Affinities lie with other Afromontane zones outside southern Africa, and the whole region, which is temperate, shows some relationship with Eurasia, e.g., *Festuca* and *Koeleria* (Gramineae), *Trifolium* (Leguminosae), and *Geum* (Rosaceae). There are also affinities with the Cape Region, and many typical Cape genera extend northward in the Afromontane Region to East Africa, e.g., *Cliffortia* (Rosaceae), *Muraltia* (Polygalaceae), and *Euryops* and *Osteospermum* (Compositae), to mention a few prominent examples (see Weimarck, 1941; Hedberg, 1965). However, many of the typical Afromontane taxa in southern Africa are derived from the surrounding lowland flora (Hilliard, pers. comm.; White, 1978), and floristic relationships of the scattered Afromontane areas are as much with adjacent areas as with more distant highlands.

6. *The Cape Region.*—This region occupies a small area at the extreme southwest of the subcontinent, and has a relatively mild, temperate, Mediterranean type climate. Rainfall is predominantly or entirely in the winter, but the eastern part also receives substantial summer rain. The characteristic vegetation is maquislike (the fynbos) with numerous shrubs or small trees with sclerophyllous or ericoid leaves. The ecology and vegetation of the area has been dealt with extensively by Taylor (1978). The Cape Region as defined here also includes a substantial temperate forest element related to the Afromontane forest, but with some notable endemics, as well as Karoo-Namib elements in the drier valleys. The constituents of the Cape Flora are sharply different from

TABLE 3. Families endemic in southern Africa.[a]

Family	Number of Genera/Species	Distribution
Stangeriaceae	1/1	Southeastern coast, Zululand to eastern Cape
Greyiaceae	1/3	Eastern mountains, Transvaal to eastern Cape
Achariaceae	3/3	Eastern mountains and coast, Transvaal to southern Cape
Bruniaceae	12/75	Southwestern Cape, only 3 species extending east of Port Elizabeth, 1 in Natal
Penaeaceae	7/21	Southwestern Cape, widespread
Stilbaceae	5/13	Southwestern Cape, Ceres to Riversdale
Grubbiaceae	1/3	Southwestern Cape, widespread
Roridulaceae	1/2	Southwestern Cape, Cedarberg to Swellendam
Geissolomataceae	1/1	Southwestern Cape, Langeberg
Retziaceae	1/1	Southwestern Cape, Stellenbosch to Bredasdorp

[a] Other families sometimes accorded recognition are Oftiaceae (1/3—Cape and Namaqualand); Curtisiaceae (1/1—Cape–eastern highlands of Rhodesia); Aitoniaceae (1/1—Little Karoo and Namibia).

those of the other parts of southern or tropical Africa, with high numbers of Proteaceae, Ericaceae, Iridaceae, Rutaceae, Thymelaeaceae, and Restionaceae, as well as Compositae and Leguminosae (only Papilionoideae), whereas Gramineae are relatively unimportant. Similarities in family composition in western Australia have often in the past prompted suggestions of a floristic relationship with the Cape Region. As Adamson (1958) has pointed out, differences are stronger than the similarities, and the Proteaceae, Rutaceae, Leguminosae, and Restionaceae of the two areas have entirely different and independent origins.

Not only is the Cape Region remarkably rich in species, but it has unusually high endemism for a continental area, in fact approaching the levels for species[4] encountered in Australia, Hawaii, and New Zealand (Table 1). Some 198 genera are endemic in the Cape Region and another 40 at least are centered here with minor extensions in adjacent areas. Eight of the ten families endemic in southern Africa occur in the Cape Region and six of these are restricted entirely to it (Table 3).

SURVEY OF FAMILIES, GENERA, SPECIES, AND ENDEMISM

ENDEMIC FAMILIES

As many as 14 endemic families have been recognized in southern Africa (Brenan, this symposium), although only ten are included here (Table 3). This compares with nine families endemic in tropical Africa (Brenan, this symposium), while three families are shared between southern and tropical Africa (Oliniaceae, Welwitschiaceae, and Melianthaceae and, if recognized, also Heteropyxidaceae, Wellstediaceae, Kirkiaceae and Curtisiaceae). The ten southern African endemic families, including 123 species, are all found in the well-watered parts of southern Africa, from the coastal belt and eastern escarpment to the mountains of the southwestern Cape. Six are in fact restricted to the

[4] Different estimates of endemism quoted by Weimarck (1941) and others are mainly due to different geographical definitions of the Cape Region, but more extensive collecting recently has extended the known ranges of several genera and species.

Cape Region, and Bruniaceae are centered here, with minor extensions to the east. These endemic Cape families are all shrubs of the fynbos, which occur mainly in montane habitats. Of the endemic families of southern Africa, only Greyiaceae and Stangeriaceae do not occur in the Cape Region, the former centered in the eastern mountains, whereas Stangeriaceae is restricted to the Tongaland-Pondoland Region.

In addition to the ten endemic families, Oftiaceae (1/3 Cape and Namaqualand) is sometimes accorded recognition, but is regarded here as Scrophulariaceae, though originally placed in Myoporaceae (Dahlgren & Rao, 1971; Goldblatt, 1976a; Leroy, 1977). Curtisiaceae (1/1 southwestern Cape and eastern highlands of Rhodesia) has also recently been accorded family status, though traditionally treated as Cornaceae—Curtisioideae (Eyde, 1967; Takhtajan, 1973; Goldblatt, 1978). Curtisioideae does not appear as closely related to Cornaceae as several other currently recognized families of this alliance. Aitoniaceae, with the monotypic *Nymania*, has been firmly assigned to Meliaceae (Pennington & Styles, 1975).

Affinities of Achariaceae are with Passifloraceae; Stilbaceae, almost certainly with Verbenaceae; Greyiaceae possibly with Melianthaceae or Sapindaceae, and Penaeaceae perhaps with Oliniaceae (Levyns, 1964) or Melastomataceae—Memecyloideae (Dahlgren, unpubl.) and certainly Myrtales. Relationships of the remainder are problematic. Retziaceae is perhaps related to Loganiaceae, especially Buddleieae (Leeuwenberg, 1964; Herbst, 1972; Goldblatt & Keating, 1976) or to Stilbaceae (Dahlgren et al., 1979). It is clearly a relict, even if distantly related to Loganiaceae. Bruniaceae, Roridulaceae, Geissolomataceae, and Grubbiaceae appear to have no close relatives. All are shrubby in habit with small to ericoid leaves. They are morphologically and anatomically unspecialized (Carlquist, 1975, 1976, 1977) and may be derived from an archaic southern African stock. They do not resemble one another closely, yet may be distantly allied; and they have been grouped in Pittosporales, a predominantly Austral order, by Thorne (1975, 1976), together forming the African-Madagascan suborder Bruniineae. Carlquist has shown that these families, all with relatively unspecialized wood anatomy, have no internal adaptations for xeric habitats. In fact, though found in a region of Mediterranean climate with summer drought, most species actually grow in moister situations often with summer moisture from cloud condensation or in marshes or seeps. They certainly appear to be mesophytic relicts surviving in wet montane habitats in a subarid region, as Carlquist (1976) has suggested.

A few families, although not strictly endemic, merit mention here as they have the majority of their taxa in southern Africa, and are centered in the southern or southwestern part of the subcontinent. These include Aizoaceae which in southern Africa has 135 genera, of which 113 are endemic, and slightly more than 2,000 species, of which 98% are endemic. As treated here, Aizoaceae includes Mesembryanthemaceae, Molluginaceae and Tetragoniaceae. Selaginaceae (10/ca. 215), also primarily southern African with a few species in East Africa and Madagascar, is related to Scrophulariaceae and to the Mediterranean Globulariaceae. All ten genera occur in southern Africa and some 204 of the esti-

TABLE 4. Ranking of families in the southern African flora by size. Percentage figures are of the total flora.

	Number of Genera	Endemic Genera		Number of Species	Endemic Species	
1. Compositae	174	80	Compositae	2,072	1,801	30%
2. Gramineae	167	23	Aizoaceae	2,020	1,896	
3. Aizoaceae	135	113	Leguminosae	1,495	1,114	
4. Leguminosae	115	20	Liliaceae	907	803	51%
5. Asclepiadaceae	60	21	Iridaceae	840	816	
6. Rubiaceae	59	8	Ericaceae	799	797	
7. Liliaceae	54	21	Gramineae	743	330	
8. Orchidaceae	54	15	Asclepiadaceae	605	526	
9. Scrophulariaceae	51	14	Scrophulariaceae	515	447	
10. Iridaceae	44	27	Orchidaceae	461	371	
11. Acanthaceae	41	6	Cyperaceae	421	218	
12. Euphorbiaceae	41	4	Euphorbiaceae	389	310	
13. Umbelliferae	32	12	Campanulaceae	380	350	
14. Labiatae	31	2	Acanthaceae	355	236	
15. Cyperaceae	30	7	Proteaceae	336	326	
16. Ericaceae	24	19	Restionaceae	316	316	
17. Rutaceae	23	13	Geraniaceae	271	261	
18. Amaranthaceae	20	3	Rutaceae	270	255	
19. Campanulaceae	18	12	Rubiaceae	234	122	
20. Amaryllidaceae	17	10	Labiatae	225	161	
			TOTAL	13,682 (74%)		

mated 210 species are endemic. Recently Hilliard & Burtt (1977) and Burtt (1977) have pointed out that Selaginaceae are as closely related to Scrophulariaceae—Manuleeae as the latter are to other tribes of Scrophulariaceae, and they therefore recommend treating Selaginaceae as a tribe of Scrophulariaceae.

SURVEY OF LARGER FAMILIES

The largest families are Compositae (2,072 species) and Aizoaceae (2,020 species) (Table 4). The latter, centered in southern Africa, are in need of critical revision and probably comprise considerably fewer species than currently recognized. Problems associated with the systematics of Aizoaceae, and succulents in general, are well known (Cole, 1969; Raven, 1970) but are gradually being resolved by critical research. Nevertheless, Aizoaceae is a major family in this region, and very characteristic of the flora of the arid parts of the subcontinent. Both Compositae and Aizoaceae exhibit an extraordinary degree of endemism, both above 85%; together they comprise nearly 30% of the species in southern Africa. The high endemism was noted very early in Compositae by Bentham (1873), who also drew attention to the relictual nature of many southern African members of this family. Leguminosae is third largest, with 1,495 species, 1,114 of which are endemic (74%). This family, though fundamentally a tropical one, shows a great development in Crotalarieae and Liparieae (tribes circumscribed after Polhill, 1976) concentrated in the Cape Region, where such genera as *Aspalathus* (255 species), *Rafnia* (22 species), *Priestleya* (18 species),

TABLE 5. Ranking of families in the Cape Floristic Region with the largest genus in each family and its percentage of the total for the family.

Family	Number of Species	Largest Genus	Number of Species	%
1. Compositae	1,034	*Senecio*	122	11.9
2. Ericaceae	765	*Erica*	605	79.1
3. Aizoaceae	728	*Ruschia*	134	18.4
4. Iridaceae	624	*Gladiolus*	71	11.4
5. Leguminosae	606	*Aspalathus*	253	41.7
6. Liliaceae	369	*Lachenalia*	55	14.4
7. Proteaceae	322	*Leucadendron*	80	24.8
8. Restionaceae	315	*Restio*	137	43.5
9. Rutaceae	250	*Agathosma*	130	52.0
10. Campanulaceae	242	*Wahlenbergia*	77	31.8
11. Orchidaceae	220	*Disa*	42	19.1
12. Cyperaceae	203	*Ficinia*	57	28.1
13. Scrophulariaceae	194	*Sutera*	34	17.5
14. Gramineae	154	*Pentaschistis*	30	19.5
15. Geraniaceae	150	*Pelargonium*	138	92.0
16. Rhamnaceae	139	*Phylica*	136	97.8
17. Polygalaceae	133	*Muraltia*	106	79.7
18. Oxalidaceae	127	*Oxalis*	127	100.0
19. Thymelaeaceae	127	*Gnidia*	48	37.8
20. Rosaceae	115	*Cliffortia*	109	94.8

and *Amphithalea* (15 species) are centered. The development of Leguminosae is mainly in Papilionoideae, which has 1,365 species, while Mimosoideae and Caesalpinioideae have only 75 and 55 species respectively.

There are six families with between 500 and 1,000 species: in order of size, Liliaceae (950 species), Iridaceae (840 species), Ericaceae (822 species), Gramineae (743 species), Asclepiadaceae (605 species), and Scrophulariaceae (515 species). Two of these, Liliaceae and Iridaceae, together with Orchidaceae (461 species), form the major part of the wealth of geophytic, petaloid monocots so characteristic of the southern African flora. These three petaloid monocot families together comprise over 12% of the flora, a unique situation, with floras of other semiarid parts of the world having a much poorer representation of petaloid monocots.

Gramineae, with some 743 native species, is an important element of the flora. Some 330 are endemic species (44%). It shows stronger relationships with the tropical African flora than other large families. Gramineae is poorly represented in the Cape Region compared to many other families, with some 154 species, only 68 of which are endemic. Most Cape grasses belong to Danthonieae, a tribe with a distinct Austral distribution.

The families for which southern Africa, particularly the Cape Region is so well known, Proteaceae (336 species), Restionaceae (316 species), Geraniaceae (271 species), and Ericaceae (822 species) are all centered in the southwestern portion of Africa and contribute substantially to the size of the flora, though they are poorly represented outside the Cape.

In the Cape Region, family composition is somewhat different (Table 5).

Compositae is still largest (1,034 species), followed by Ericaceae (765 species), Aizoaceae (728 species), Iridaceae (624 species), and Leguminosae (606 species). The petaloid monocot families—Iridaceae, Liliaceae, and Orchidaceae—comprise 1,213 species, or nearly 15% of the total flora. If Amaryllidaceae, Haemodoraceae, Tecophilaeaceae, and Hypoxidaceae are included, petaloid geophytic monocots account for 1,336 species, 16% of the Cape Flora, and for two-thirds of the monocots of this flora, a situation that appears unparalleled anywhere in the world.

The very characteristic families, Proteaceae and Restionaceae, assume importance in terms of number of species in the Cape Region, far exceeding Graminae, Euphorbiaceae, and Asclepiadaceae, which are more tropical families that are well represented in southern Africa as a whole. Some of the larger Cape families listed exhibit a pattern of one very large genus and few other species (Table 5). More than half the family Rutaceae consists of species of *Agathosma*, and this pattern is even more accentuated in *Phylica*, with 136 species of 139 Rhamnaceae, *Muraltia*, with 106 species of 133 Polygalaceae, *Cliffortia*, with about 109 species of 115 Rosaceae, and *Pelargonium*, with 138 species of 150 Geraniaceae. All 127 species of Oxalidaceae in the Cape Region belong to *Oxalis*.

ENDEMIC GENERA

For southern Africa as a whole some 560 of 1,930 native genera are endemic (29%). These are listed in Appendix 2 with ranges and numbers of species. A further 50 genera at least have the majority of their species or distribution in southern Africa, with a few species extending locally into tropical Africa. Some examples of this pattern are *Anastrabe* and *Manulea* (Scrophulariaceae), *Harpephyllum* (Anacardiaceae), *Putterlickia* (Celastraceae), *Dimorphotheca*, *Leontonyx*, *Othonna*, *Pteronia* and *Sphaeroclinium* (Compositae), *Craterocapsa* (Campanulaceae), *Leucosidea* (Rosaceae), and *Curtisia* (Cornaceae). *Cliffortia* (Rosaceae) and *Muraltia* (Polygalaceae), each with over 100 species in the Cape Region, extend through eastern South Africa with a few species reaching as far as East Africa (Table 11). This pattern is mirrored in several smaller genera also: for example, *Moraea*, *Hesperantha*, *Dierama* (all Iridaceae), *Hebenstreitia* and *Selago* (Selaginaceae), *Euryops* and *Felicia* (Compositae). A few genera, including *Leyssera*, *Ifloga*, *Lasiopogon*, *Lasiospermum*, *Osteospermum* (Compositae) and *Gynandriris* (Iridaceae), are essentially southern African, with a single species also occurring in the Mediterranean area or Middle East (Table 11).

Of the endemic genera, 198 are restricted to the Cape Region and at least another 50 are centered in this area with very minor extensions outside the Cape (Table 2). A second important center of endemism is the Karoo-Namib Region with some 80 endemic genera, 50 of which belong to Aizoaceae—Mesembryanthemoideae. The Afromontane areas of southern Africa also form an important center with some 20 genera endemic or concentrated here. Boundaries of this region are often indistinct with much interfingering in the east and west with adjacent floristic zones. In the Tongaland-Pondoland Region there are perhaps

TABLE 6. Ten largest genera in southern Africa and in the Cape Region with percentage of the total flora.

Southern Africa		Cape Region	
1. *Erica* (Ericaceae)	635	*Erica* (Ericaceae)	605
2. *Ruschia* (Aizoaceae)	326	*Aspalathus* (Leguminosae)	253
3. *Senecio* (Compositae)	285	*Pelargonium* (Geraniaceae)	138
4. *Aspalathus* (Leguminosae)	255	*Restio* (Restionaceae)	137
5. *Helichrysum* (Compositae)	245	*Phylica* (Rhamnaceae)	136
6. *Euphorbia* (Euphorbiaceae)	235	*Ruschia* (Aizoaceae)	134
7. *Pelargonium* (Geraniaceae)	213	*Agathosma* (Rutaceae)	130
8. *Conophytum* (Aizoaceae)	210	*Oxalis* (Oxalidaceae)	127
9. *Indigofera* (Leguminosae)	209	*Senecio* (Compositae)	122
10. *Oxalis* (Oxalidaceae)	201	*Cliffortia* (Rosaceae)	109
TOTAL	2,822 = 15.3%	TOTAL	1,891 = 22.3%

15 endemic genera. Some 15 genera are restricted to the Kalahari-Highveld and only 2 to the southern African part of the Zambezian Region.

In terms of numbers of endemic genera, Aizoaceae is the most important family with 113 in southern Africa, all but five belonging to Mesembryanthemoideae, which is centered in the arid regions of the southwest. Compositae has 80 endemic genera, best represented in Inuleae and Anthemideae, as well as in Calenduleae and Arctotideae, which are centered in the south and west. Petaloid monocots form another major group with Iridaceae having 27 of 44 genera endemic, Liliaceae 22 of 56 and Amaryllidaceae 10 of 17, southern Africa being the center for Iridaceae—Ixioideae and for Amaryllideae. Other important groups are Gramineae with 23 endemic genera if the segregates of *Danthonia* are accepted, as they are here, otherwise only 20; Asclepiadaceae with 21 endemic genera; Ericaceae 19; Scrophulariaceae 16; Orchidaceae 15; Umbelliferae 12; Restionaceae 11; and Proteaceae 10.

Clearly, massive evolutionary radiation in a number of isolated herbaceous and woody monocot and dicot genera is a characteristic feature of the southern African flora. This has resulted in the development of several very large genera in the flora, and in a remarkably high species per genus ratio. Ten genera in southern Africa have over 200 species (Table 6). The largest is *Erica* with some 635 species, mostly found in the Cape Region as are the other genera except *Ruschia*, which is widespread in arid areas. The number of species in the 10 largest genera in southern Africa is 2,799 or 15.3% and for the Cape Region alone, 1,891 or 23.3%. In terms of genus per species ratios (Table 3), the figure for southern Africa is 7.7 and for the Cape Region 8.9, both remarkably high on a world scale (Table 7).

ENDEMIC SPECIES

Of the approximately 18,500 native species in southern Africa about 14,820 (80%) are endemic, a percentage unusual for a continental area. Similar proportions of endemism are mainly associated with whole isolated land masses such as Australia (ca. 85%), New Zealand (ca. 81%), Hawaii (ca. 92%). The

TABLE 7. Selected statistics for parts of southern Africa and various comparable regions, with the ten largest genera, monocots, Compositae and annuals as percentage of total flora.

Region	Species per Genus	Ten Largest Genera	Monocots	Compositae	Annuals
Southern Africa	7.7	15.1	23.0	11.0	7.0
Cape Region	8.9	22.1	24.2	11.9	6.4
Cape Peninsula[a]	4.2	17.5	34.6	11.5	9.6
Natal[b]	3.9	17.0	27.1	11.4	6–7
Gray's Manual Area[b] (Eastern North America)	5.2	21.8	28.2	12.7	8.7
Europe[c] (*Flora Europaea*)	7.8	14.0	18.0	12.0	?
California Floristic Province[a]	5.6	15.2	19.2	13.6	27.4
Carolinas[a]	3.5	14.5	23.6	10.4	3.8
Sonoran Desert[a]	3.3	12.8	12.1	15.0	21.4
Texas[a]	3.9	10.2	24.4	13.4	20.4
Hawaii[a]	7.5	42.1	8.5	11.4	0.04
New Zealand[a]	7.4	26.3	27.3	12.5	6.0

[a] Data from Raven & Axelrod (1978).
[b] Data from Ross (1973), with estimate of annuals from Bews (1916) a figure "including many not native."
[c] Webb (1978), including introduced taxa.

very high percentage of endemism in southern Africa supports the contention that this region forms a coherent unit, however artificially the boundaries may appear to have been drawn. The level of endemism also emphasizes the degree to which the southern African region has evolved in isolation for a considerable period of time. Following the example of Raven & Axelrod (1978) aspects of species and generic endemism will be discussed in relation to statistics presented in Table 7.

As already mentioned in discussing generic endemism, southern Africa has a very high number (7.7) of species per genus, while the Cape Region, the only local area for which I have been able to provide data, has 8.9 species per genus (Table 7, column 1). These figures are striking and are approached only by the islands of New Zealand and Hawaii as well as by the very large *Flora Europaea* area. As elaborated by Raven & Axelrod (1978) in relation to the California Floristic Province (where there are 5.6 species per genus), high levels such as these suggest major bursts of speciation in isolated genera which thus contribute very unevenly to the flora. The Cape Region appears quite exceptional in this respect and southern Africa somewhat less so, although the figure here includes the Cape Region. However, even with the Cape Region excluded, there are some 7.1 species per genus in southern Africa, indicating that major episodes of speciation have played a significant role here too.

As regards percentage of total flora included in the ten largest genera—second column of Table 7—southern Africa appears unexceptional (15.1%) while the Cape Region (22.1%) has a relatively high proportional contribution from a few genera, approaching the situation in New Zealand (26.3%), but nothing like Hawaii, for example, with 42.1%.

Both the proportion of monocotyledons and contribution of Compositae to the total flora, in southern Africa as a whole and the Cape Region, appear unremarkable. Usual proportions of monocotyledons range around 25%, while Com-

positae generally constitute 10–12% of a flora with a somewhat lower figure for moist tropical areas. The fact that the proportion of monocotyledons is normal in the Cape is surprising since in the Cape Peninsula, a small part of the Cape Region, monocotyledons comprise some 34.6% of the flora (Adamson & Salter, 1950; Raven & Axelrod, 1978). An explanation for the richness of monocots on the Cape Peninsula is not known but may lie partly in that this area is particularly well watered and has more than the usual marshy situations, conditions where, at least in the Cape, there are more species of Restionaceae and Cyperaceae as compared to drier areas. In terms of the monocot families represented, southern Africa, and especially the Cape, are extraordinary with 14% and 16% petaloid monocots respectively.

The last column of Table 7 indicates that southern Africa, including the Cape, has very few annual species in comparison to the total flora. There are some 1,308 annuals in southern Africa (7%) and an estimated 550 in the Cape Region, only 6.4%. Comparable areas for which this information is available (Raven & Axelrod, 1978), such as the California Floristic Province (27.4%), and the State of California (28.6%) have many more annuals proportionately, as do other arid or semiarid areas, especially those with arid climates and moist winters (Raunkiaer, 1934). Figures are not available for many other parts of the world with a Mediterranean climate except for the Mediterranean vegetation of Palestine (Orshan, 1953), which, with 30% annuals, appears comparable to California. Examples given by Raunkiaer for local lowland areas in Greece, Italy, and elsewhere in the Mediterranean suggest even higher proportions of annuals. In general annuals appear to comprise a high proportion of floras in warm semiarid to arid areas with winter rainfall, and particularly in the Old World in the Mediterranean and the Middle East (Raunkiaer, 1934; Raven & Axelrod, 1978). In southern Africa the reasons associated with the low proportion of annuals require investigation. Low frequencies of annuals have also been noted by Bews (1916) for Natal, 6–7%, by Compton (1929) for the arid Whitehill flora of the western Karoo, 11%, by Adamson (1927), 5–7%, and by Cody & Mooney (1978) for Jonkershoek, a small area in the Cape Region. A high frequency of annuals has been recorded in southern Africa for the southern Kalahari (Leistner, 1967) where 33% of the 444 species in this flora are annual.

The southern African annuals are predominantly dicots (Table 8) with Cyperaceae (40 annuals), Liliaceae (1 annual), Gramineae (ca. 150 annuals), Juncaceae (6 annuals), Commelinaceae (4 annuals), contributing to a total of some 205 annual monocots or only about 15.8% of the total 1,297 annuals (one of which, *Selaginella pygmaea*, is a Pteridophyte). This differs somewhat from the situation Raven & Axelrod (1978) describe in California where of a total of 1,098 annual species only 85 (7%) are monocots. Dicots are better developed in California generally but especially so are annuals: there are more annual dicots in California than in all southern Africa. Among the southern African dicots Compositae (235), Aizoaceae (135), and Scrophulariaceae (192) contribute strongly to the annual flora, as well as Campanulaceae (53) and Leguminosae (51). The greatest generic contributions to annual species come from *Nemesia* (50), *Polycarena* (36), and *Diascia* (32) (all Scrophulariaceae) and

TABLE 8. Families of southern Africa and the Cape Region with the largest number of annual species.

Southern Africa		Cape	
Compositae	235	Compositae	122
Scrophulariaceae	192	Scrophulariaceae	106
Gramineae	150	Aizoaceae	60
Aizoaceae	135	Campanulaceae	33
Campanulaceae	53	Cruciferae	32
Leguminosae	51	Crassulaceae	22
Cruciferae	42	Cyperaceae	22
Cyperaceae	40	Gramineae	20
Selaginaceae	31	Selaginaceae	18
Gentianaceae	29	Gentianaceae	17

from *Senecio* (ca. 33) (Compositae) and *Wahlenbergia* (ca. 30) (Campanulaceae). In the Cape Region there are only some 52 annual monocots, 9.5%, of the total annual flora. The decrease in proportion of annuals is due to the paucity of annual grasses in the Cape where annual dicots are better represented proportionately than in southern Africa.

GEOGRAPHICAL AND PALEOBOTANICAL SETTING

Southern Africa is unusually rich in native vascular plants compared with other temperate regions of comparable size and with portions of tropical Africa, and far exceeds any area of similar size in degree of endemism. The Cape Region, for its small size, has a particularly large flora, comparable in numbers of species with some of the richest areas of the Neotropics (Table 1). It has a level of endemism far in excess of any tropical area of comparable size.

The principal reasons for the wealth of species in southern Africa are the following. *First*, environmental diversity is great due to high relief, with humid coastal forest in the east, giving way to a large montane belt, a high interior plateau dipping westward and becoming progressively more arid to form the Karoo and the Kalahari Desert, while the western coastal belt forms the extremely arid Namib Desert. The south and southwest are very mountainous and dry valleys alternate with well-watered mountain belts. *Second*, two entirely different climatic regimes prevail, with summer rainfall/winter drought in the north, east, and interior, and winter rainfall and summer drought in the southwest, while the eastern part of the south coast essentially receives rain all year and has an equable maritime climate. *Third*, recurrent climatic fluctuations since the mid-Pliocene stimulated speciation in plants suited to a region of diverse topography, predominantly arid climate, and diverse soil types. *Fourth*, numbers of relicts have survived in sheltered pockets of equable climate along the coasts, in both summer and winter rainfall areas. Though no analysis of relict plant groups has been made for southern Africa, Adamson (1948) makes a point of their significance. There are clearly many species in this category to be found wherever favorable conditions persisted throughout the extreme arid phases of the Pliocene and Quaternary, including all of the endemic families of the Cape Region.

These conditions are to a greater or lesser degree shared by all areas of semiarid and Mediterranean climate, and most of them have relatively high numbers of species and high endemism. Southern Africa, however, seems exceptional, and the Cape Region is particularly remarkable. Reasons for this are not at all clear. It remains to be demonstrated that southern Africa is more diverse geographically, edaphically or climatically, or whether more relicts are located here than in comparable areas. In one condition, however, southern Africa does differ from other regions. The Mediterranean and arid belts form the southern tip of the continent with no temperate land extension polewards, as there is in North and South America and in Eurasia.

This geographical situation has been used to explain some of the richness and endemism in the extreme south (Thiselton-Dyer, 1909). The so-called *cul-de-sac* theory envisages the flora of the southwest as having evolved in relative isolation from the rest of Africa, but being at the same time also an end point for successive southward waves of plant migration. This idea of large numbers of species accumulating at the end of the continent is unsatisfactory and has been widely rejected (Bews, 1925; Adamson, 1948: 461). However, the extraordinary level of endemism found in southern Africa and the Cape is explicable to some extent by its geographic situation. There is no cool temperate flora extending south with which some species might be shared, as there is in the Mediterranean climate belts of California, Chile, and the Mediterranean basin.

LANDSCAPE

Much of southern Africa consists of an elevated rolling plain with an average altitude of 1,500 m. The plain is broken abruptly in the east and south by steep escarpments and mountain belts. More exactly, from the Transvaal to the eastern Cape the surface is built up of a series of steplike escarpments with the interior plateau a continuation of the summit of the last escarpment. The Cape mountains in the south and southwest are true mountains, consisting basically of much folded strata subsequently faulted in complex fashion (du Toit, 1954). The Cape Region thus consists of several steep mountain chains lying parallel to the coast behind one another, separated by long valleys (King, 1967).

The interior plateau dips gradually to the west where the coastal escarpments are less developed and the rivers draining the central and eastern interior all run the longer distance to the west coast. The Karoo and the Kalahari are arid interior basins of the plateau. The coastal plain on the west coast is also narrow, and with the cold Benguela Current alongside, forms the extremely dry Namib Desert, extending from just south of the mouth of the Orange River to southern Angola.

SOILS

Without going into detail about soil types in southern Africa, it is necessary to mention some peculiarities which are important in floristic considerations. The infertile, acidic and coarse grained siliceous soils derived from sandstones of the Cape System are particularly unusual and closely associated with sclerophyll vegetation. These sandy soils are found mainly in the Cape Region and

extend along the south coast locally to Natal. The most characteristic elements of the Cape Flora are found on this substrate, and many Cape taxa extending east of the Cape Region grow only where these sandy soils occur.

In the Cape Region the mountains are mostly sandstone and the valleys and flats shale. The dissected topography here has its counterpart in a mosaic of two sharply different soil types which help explain the richness and variety of the flora, as many taxa are partly or entirely restricted to one major soil type. This situation, though well known, has not been studied in detail, and most recent monographs acknowledge its importance, e.g., Rourke (1972) for *Leucospermum*; Williams (1972) for *Leucadendron*; Goldblatt (1976b) for *Moraea*; while Dahlgren (1968) has dealt with edaphic factors in detail for *Aspalathus*.

Limestone outcrops are local and also sustain important differences in the flora. Limestone in the southern Cape in particular has characteristic endemic species, a fact emphasised by Muir (1930), who lists the flora of the limestone hills near Riversdale, Weimarck (1941: 62), Acocks (1953), and others. The recent studies of Dahlgern (1968), Rourke (1972: 182), Williams (1972: 397), and Milewski (1977) also mention the significance of limestone substrates for particular plants.

Extensive outcrops of serpentine and other peculiar mineral rich soils occur in southern Africa (Wild, 1978), especially in the Transvaal, but also in Swaziland, Botswana, and Namibia. In many parts of the world such substrates often harbor distinct plant communities and endemic taxa, and serpentine endemics are particularly important in the California flora (see Raven & Axelrod, 1978, for survey). In tropical Africa where Shaba (Zaïre) and Rhodesia have been investigated extensively (Wild & Bradshaw, 1977; Wild, 1978), there are numerous characteristic taxa on copper, nickel, and cobalt rich soils and several species endemic on such soils. In Rhodesia, which has large serpentine outcrops, Wild (1965, 1968) has recorded at least 320 tolerant species and 22 endemics. In contrast, virtually nothing is known about the flora of serpentine and other anomalous soils in southern Africa. It remains to be seen whether there are any taxa or communities characteristic of such soil types, but in the light of much information from elsewhere in the world, including adjacent south tropical Africa, serpentine and other ultrabasic soils would seem likely to be responsible for some of the plant diversity of southern Africa.

CLIMATE AND RAINFALL

In summer, most of southern Africa receives rainfall from moist air flowing from the Congo as the intertropical convergence moves southward. Convectional and orographic precipitation occur, highest in the northeast and diminishing in the center and south (Griffiths, 1972). The cold north-flowing Benguela Current off the west coast controls the climate of the western subcontinent to a large extent (van Zinderen Bakker, 1975; Tankard & Rogers, 1978). This current, which wells up near Cape Town, has a drying effect along the whole coast as far north as the equator, with the resulting high pressure belt over the west coast and south Atlantic inhibiting the flow of moist tropical air westward.

In winter, a second weather system brings moisture-bearing air from the

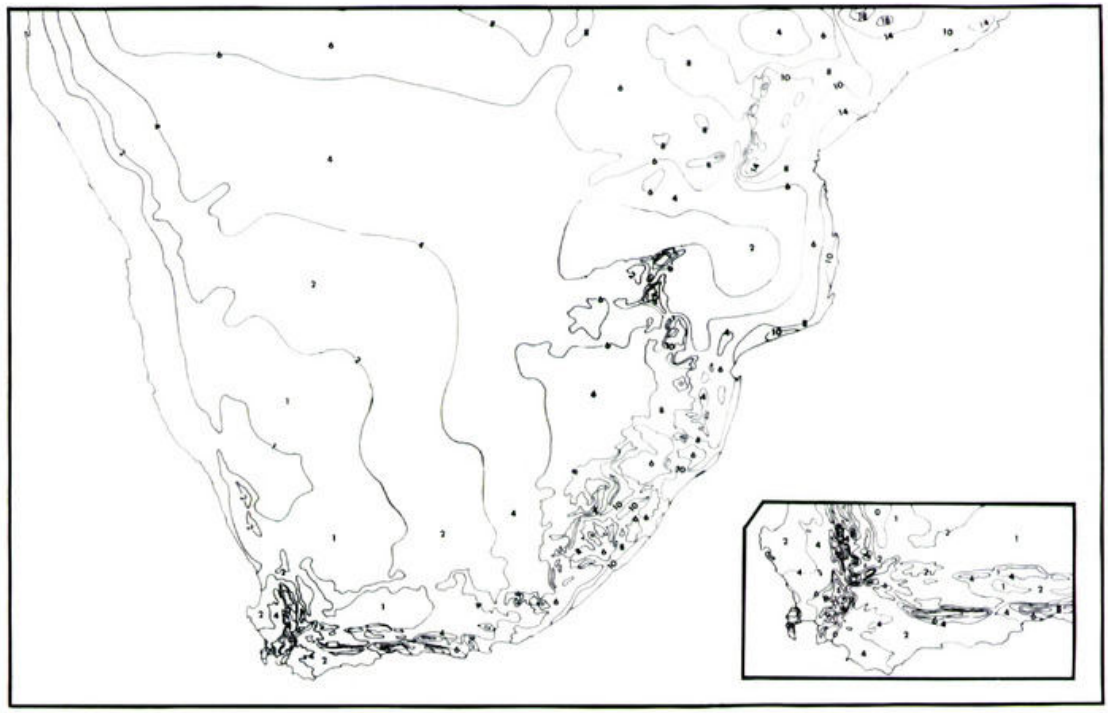

FIGURE 4. Annual rainfall in southern Africa after Jackson (1961). Figures refer to 100 mm of rainfall.

west as the south Atlantic anticyclone moves some 4° equatorward and northwesterlies provide cyclonic and orographic rain to the west coast south of about latitude 28° and to the southern coast. Winter cyclone-produced cold fronts also bring some snow in higher regions of the interior. The climate of the southwest and south coast with summer drought and cyclonic winter rainfall is thus typically mediterranean.

The southeast trade winds of the Indian Ocean have local effects on the prevailing pattern as they bring some rain to the coast and seaward slopes of the mountains. This affects the Cape Region as well, with summer mist or rain produced as far west as Cape Town. These winds play a significant role on the west coast in shifting warmer surface water away from the coast, thus amplifying the upwelling of the Benguela Current.

In terms of measurable precipitation (Jackson, 1961) the mountains of the Cape Region, especially in the southwest, are wettest, with 1,000–1,800 mm falling mainly in winter but also with appreciable summer rain and cloud condensation (Fig. 4). In the lowland areas of the Cape, rainfall is much lower, about 400–500 mm with little summer precipitation. Rainfall in the Namib Desert on the west coast is less than 100 mm per annum. This increases to the east, with most of the Karoo and Namaqualand in the northern Cape Province receiving between 100 and 250 mm per annum. The Kalahari-Highveld is wetter with 350–600 mm, with even more towards the eastern highlands. The highlands and eastern escarpment receive 600–1,000 mm, with 1,400 mm locally and the mean for the southeastern coast ± 900 mm, distributed mainly in summer.

The climate of the region is thus predominantly arid to semiarid, with rela-

tively mesic conditions prevailing only in the eastern third of southern Africa as well as along the southern coast. Although the region lies partly in the tropics, its high elevation, with dryness and widespread frost in winter, result in much of its flora being strongly seasonal with growth in the warm months. This pattern is reversed in the west and south which have a Mediterranean climate with mild, wet winters and relatively dry summers. Between the fairly well-watered eastern and southwestern parts of southern Africa, there are three distinct desert or semidesert areas: the summer rainfall subtropical Kalahari, the summer rainfall temperate Karoo, and the winter rainfall Namib-Namaqualand belt.

PALEOBOTANICAL OUTLINE

It is difficult to judge, except in general terms, the effects of the geological past on the flora of the subcontinent. The fossil record for plants in Africa generally, but especially in the south, is poor from the Jurassic until the Quaternary (Plumstead, 1969). Thus there is a great gap during the time that the angiosperms evolved and became dominant during the Cretaceous, this gap extending until the Pliocene. An excellent study of this period by Axelrod & Raven (1978) surveys the entire Late Cretaceous and Tertiary for Africa. Their critical analysis of the few fossil floras available in the light of plate tectonics and evidence from other parts of the world has produced a generalized picture for southern Africa. Significant features of the Cretaceous-Tertiary history of Africa are the following.

1. Africa in the late Cretaceous and Paleocene lay some 15° to the south, well in the region of westerlies, and thus the southern third of the continent probably had a cool wet climate. Relief was low, and a forest flora of the *Podocarpus-Nothofagus* type (not necessarily with *Nothofagus*) is implied for the south, such as occurs today in temperate Australasia and southern South America. Temperate forest existing in the southern Cape today, which is dominated by *Podocarpus*, may be a relict of this flora.

2. By the close of the Cretaceous, Africa was isolated by surrounding ocean, and well separated from South America and India-Madagascar. Direct migration of plants to and from central and southern Africa was limited after the mid-Cretaceous, although indirect interchange with South America was much easier than at present (Raven & Axelrod, 1974). A warm humid climate and low relief probably existed in Africa, except in the cooler south, and consequently a tropical forest flora probably extended over most of the continent. Pockets of aridity are likely even at this time at the edge of the tropics due to high pressure cells and in edaphically dry sites in both tropical and temperate zones (Axelrod, 1972). The small Oligocene fossil assemblage from Banke in Namaqualand, with sclerophyllous characteristics, suggests the evolution of southern sclerophylls from this time, if not earlier, probably on infertile soils.

3. In the later Oligocene the pattern of low relief in Africa (King, 1967) was broken as uplift, especially along the east coast, took place and the present landscape of the continent began to take shape. Uplift implies the formation of cooler and drier belts, especially in the south but also in the tropics.

4. At the same time Australia separated finally from Antarctica which moved south becoming progressively more frigid and a circum-Antarctic circulation was initiated. Progressive drying and cooling effects in the south increased at this time.

5. By mid-Miocene the union of Africa-Arabia with Eurasia was effected, closing the Tethys Sea. Direct migration of the northern Eurasian flora into Africa was possible once again, probably from the Miocene. The newly uplifted highland areas in East Africa became an increasingly significant route for migration to southern Africa.

6. From the Miocene onward, the climate in southern Africa deteriorated. With the continent essentially lying in its present position at the edge of the westerlies, and the influence of cold Antarctic water becoming stronger, aridity would have been increasingly significant. Drought-adapted plants would thus have evolved rapidly from this time.

7. From the late Pliocene onward, important coastal uplift again took place so that the characteristic plateau-escarpment, narrow-coastal-belt landscape of southern Africa was finally formed. Major climatic fluctuations, coinciding with glacial and interglacial periods, resulted in massive migrations of the flora. Changes in climate and of flora are well documented (Martin, 1968; Schalke, 1973; van Zinderen Bakker, 1974, 1978). The Cape Flora, recognizable from pollen samples, is known to have extended to the north at times while the temperate forest covered large areas which are now sclerophyll (Schalke, 1973; van Zinderen Bakker, 1978). A scenario for this period is described in detail by van Zinderen Bakker (1974). These climatic fluctuations must have been responsible for extinction on a large scale and resulted in the restriction of the more mesophytic taxa to favorable sites, hence the number of relicts confined to the coastal and mountain belts from the Cape to Natal. These climatic fluctuations probably were also the cause of the tremendous bursts of speciation in some genera of the Cape and adjacent arid belts as Levyns (1954), Taylor (1978), and others have envisaged. Elimination of some taxa would give opportunities for the evolution of the remaining species into vacant or newly created niches, while the fragmentation of large populations into smaller local ones would promote divergence by genetic drift and rigorous selection in harsher conditions. With amelioration of the climate, changes would favor some taxa more than others, their populations would grow, hybridize with related taxa, and variation and speciation would continue to expand.

Relationships of the Southern African Flora

cosmopolitan, pantropical, and paleotropical families and genera

Of the 200 families of seed plants in southern Africa the majority, some 152, are either more or less cosmopolitan or pantropical (Table 9). A few are represented in the flora by a single species, occurring only in the extreme northern parts, e.g., Opiliaceae, Gyrocarpaceae, Aristolochiaceae, and Cabombaceae. Cactaceae, basically New World, is widespread only by virtue of the easily dispersed *Rhipsalis*, only one or a few species of which occur in Africa and tropical Asia. A few of these widespread families, notably Aizoaceae and Crassulaceae,

TABLE 9. Relationships of southern African phanerogamic families.

Cosmopolitan/Pantropic (not necessarily including Australasia)	152 (Including Aizoaceae; Cactaceae)
Paleotropic (including Australasia)	5 Flagellariaceae, Pittosporaceae (Balsaminaceae, Dipterocarpaceae, Musaceae)
African-Madagascan	6 Hydrostachyaceae, Montiniaceae, Myrothamnaceae, Ptaeroxylaceae, Selaginaceae, Sphenocleaceae (Androstachyaceae, if recognized)
African	4 Melianthaceae, Oliniaceae, Welwitschiaceae (and if recognized, Curtisiaceae, Heteropyxidaceae, Kirkiaceae, Wellstediaceae)
African-Eurasian	10 Balanitaceae, Dipsacaceae, Moringaceae, Neuradaceae, Pedaliaceae, Resedaceae, Salvadoraceae, Tamariacaceae, Trapaceae, Vahliaceae
African-New World	7 Canellaceae, Hydrophyllaceae, Hydnoraceae, Loasaceae, Tecophilaeaceae, Turneraceae, Velloziaceae
African-Australian (and South America)	7 Aponogetonaceae, Cunoniaceae, Escaloniaceae, Haemodoraceae, Podocarpaceae, Proteaceae, Restionaceae (possibly Monimiaceae, Gunneraceae, and if recognized, also Philesiaceae)
Endemic	10 Table 2

can be said to have their center in southern Africa, and several others have undergone particularly extensive radiation here. Among the latter are Compositae—Inuleae, Arctoteae and Calenduleae; Iridaceae; Liliaceae—Aloineae; Ericaceae—Ericoideae; Thymelaeaceae—Thymelaeeae; Rutaceae—Diosmeae; Asclepiadaceae; Geraniaceae; Scrophulariaceae; Oxalidaceae; Zygophyllaceae. The region is also perhaps the center for Hypoxidaceae and Amaryllidaceae—Amaryllideae.

Five families in southern Africa can be said to be Paleotropical (Table 9). Dipterocarpaceae[5] (barely represented here, with one record in northern Botswana); Ptitosporaceae (mainly Australasian with *Pittosporum* in forests of Asia, Africa, and Madagascar); and Flagellariaceae. Balsaminaceae, poorly represented in southern Africa, falls in this group, although it also has minor representation in North America. Perhaps Musaceae (here including Strelitziaceae) also belongs here, although the monotypic *Phenakospermum*, related to *Ravenala*, occurs in the Neotropics. (Balanitaceae, Pedaliaceae, Vahliaceae, and Salvadoraceae are treated in the following pages as Afro-Eurasian families.)

At generic level, the cosmopolitan or pantropical element comprises 22.8% of the flora, or about 425 genera (Table 10). This includes many aquatics, marine and fresh water, as well as some tropical groups rather poorly represented in southern Africa and the large worldwide genera like *Senecio*, *Euphor-*

[5] A monotypic subfamily of Dipterocarpaceae has recently been described (by Maguire et al., 1977) from South America.

TABLE 10. Relationships of southern African phanerogamic genera.

Cosmopolitan/Pantropic (not necessarily including Australasian)	423	(22.8%)
Paleotropic (including Australasian)	255	(13.7%)
African-Madagascan	116	(6.2%)
African	357	(19.1%)
African-Eurasian	78	(4.2%)
African-New World	48	(2.5%)
African-Australian (and South America)	23	(1.2%)
Endemic	560	(30.2%)
TOTAL	1,860	

bia, *Eragrostis*, and *Chenopodium*. Strictly Paleotropic genera (not always in Australia) number 255, 13.7% of all genera in southern Africa.

TROPICAL AFRICAN AND AFRICAN-MADAGASCAN FAMILIES AND GENERA

The southern (-tropical) Africa-Madagascan element (Table 10) is significant with Selaginaceae (essentially southern African and only a few species also in tropical Africa and Madagascar); Ptaeroxylaceae, ditypic, with *Ptaeroxylon* in south tropical Africa, *Cedrelopsis* in Madagascar; Hydrostachyaceae; Myrothamnaceae; and Montiniaceae with *Montinia* in the Cape to southern Angola and *Grevea* in tropical Africa and Madagascar (Milne-Redhead, 1955; Letouzey, 1977). Sphenocleaceae may belong here, but it may better be regarded as a Paleotropical family. If recognized as separate from Euphorbiaceae, Androstachyaceae must be added to this group.

Some 114 genera of the southern African flora occur in tropical Africa and Madagascar. Essentially tropical groups predominate here but also included are *Aristea* (Iridaceae), *Hebenstreitia* (Selaginaceae), and *Philippia* (Ericaceae), typical Cape-Afromontane taxa, and *Kniphofia* (Liliaceae). Only two genera, *Ernestimeyera* (= *Alberta*: Rubiaceae) and *Protorhus* (Anacardiaceae) are restricted to Madagascar and southern Africa. The species of *Geissorhiza*, confined to the Cape Region, that have been described from Madagascar, are misplaced in this genus and perhaps belong to *Gladiolus*.

Strictly tropical and southern African families are few, including only Oliniaceae (Myrtales), Melianthaceae (Sapindales?) and Welwitschiaceae, the peculiar relict gymnosperm of the Namibia-Angola coastal desert. If accorded recognition, Curtisiaceae (mentioned already), Kirkiaceae (Simaroubaceae here), and Wellstediaceae (Boraginaceae here) could be added to this list. The latter has one species in western southern Africa and one in northeast Africa and Socotra. *Heteropyxis*, frequently assigned its own family, seems best placed in Myrtaceae (Johnson & Briggs, 1978).

A large group of about 360 genera occurs only in tropical and southern Africa (Appendix 3). Some 50 at least are essentially endemic to the subcontinent with minor extensions in south tropical Africa. Many genera belong to the reverse class, predominantly tropical African, and barely represented in southern Africa. Among the latter, the following are some tropical African genera that extend only into northern Namibia, the Caprivi Strip, northeast Botswana or

extreme northern Transvaal: *Amblygonocarpus*, *Brachystegia*, *Guibourtia*, *Julbernardia*, *Baikiaea* (all Leguminosae); *Byrsocarpus* (Connaraceae); *Leiothylax* (Podostemaceae); *Pleiotaxis* (Compositae); and *Oenostachys* (Iridaceae).

There appear to be three significant distribution patterns among the genera of southern and tropical Africa. The majority are tropical taxa, more or less widespread in tropical or south-tropical Africa with their southern limit in the warmer parts of southern Africa. A second group are arid elements of the Karoo-Namib and Kalahari which are absent or have poor representation in the tropics but occur also in northeast Africa. Many arid taxa with distributions of this type extend to the Middle East and northwest India and sometimes to arid southwest Madagascar and are discussed more fully in the section that follows. Examples of strictly African genera with this distribution are *Kissenia* (Loasaceae), *Babiana* (Iridaceae), and *Wellstedia* (Boraginaceae) (Table 11). *Parkinsonia* (Leguminosae) and *Thamnosma* (Rutaceae) have this range in Africa, but also occur in arid areas in the New World (Table 12).

A third group comprises temperate southern African genera, mostly centered in the Cape, which extend outside southern Africa mainly in highland areas, a Cape-Afromontane group (Table 11) (Weimarck, 1941: 90–97). Some genera with this distribution extend well into Eurasia also, such as *Gladiolus* and *Romulea* (Iridaceae) or barely reach the Mediterranean, like *Osteospermum* (Compositae).

AFRICAN-EURASIAN TAXA

While the number of strictly African families is small, there is a substantial Afro-Middle Eastern or African-European-Western Asian representation at the family level, predominantly of xeric groups (Table 10). In the first category are Vahliaceae, and the following, disjunct between southern Africa and northeast Africa: Neuradaceae, Moringaceae (also Madagascar), and Resedaceae.[6] Balanitaceae and Salvadoraceae, though with minor extensions to Burma and the Philippines respectively, belong here, as does Pedaliaceae.[7] More widespread, and in Europe and temperate Asia as well, are Tamaricaceae, Trapaceae, and Dipsacaceae, the latter a temperate family found only in montane regions in the tropics.

Conspicuous south-north distributions at subfamily level are Iridaceae—Ixioideae, very clearly centered in southern Africa, and Ericaceae—Ericoideae (and *Erica* itself) which is very diversified in southern Africa, especially in the Cape Region where 23 genera (19 endemic) and 765 species (753 endemic) occur. Although Ericaceae appears a basically north temperate family (Levyns, 1964), the representation of Ericoideae in Africa may be very old (Raven & Axelrod, 1974) with Ericaceae having originated in west Gondwanaland. Ericoideae in Europe may only date from the Oligocene when migration between Africa and Eurasia was facilitated as these landmasses moved closer, and at the same time coastal uplift in Africa made temperate habitats available in tropical Africa for

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[6] The single species of Resedaceae, *Oligomeris linifolia*, in southwest North America may be recently introduced there (Raven, 1971).

[7] The record of one species, *Rogeria brasiliensis* = *Pterodiscus gayii*, in Brazil appears erroneous (Decaisne, 1865), having arisen due to confusion over an early Angolan collection.

TABLE 11. Some genera of southern Africa with north-south distributions, having limited ranges in Africa or extending into Eurasia, sometimes absent from tropical Africa.

1. Southern Africa-northeastern Africa (including southwestern Arabia)

Angkalanthus
Babiana
Cotyledon
Echidnopsis
Erythrophysa
Kissenia
Macowania
Sesamothamnus
Tetrapogon
Tribulocarpus
Wellstedia

2. Southern Africa-north Africa, Mediterranean and Eurasia

(Centered in s. Africa)
Aizoon
Asthenatherum
Citrullus
Hertia
Gynandriris
Ifloga
Lasiopogon
Lasiospermum
Leyssera
Rogeria
Schismus
Stipagrostis

(Centered in Eurasia)
Ajuga
Andrachne
Ballota
Bartsia
Bupleurum (also North America)
Capnophyllum
Chenolea
Conium
Corallocarpus
Dactyliandra
Dyerophytum
Emex
Erodium
Forskaolea
Geum
Halopeplis
Kochia
Laurentia
Mathiola
Matricaria
Moringa
Oligomeris
Papaver
Seetzenia
Tamarix
Torilis
Trigonella
Valerianella

3. Southern Africa-African mountains (-southwestern Arabia) decreasing northwards (a few also occur in Madagascar)

(Centered in Cape Region)
Aristea
Cliffortia
Disa
Euryops
Felicia
Ficinia
Hesperantha
Moraea
Muraltia
Passerina
Pentaschistis
Phylica
Philippia
Protea
Restio
Ursinia
Stoebe
Struthiola

(Centered in eastern s. Africa)
Alepidia
Anomatheca
Dierama
Dietes
Kniphofia
Knowltonia
Merxmuellera

(Widespread in s. Africa)
Albuca
Athanasia
Berkheya
Cyphia
Cyrtanthus
Delosperma

4. Southern Africa-Africa (mainly montane) -Eurasia (or north temperate)

(Centered in Cape Region)
Erica
Gladiolus
Osteospermum
Pelargonium (-Australia)
Romulea

(Centered in s. Africa)
Androcymbium
Argyrolobium
Helichrysum (-Australia)
Lotononis

(Centered in Eurasia)
Astragalus
Anemone
Cephalaria
Dianthus
Lepidium
Scabiosa
Thalictrum
Valeriana

the first time since the Cretaceous. There are relatively few Ericoideae on the African mountains (*Erica*, *Blaeria*, *Philippia*) and the Madagascar highlands (*Philippia* only). Iridaceae—Ixioideae extend from the Cape through tropical Africa to Europe and western Asia, and *Gladiolus* covers this whole range, other genera being more restricted.

TABLE 12. New World-African (-Madagascan) genera also in southern Africa.

1. Tropical Forest and Savanna

Annona (Annonaceae)
Anthephora (Gramineae)
Asclepias (Asclepiadaceae)
Ascolepis (Cyperaceae)
Aspilia (Compositae)
Caperonia (Euphorbiaceae)
Cienfugosia (Malvaceae)
Ctenium (Gramineae)
Duvernoia (Acanthaceae)
Eriochrysis (Gramineae)
Eustachys (Gramineae)
Guibourtia (Leguminosae)
Hilleria (Phytolaccaceae)
Hyperthelia (Gramineae)
Hyptis (Labiatae)
Kosteletzskya (Malvaceae)
Lippia (Verbenaceae)
Loudetia (Gramineae)
Maprounea (Euphorbiaceae)
Mitracarpum (Rubiaceae)
Newtonia (Leguminosae)
Ocotea (Lauraceae)
Olyra (Gramineae)
Paratheria (Gramineae)
Pentodon (Rubiaceae)
Piriqueta (Turneraceae)
Raphia (Palmae)
Rhipsalis (Cactaceae, also Asia)
Rhytachne (Gramineae)
Sclerocarpus (Compositae)
Siphonoglossa (Acanthaceae)
Sorghastrum (Gramineae)
Swartzia (Leguminosae)
Syngonanthus (Eriocaulaceae)
Tapura (Dichapetalaceae)
Trachypogon (Gramineae)
Trichoneura (Gramineae)
Willkomia (Gramineae)

2. Aquatic

Eichhornia (Pontederiaceae)
Genlisea (Lentibulariaceae)
Heteranthera (Pontederiaceae)
Wolffiella (Lemnaceae)
Wolffiopsis (Lemnaceae)

3. Predominantly Arid Zones

Fagonia (Zygophyllaceae, also Eurasia)
Haematoxylum (Leguminosae)
Hoffmanseggia (Leguminosae)
Menodora (Oleaceae)
Nicotiana (Solanaceae, also Australia)
Parkinsonia (Leguminosae)
Thamnosma (Rutaceae)
Turnera (Turneraceae)

At generic level, there is a substantial arid southern Africa–Middle East distribution pattern, noted above in a few families (Table 11). This usually involves the dry Horn of Africa and as far east as northwest India (Verdcourt, 1969; de Winter, 1971; van Zinderen Bakker, 1975) and often the Mediterranean basin. Dealt with extensively by de Winter (1971) for all taxonomic levels, notable examples are *Tetrapogon*, *Schismus*, *Stipagrostis* (Gramineae); *Moringa* (Moringaceae) and *Cytinus* (Rafflesiaceae), both also in Madagascar; *Seetzenia* and *Fagonia* (Zygophyllaceae), the latter also in America; *Forskaolea* (Urticaceae); *Tamarix* (Tamaricaceae); *Dyerophytum* (Plumbainaceae); *Gynandriris* (Iridaceae); *Emex* (Polyonaceae); *Oligomeris* (Resedaceae—occurring also in North America; it may be introduced there according to Raven [1971]) (Table 11).

Not involving particularly xeromorphic groups are *Papaver* with one species widespread in eastern South Africa, otherwise in the Northern Hemisphere; *Orobanche* (Orobanchaceae), with one or two species native in southern South Africa; *Ifloga*, *Lasiopogon*, *Leyssera*, and *Lasiospermum* (Compositae), predomi-

nantly of the Cape Region with a single species of each genus north of the Sahara. Other examples (Table 11) include *Myosurus* (Ranunculaceae), also in Australia; *Valerianella* (Valerianaceae) with one species endemic in the Cape Region; *Gladiolus* and *Romulea* (Iridaceae), centered in the Cape but extending through the African highlands to Eurasia; *Matthiola* (Cruciferae), Eurasian with one species in South Africa; *Laurentia* (Campanulaceae), Mediterranean and Cape (American species of *Laurentia* are now placed elsewhere); and *Scabiosa* and *Cephalaria* (Dipsacaceae), centered in Eurasia, but with a few species in the African highlands and several in southern Africa.

NEW WORLD-AFRICAN (-MADAGASCAN) FAMILIES AND GENERA ALSO IN SOUTHERN AFRICA

African-New World distributions, unlike the foregoing, are rather unusual, but for southern Africa involve as many as seven families (Table 9) and many more genera (Table 12). This pattern has been reviewed extensively by Thorne (1972). At the family level are the following examples. In Loasaceae, only the genus *Kissenia* is African and disjunct with one species in the southwest and one in the northeast and also in neighboring southern Arabia. Hydrophyllaceae is predominantly North American (see Raven & Axelrod, 1978 for survey of family), but with *Hydrolea* widespread in the tropics. *Codon*, endemic in southern Africa, is the only exclusively Old World genus of this family. Tecophilaeaceae is predominantly southern in distribution, both in Africa and in South America, but with the monotypic *Odontostomum* in California. Velloziaceae, Hydnoraceae, and Canellaceae, all also in Madagascar and the Neotropics, have no genera common to the New and Old World and are about equally represented on both sides of the Atlantic. Their distribution patterns may well have resulted from relatively ancient disjunctions (Raven & Axelrod, 1974: 607–609). Lastly, Turneraceae, which has seven genera, appears more diversified in Africa, with the two New World genera, *Turnera* and *Piriqueta*, also in Africa. In the case of *Turnera*, the one species in Africa is restricted to Namibia, and the remaining 59 in America.

There are some 111 genera restricted to America and Africa (including Madagascar) as estimated by Thorne (1972) but fewer, an estimated 48 occur in southern Africa. Most appear to belong to easily dispersed groups including for southern Africa, some 12 genera of Gramineae, almost all of tropical savannas, two genera of Compositae, three Leguminosae and two Rubiaceae, also of similar habitats (Table 12). Among aquatics are two genera of Lemnaceae (*Wolffiopsis* and *Wolffiella*); *Genlisea* (Lentibulariaceae); and *Eichhornia* and *Heteranthera* (Pontederiaceae). These two broad groupings involve tropical Africa primarily, with these genera poorly distributed in southern Africa.

Among the more interesting disjuncts are a group of xeromorphic taxa found in arid southwestern Africa and in America. These include *Menodora* (Oleaceae; southwestern Africa, South America and Mexico-southwestern U.S.), *Thamnosma* (Rutaceae; southwestern Africa, northeast tropical Africa and North America), *Nicotiana* (Solanaceae; one species in Namibia, otherwise widespread in America and also in Australia); the Caesalpinioid legumes *Hoffmanseggia*

(south tropical Africa and America), *Parkinsonia* (southwestern and northeastern Africa and tropical America), and *Haematoxylum* (southwestern Africa, Mexico and West Indies); and *Turnera* (Turneraceae), one species of which is endemic in Namibia, the remaining widespread in America.

Most New World-African (-Madagascan) disjunct genera are likely to have achieved this distribution in fairly recent times by long distance dispersal. This would probably have been easiest during the more extreme arid phases of the later Tertiary for the distinctly arid elements. More direct migration would seem unlikely except for the few sufficiently ancient to have been in existence in the Paleogene when Africa and South America were substantially closer (Axelrod & Raven, 1978), with numerous islands in the then shallower Atlantic leaving much smaller water gaps.

Some of the disjunct families, especially those with good representation on both sides of the Atlantic, were probably in existence in the early Tertiary when the Atlantic was much narrower and short distance migration was thus possible. Velloziaceae, Tecophilaeaceae, Turneraceae, Hydnoraceae, and Canellaceae, having differentiated by late Cretaceous in West Gondwanaland, could perhaps have migrated more or less directly or by island hopping into the early Eocene. The only non-American genus of Loasaceae, *Kissenia*, might also have some antiquity in Africa (Raven & Axelrod, 1974).

AUSTRAL TAXA

Families, Subfamilies, and Tribes.—Relatively few taxa are restricted to all of the southern continents (some widespread weeds excepted), and these are mainly at family or subfamily level (Tables 10, 13). These, or elements common only to southern Africa and Australasia, have been the subject of much interest in relation to the Cape Flora (Adamson, 1948, 1958), for most distributions of this type involve the Cape Region more than the rest of southern Africa. Most well known are Proteaceae and Restionaceae and these will be discussed more fully below. Another important example is Cunoniaceae with two genera each with a single species in southern Africa, *Platylophus*, a Cape forest endemic, and *Cunonia*, widespread in the temperate Cape forest and also in sheltered areas in eastern South Africa. *Cunonia* is otherwise restricted to New Caledonia. The most widespread member of Cunoniaceae is the tropical genus *Weinmannia*, occurring in Madagascar and the New World, as well as Asia and Australasia where Cunoniaceae are most diversified.

Haemodoraceae is centered in Australia, but is well represented in the Cape Region by three genera with a fourth, *Barberetta*, in the eastern Cape and Natal. The family also occurs in North and South America. Another monocot alliance, Philesiaceae (Hutchinson, 1959), more usually included in Liliaceae, includes *Behnia* in eastern south and south tropical Africa, and other genera in temperate South America and Australia. To these monocots Liliaceae—Colchicoideae (Wurmbeoideae) can perhaps be added. This subfamily is best developed in southern Africa, with some species in tropical Africa and Madagascar and Eurasia, where the very reduced *Colchicum* (and *Merendera*) and one species of *Androcymbium* occur. *Wurmbea* is disjunct between Africa and Austral-

TABLE 13. Survey of southern (-tropical) African-Australasian genera.

Aizoaceae	
Carpobrotus	17 Cape; 5 Australia, also New World
Disphyma	1 Cape and Australia
Tetragonia	33 southern Africa; 20 Australasia, also South America
Aponogetonaceae	
Aponogeton	12 southern and tropical Africa; 8 Australia, tropical Asia, with 2 fossil records from Argentina
Bombacaceae	
Adansonia	7 Africa and Madagascar; 2 western Australia
Campanulaceae	
Grammatotheca	1 southern Africa and Australia where it may be introduced
Compositae	
Athrixia	12 Africa and Madagascar; 8 Australia
Cotula	Many on all southern continents
Helipterum	12 Cape; 50 Australia
Cunoniaceae	
Cunonia	1 Cape; 12 New Caledonia
Cyperaceae	
Carpha	3 southern Africa; 11 circum-Antarctic
Costularia	3 Africa and Madagascar; 11 Australia
Tetraria	45 Africa (mainly Cape); 5 Australasia and Borneo
Gramineae	
Triraphis	4 tropical and southern Africa; 2 Australia
Iridaceae	
Dietes	5 Africa; 1 Lord Howe Island
Liliaceae	
Bulbinella	5 southern Africa; 10 New Zealand
Caesia	3 South Africa and Madagascar; 5 Australia
Wurmbea	12 southern and tropical Africa; 12 Australia
Menyanthaceae	
Villarsia	1 Cape; 1 southeast Asia; 12 Australia
Myrtaceae	
Metrosideros-Mearnsia	1 Cape; 60 Australasia–Pacific
Podocarpaceae	
Podocarpus	Many on all southern continents, extending to tropics
Portulacaceae	
Anacampseros	40 southern Africa; 1 Australia
Rosaceae	
Acaena	1 Cape and Karoo; 90 circum-Antarctic and California
Sapindaceae	
Atalaya	3 southern Africa; 6 (Indonesia–) Australia
Urticaceae	
Australina	6 tropical and southern Africa; 4 Australasia

asia, whereas *Iphigenia* occurs as well in India and Madagascar. Two other prominent liliaceous disjuncts are *Caesia*, in South Africa, Madagascar, and Australia, and *Bulbinella*, which, with several species in and around the Cape Region and also New Zealand, clearly needs investigation.

The native southern African conifers, *Podocarpus* and *Widdringtonia*, are both clearly Austral (Li, 1953) and are an ancient element. Both are represented in the Neogene fossil record, with *Podocarpus* also recorded from pre-Creta-

ceous time. *Widdringtonia*, which extends from the Cape to Malawi (Kerfoot, 1975), belongs to the widespread Cupressaceae. It is placed in the predominantly southern Callitroideae (only *Tetraclinis* in North Africa occurs in the Northern Hemisphere), and *Widdringtonia* is related closely to the Australasian *Libocedrus*, *Diselma*, and *Austrocedrus* (Gaussen, 1968; Florin, 1963). Northern fossils assigned to *Widdringtonia* probably are misplaced according to Florin.

Three other families, Gunneraceae, Escaloniaceae, and Monimiaceae, each with a single species in southern Africa, may also be considered Austral. The latter, represented by the monotypic *Xymalos* in Africa, is well developed in adjacent Madagascar, and the Mascarene Islands and possibly represents an ancient tropical element now reduced to near extinction in tropical Africa, rather than an Austral one. Monimiaceous wood has been identified from the upper Cretaceous of Pondoland (Muller-Stoll & Mädel, 1962). Dyer (1975) places *Xymalos* in Trimeniaceae and this treatment, if correct, would strengthen the Austral character of the genus with the other representatives of this family being *Trimenia* and *Piptocalyx* in Indonesia, New Guinea, and Australia.

In Leguminosae, the distribution of the relatively primitive Podalyrieae in the Cape Region and Australia has often been cited as an example of the affinities of these floras. Polhill (1976) regards the similarities here as convergent, with Australian and Cape "Podalyrieae," derived independently from unspecialized tropical ancestors (Sophoreae).

Australian-South African Genera.—At the generic level several Austral or African-Australian groups stand out, though the number is small, some 25 (Table 13). In Aizoaceae these include *Disphyma* (one species, salt flats or coastal, Cape and Australia), *Carpobrotus* (about 25 species, mostly coastal, Cape and adjacent areas, Chile, Australia, and California), and *Tetragonia* (about 33 species, desert or coastal in southern Africa, coastal in western South America and Australasia). All seem relatively easily dispersed (Raven, 1973; Seavey & Raven, 1977) and not ancient links between southern land masses.

Among the inuloid Compositae, *Helipterum* (Cape and Australia) and *Athrixia* (Africa, Madagascar, and Australia) are disjunct, although there is some question as to whether Australian representatives are actually congeneric with the African ones (Bentham, 1873: 423). The one species of the Australian *Cassinia* in South Africa is now regarded as belonging to a different though closely related genus, *Rhynea* (Hilliard, 1977). Inuleae are well developed in Australia and in Africa, in the south particularly, but *Gnaphalium* is very widespread, and *Helichrysum*, also well represented in Madagascar, occurs in Eurasia, southern India, Ceylon, and Australia. The group is evidently easily distributed and the connection is probably via Asia.

In Bombacaceae the range of *Adansonia* (9 species) has received much attention with the one or two species in Western Australia apparently closely related to some in Madagascar (Perrier de la Bâthie & Hochreutiner, 1955). Long distance dispersal appears the most likely explanation for this distribution (Raven & Axelrod, 1974). *Dietes* (Iridaceae) is a similar case with five species in east tropical and southern Africa and one, undoubtedly related, on Lord Howe Island between Australia and New Zealand. *Dietes* probably achieved this dis-

tribution through long distance dispersal, although it is not possible to say when and how. *Dietes*, being one of the more primitive African genera of the family, might be of Paleogene origin. The distribution of *Villarsia* (Menyanthaceae) is as remarkable as *Dietes*: there are 12 species in Australia, one in southeast Asia and one in the Cape Region. The Cape *Villarsia capensis* is heterostylous and strongly self-incompatible (Ornduff, 1974) and is related to eastern Australian species rather than to those in western Australia. The distribution of *Atalaya* (Sapindaceae), with three species in southern Africa and six in Indonesia and Australia, probably is another example of long distance dispersal, perhaps in mid-Tertiary times. The occurrence of a single distinctive species of *Mearnsia* ("*Metrosideros angustifolia*") (Myrtaceae; Dawson, 1975) in the Cape Region, the rest of the complex being Australasian and Pacific, may have dispersed around the Indian Ocean like *Adansonia*, but in reverse direction (Raven & Axelrod, 1974).

In Rosaceae, *Acaena*, essentially circum-Antarctic, but in the New World also to California and Hawaii, has only a single species in the Cape Region and nearby mountains and is easily dispersed by birds. The widespread *Cotula* (Compositae) is concentrated in the southern continents. Like *Acaena*, it is probably readily dispersed.

In Cyperaceae, *Carpha* is circum-Antarctic, *Costularia* occurs in Africa, Madagascar, and Australia, and *Tetraria* is found predominantly in the Cape and in Australia. Gramineae—Danthonieae also seems primarily Austral and is particularly well represented in temperate South Africa. If taken in its wide sense, *Danthonia* is a disjunct Austral genus with very minor representation north of the equator, but the African species have been segregated in several genera—*Karoochloa*, *Merxmuellera*, *Dregeochloa*—all of more restricted range. The Austral connection remains, however, at the tribal level.

The predominantly southern distribution of Proteaceae is well known, with the family centered in the Australasian region, but with significant representation in South America and in Africa, where in both areas concentration decreases towards the equator. The phytogeography of the family has recently been critically surveyed (Johnson & Briggs, 1975, 1978). In Africa and Madagascar, only two subfamilies, Grevilleoideae and Proteoideae, of five now admitted by Johnson & Briggs (1975) occur, and only the latter, Proteoideae, are well represented. The family is best developed in the south and 12 of the 13 African genera occur in the Cape Region, where 10 are endemic, including the only strictly African grevilleoid genus, *Brabeium*. The remaining genus *Faurea*, also in Cape temperate forest, is widespread in tropical Africa, and also occurs in Madagascar. Only *Protea* and *Faurea* are well represented in tropical Africa, and *Faurea*, with an elongated inflorescence and forest savanna habitat, appears primitive in the subfamily. Although *Faurea* itself is not likely to have been the direct ancestor of the remaining proteoid genera (Johnson & Briggs, 1963, 1975) a more generalized ancestral form could well have been. African Proteoideae may thus have had an origin from tropical African forest ancestors of the *Faurea* type.

Grevilleoideae, an essentially tropical group (Johnson & Briggs, 1975) has

one genus, *Brabeium*, in the Cape and one, *Malagasia*, in Madagascar. Elsewhere the subfamily occurs in tropical Australasia and in South America. *Brabeium* appears significantly southern until the basically tropical nature of Grevillioideae is recognized, and it seems most likely to be the only surviving representative of a subfamily now extinct in tropical Africa. The existence of *Malagasia*, a monotypic genus of the subfamily in Madagascar, appears to reinforce this point of view. With these facts in mind, I have no difficulty in supporting a tropical African origin for southern African Proteaceae (Levyns, 1958; Beard, 1959; Johnson & Briggs, 1963, 1975; Raven & Axelrod, 1974), and a tropical origin for the family as a whole, as argued by Johnson & Briggs (1963, 1975). This would imply Late Cretaceous dispersal over some water gaps in the subtropical region now occupied by the Indian Ocean (Raven & Axelrod, 1974).

Restionaceae, the other major so-called southern element in the southern African flora, has a distribution similar to that of Proteaceae, although it is represented in South America only by one genus, which is common to Australia. Restionaceae is more diverse anatomically and palynologically in Australasia (Cutler, 1972; Johnson & Briggs, 1978; Ladd, 1977), but there are more species in Africa where the family is almost entirely confined to the Cape and adjacent areas. Only two species, both of *Restio*, the least specialized of the African genera, occur outside South Africa itself, one in Malawi and one in Madagascar. Contrary to some current views, Australasia and Africa share no genera, and the groups found on the two continents are not closely related (Gilg-Benedict, 1930; Johnson & Briggs, 1975, 1978; Cutler, 1969). Reports of Restionaceae pollen from the Eocene of Europe (see Chandler, 1964, for survey) are remarkable if correct (Levyns, 1964; Raven & Axelrod, 1974), and as Johnson & Briggs (1978) suggest, may well represent extinct unrelated or distantly allied monocotyledonous groups. Restionaceae has minor extensions in tropical Asia to Indochina, but seems basically southern, more so than Proteaceae. With more limited fundamental variation in Africa at higher taxonomic levels, Restionaceae may have reached here from Australia by dispersal across a narrow Indian Ocean in the Late Cretaceous. This may best account for its very southern distribution pattern in Africa as suggested by Raven & Axelrod (1974) and Cutler (1972).

Summarizing Austral distribution patterns, there are relatively few genera common to Australasia (and South America) and southern Africa (Adamson, 1958), and these probably achieved this distribution by long distance dispersal. Several seem easily distributed—*Acaena*, *Carpobrotus*, *Tetragonia*, *Costularia*, *Cotula*—while others like *Adansonia*, *Dietes*, *Villarsia*, and *Mearnsia* are so disproportionately represented in one or the other area, that long distance dispersal seems again likely, however difficult this may be to envisage.

At the family level Proteaceae seems basically tropical, and the richness in southern Africa is likely to have evolved from tropical African ancestors rather than from any direct Austral migration. Restionaceae and Cunoniaceae in southern Africa may have been derived from tropical African ancestors now extinct there, but perhaps reached south tropical Africa early in the Paleogene by dispersal across a narrower Indian Ocean. Direct Austral links with the southern

African flora are in fact probably limited to the gymnosperms *Podocarpus* and *Widdringtonia* with other groups having had a history in Africa as a whole (Proteaceae) or having reached south or south tropical Africa early from Australasia.

ORIGINS OF THE FLORA

Simplifying the patterns discussed, it is clear that a large proportion of the southern African flora is part of a cosmopolitan or pantropical flora, including for example Rubiaceae, Gramineae, Leguminosae—Caesalpinioideae, and Cucurbitaceae, groups in which the endemic element is small. Such groups are particularly well represented in the Kalahari-Highveld Region, and become dominant in the Zambezian flora in the northern part of southern Africa. Evolution from tropical African forest and savanna elements for most of the constituents of these regions is suggested, with some taxa arriving from the Asian and New World tropics by long distance dispersal or from Asia by more or less direct migration before the formation of deserts in North Africa and Eurasia.

The arid Karoo-Namib flora received some of its peculiar elements by short distance dispersal or by direct migration from arid Eurasia via Somalia-Kenya (with the reverse also taking place), and conditions for this were probably best when arid phases of the Pleistocene were at a maximum and distances between arid zones least (Verdcourt, 1969; Raven, 1972; van Zinderen Bakker, 1975; Werger, 1978b), or possibly when a continuous arid belt existed across Africa. A few taxa may have reached here directly by long distance dispersal (Axelrod & Raven, 1978) from South America, e.g., *Nicotiana*, *Turnera*, *Menodora*, *Haematoxylum*, also during arid phases of the latest Tertiary and Quaternary. The highly endemic nature of this specialized desert flora, however, suggests that much of it has evolved in southern Africa over a very long period. There has always been a zone of reduced precipitation between tropical and temperate regions, as well as edaphically dry habitats (Axelrod, 1972), where drought adapted plants existed. The present Karoo-Namib flora would thus be derived in part from an ancient xeric stock in which evolution and radiation were promoted from the Neogene as the African climate became progressively drier.

Additions to this ancient stock probably occurred continuously from tropical African elements to the north (Bews, 1925; Levyns, 1964) and from an old temperate southern African flora (Compton, 1929). Woody taxa in the Karoo-Namib have tropical affinities, e.g., *Rhigozum* (Bignoniaceae); *Erythrophysa* (Sapindaceae); *Commiphora* (Burseraceae); *Nymania* (Meliaceae); *Euclea* (Ebenaceae). The relationship between the Cape and Karoo floras has often been noted (Bolus, 1905; Acocks, 1953: 5), and many Compositae, Scrophulariaceae, and Selaginaceae important in the Karoo seem most closely related to Cape rather than to tropical taxa, as is the case with *Oxalis* (Oxalidaceae), *Babiana* and *Gladiolus* (Iridaceae), *Pelargonium* (Geraniaceae), and other herbaceous forms. Relict patches of Cape Flora in favorable sites are characteristic in Namaqualand and the southern Karoo, though the two floras do not appear to merge to any extent (Levyns, 1964).

The Tongaland-Pondoland coastal forest is clearly related to the East African coastal tropical forest, and secondarily to the Guinea-Congolean tropical rain forest. The region is reviewed in detail by Moll & White (1978). It is much restricted now to the most mesic sites in southern Africa and was presumably more widespread in warmer and moister phases of the later Tertiary and Quaternary and ultimately continuous with an earlier, widespread tropical African forest. *Rhynchocalyx* (Lythraceae or Crypteroniaceae (van Beusekom-Osinga & van Beusekom, 1975)) and the cocosoid palm *Jubaeopsis* are conspicuous relicts here.

The Afromontane regions of southern Africa have some taxa in common with similar floras in tropical Africa, such as *Helichrysum* (Compositae), *Craterocapsa* (Campanulaceae), *Kniphofia* (Liliaceae), and *Dierama* (Iridaceae). Its links to the Cape Flora seem much closer, many typical Cape genera extending to the Drakensberg, for example, *Watsonia* (Iridaceae), *Erica* and *Philippia* (Ericaceae), *Cliffortia* (Rosaceae), *Muraltia* (Polygalaceae), and *Aspalathus* (Leguminosae). The contribution of Cape taxa to the Afromontane zones decreases towards the equator, and northern temperate elements become more common, e.g., *Juniperus* (Cupressaceae), *Sedum* (Crassulaceae), *Carduus* (Compositae), *Delphinium* (Ranunculaceae) (Hedberg, 1965). North temperate taxa in the southern African-Afromontane flora are few, including Dipsacaceae, *Lepidium* (Cruciferae), *Thalictrum* (Ranunculaceae), *Vaccinium* (Ericaceae), and *Festuca* and *Koeleria* (Gramineae).

The origin of the Cape Flora, the most distinctive in Africa, presents the greatest problem. As discussed, the so-called Austral or temperate southern element suggestive of ancient links with other southern lands is relatively small. Some of them like Proteaceae may have evolved from ancient tropical African rather than from more temperate southern ancestors derived directly from Australia or South America. At present it seems that a true Austral element is restricted to the conifers *Widdringtonia* and *Podocarpus*, which may have been in southern Africa since these groups evolved and possibly some other elements of the Cape temperate forest (?Cunoniaceae). Restionaceae probably arrived in southern Africa in Late Cretaceous or Paleogene time (Axelrod & Raven, 1978), across a narrower Indian Ocean.

Direct contributions from other floras are minor except from the Karoo-Namib, whence a substantial representation of Aizoaceae, and perhaps other succulents derives. Taxa of north temperate origin apart from Ericaceae—Ericoideae, which might equally be an ancient temperate African group, may be *Lobostemon* and *Echiostachys* (Boraginaceae) (Levyns, 1964), related to the northern *Echium*, and the three endemic genera of Papaveraceae—Fumarioideae, a subfamily centered in the Mediterranean and Middle East. There are few other examples (Burtt, 1971; Quézel, this symposium), e.g., the single native Cape species of *Erodium* (Geraniaceae), *Valerianella* (Valerianaceae), *Ballota* (Labiatae), and *Bupleurum* (Umbelliferae). Other northern genera like *Linum*, *Anemone*, *Silene*, *Scabiosa* and *Dianthus* have species in the Cape but occur elsewhere in southern Africa and often in Afromontane areas as well. In Ericaceae, Levyns (1964) suggests that the family migrated from Eurasia, if so, prob-

ably after mid-Oligocene time, via the African highlands to the Cape. The endemic Cape genera which are highly specialized (Oliver, 1977a) could have evolved once Ericaceae reached the Cape on the peculiar, infertile and acidic sandy soils of the region, but the subfamily can equally well be seen as being an ancient southern group, with migration having taken place from the Cape to Eurasia. The massive speciation in the Cape, however, probably occurred from the Pliocene onward.

For the remainder, such typical elements as Rutaceae–Diosmeae and Thymeleaceae probably evolved gradually from tropical ancestors (Bews, 1925). Significantly the most primitive and widespread genus of Diosmeae, *Calodendrum*, is a broad-leafed tree widespread in Africa (Levyns, 1964), while more primitive broad-leafed Thymelaeaceae such as *Octolepis* and *Peddiea* occur in Africa, in forest habitats, but are not found in the Cape. Origin of the Cape Penaeaceae, all sclerophyllous shrubs, from the broad-leafed African family Oliniaceae, suggested by Levyns (1964), or from other African Myrtales may be a parallel example (Mújica & Cutler, 1974; Rao & Dahlgren, 1969).

Iridaceae, a family most diversified and best represented in Africa, could have evolved the peculiar corm-bearing geophytes of the Cape Region and nearby areas from less drought-adapted, forest forms (e.g., *Dietes*) or from evergreen highland genera (e.g., *Dierama*), as climates deteriorated from the Oligocene onwards (Goldblatt, 1976c). This family is not as strongly restricted to the Cape Region as many others, with many genera quite widespread. Quaternary bursts of speciation apparently have resulted in the overwhelming numbers in the Cape Region today. Papilionoideae—Podalyrieae, Liparieae, and Crotalarieae—so well represented in the Cape and with the latter also in tropical Africa, appear to have differentiated in or near the Cape from Sophoreae still occurring there (Polhill, 1976) and may have radiated subsequently in tropical Africa, Eurasia, and elsewhere.

If it is possible to generalize briefly for so large and diverse a flora, it seems that the Cape Flora is a fundamentally African one as Adamson (1958) and Levyns (1964) asserted, having evolved gradually during the Tertiary from two main sources: first, from an ancient temperate southern African flora probably not much younger than the angiosperm group as a whole (Africa was situated 15°S in the Cretaceous, providing a substantial temperate land surface); second, from tropical African elements, possibly via an upland temperate African pathway. Additions from Eurasia either migrating south in Neogene time and, more recently, along the uplifted African highlands or arriving by long distance dispersal are minor by comparison. The small Austral element of recent genera probably reached the Cape by long distance dispersal (e.g., *Villarsia*, *Metrosideros-Mearnsia*, and *Acaena*). In contrast, ancient Austral cool temperate elements are few, such as *Podocarpus* and *Widdringtonia*, which may be relicts of a truly south temperate (*Nothofagus* type) rain forest such as is still found in southern Australasia and South America.

Evolution of this rich and diverse flora, which has few direct relationships, must have been long and complex. Differences between the Cape Flora and

other African floras surely indicate its great antiquity, reflecting the divergent development of temperate and tropical floras, isolated increasingly since the Paleogene by a belt of increasing aridity. The Cape Flora is essentially the temperate flora of the southern end of Africa, but its peculiarities are strongly linked to the unusual infertile soils of the Cape System. The Mediterranean climate that prevails over most of the Cape Region seems to have been of Quaternary origin (Raven, 1973; Axelrod, 1973) and to have affected the flora mainly by stimulating speciation in an already rich and complex area. Conditions of extreme climatic fluctuation and aridity during the Quaternary would appear to have been directly responsible for the extraordinary richness of the southern African flora. This is in marked contrast to the situation in tropical Africa. Dry phases of this period are believed to have caused massive extinction resulting in the very depauperate tropical African flora (Richards, 1973; Raven & Axelrod, 1974) compared with that of the Neotropics and Asia. It would seem that Africa is the "odd man out" not only in its poor tropical flora but in its remarkably rich southern temperate flora.

THE CAPE AS A MEDITERRANEAN FLORA

The distinctive Cape flora is usually defined by its characteristic element, the fynbos, and I have drawn the boundaries of the Cape Floristic Region around the major belts of this vegetation type. The distribution of fynbos however, follows a geological rather than climatic pattern, with most fynbos, and certainly all fynbos in marginal areas, restricted to sandstones of the Cape System. The climate of southwestern Africa is influenced by winter cyclonic rain, but the pattern of winter rainfall (Fig. 5) does not follow, except very generally, the distribution of Cape sandstones, with winter rainfall extending somewhat inland and far to the north of the Cape Region as here defined. Moreover, in the eastern portion of the Cape Region at least half of the precipitation (Adamson, 1938; Coetzee & Werger, 1975) falls in summer months, and this is especially true of the fynbos-clothed Langeberg, Swartberg, and Outeniqua Mountains of the southern Cape. The dry lowlands between these mountains are more dependent on winter rainfall, which is more important here than any summer precipitation.

The correlation between the Cape Floristic Region and Mediterranean climate is thus a loose one, as pointed out by Marloth (1929) and others, and the adaptations of the fynbos are not primarily to the winter rainfall pattern but more likely to peculiar soils under climates of rather irregular but year-round rain. Of course, many species in the Cape flora, whether fynbos or other vegetation, occur in the western half of the Cape Region, where a strictly Mediterranean climate does prevail. There is no difference in the proportion of winter rainfall (over 70%) in the western part of the Cape Region and in the Karoo-Namib Region to its north and east, but the amount of rainfall decreases outside the Cape Region. Local areas of higher rainfall, however, also have relict patches of Cape flora (Marloth, 1929; Adamson, 1958) though not on notably infertile soils, e.g., *Protea* and *Leucospermum*, Restionaceae, and Ericaceae on the upper Ka-

miesberg; *Phylica*, *Cliffortia*, *Lobostemon*, *Muraltia*, and *Erica plukenetii* on the Spektakelberg; and *Muraltia*, *Cliffortia*, Restionaceae, and Iridaceae on the Roggeveld escarpment and Hantamsberg. These islands of vegetation with some elements of Cape flora do not have Cape sandstone soil, and although they do have as much rainfall as occurs in dry parts of the Cape Region, lack true fynbos. Climate in the Karoo-Namib immediately north of the Cape Region can nevertheless reasonably be called Mediterranean in terms of amount and annual distribution of rainfall, receiving as much moisture as the California Central Valley, the Mediterranean flora of northern Baja California, the dry interior of Spain, or the north coasts of Egypt and Libya.

The Cape Flora, clearly a remarkably distinct floristic unit, occurs in a region of predominantly Mediterranean climate, but, with up to 60% summer rain locally, is thus not strictly the flora of Mediterranean southern Africa. In practical terms it is, however, often convenient to consider it as such, since regions of predominantly winter rainfall to the north have less rain (Fig. 5) and a very characteristic semidesert vegetation unrelated to the Cape fynbos. A rigid definition of the flora of Mediterranean South Africa would, however, probably include all of the Cape Region and parts of the northwestern Cape Province (i.e., Namaqualand) depending on the climatic criteria used.

The Cape Region and Namaqualand have all the characteristics of Mediterranean floras as outlined by Raven (1971, 1973). These are first, medium to low precipitation in the cool part of the year, a dry summer, and flowering concentrated in the spring. Second, a vegetation of sclerophyllous shrubs and evergreen trees with a tendency for small, simple leaves. Third, a strong degree of adaptation to fires, seen especially in the development of underground organs and in seed germination after burning. Fourth, a comparatively rich flora with many very local species. Fifth, an uneven radiation of isolated dicot and monocot groups resulting in several conspicuously large genera and a high species to genus ratio. A rich annual flora is characteristic of the California Floristic Province and the Mediterranean, but there are relatively few annuals in the Cape Region, and not many more in the winter rainfall belt to its north. There also appears to be a poor annual flora in the parts of Western Australia with a Mediterranean climate (Raven, pers. comm.), where the sclerophylls are also associated with infertile soils.

The Cape Region, as compared to other areas of Mediterranean climate, stands out as being particularly rich in species and with very high endemism at species and genus level. Raven (1971) suggests about 10% genera and 40% species endemic in the Mediterranean, while 6.5% genera and 47.7% species are endemic in the California Floristic Province (Raven & Axelrod, 1978) as compared with 20.7% genera and 73.1% species endemic in the Cape Region. The Cape Region also stands out as being unusually high in petaloid monocots which comprise some 16% of the total flora, and though the Cape does not have an unusual number of monocots on a world scale, it has proportionately more monocots than California. The Cape Flora also has far more succulent species than other regions of Mediterranean climate.

Reasons for the unusual richness and high endemism in the Cape Flora are

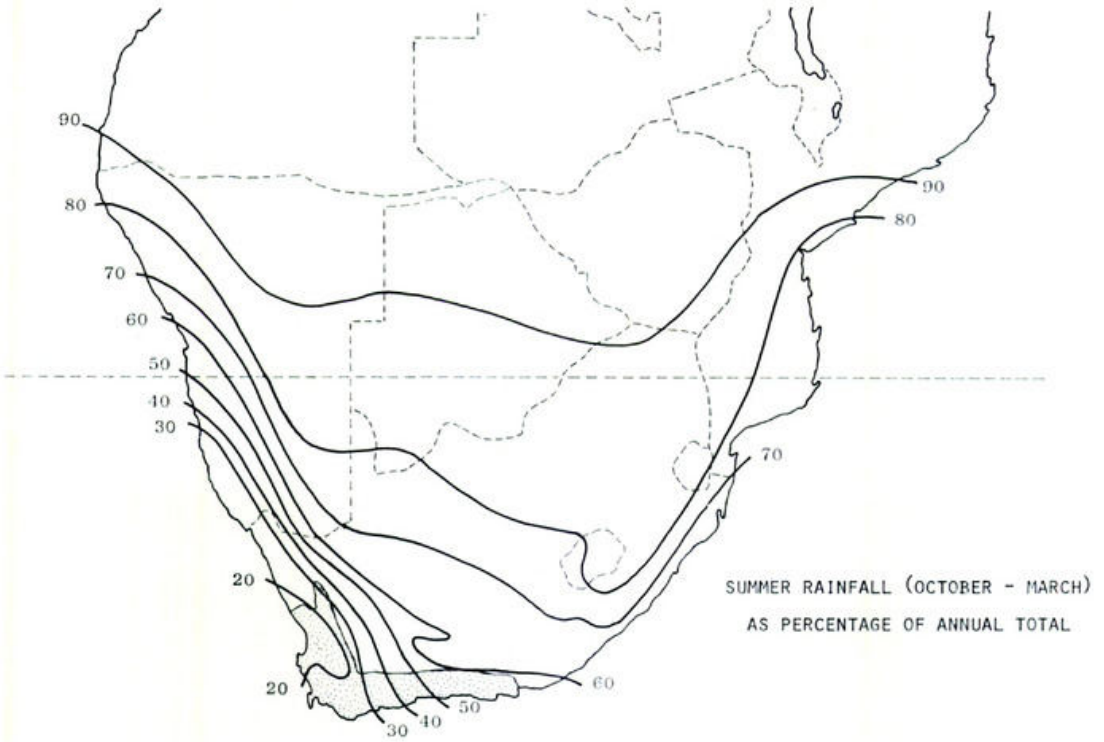

FIGURE 5. Summer rainfall (October–March) as a percentage of the annual total for southern Africa, with the Cape Floristic Region shadowed.

not at all clear. Since climates are comparable in all Mediterranean areas of the world, the explanation must lie elsewhere. It may lie partly in topography and partly in soil. The Cape Region has a very dissected landscape consisting of several steep mountain ranges aligned parallel to the coast and in series behind one another. Each range has appreciable differences in climate and each is isolated from the next by drier flats or valleys, themselves climatically distinct and isolated. This mosaic is reinforced by soil differences, the mountains generally being composed of sandstone rocks and the valleys of shale. There are also large areas of low-lying coastal sands and some limestone.

While this landscape under Mediterranean climatic conditions would obviously promote great species diversity, it is not at all certain that it would account for the far greater numbers of species than are found elsewhere. The topographic and climatic diversity is no more than in California for example. The insect fauna, especially the bee fauna, of the Cape is not particularly rich (Michener, this symposium and pers. comm.), so that a diversity of pollinators does not help in explaining the richness. In fact, the Cape Region is far poorer than California or the Mediterranean in bees, both polylectic and oligolectic. Western Australia, much poorer in species than the Cape (Raven, pers. comm.), has a well-developed series of infertile soils with a characteristic sclerophyllous vegetation that is not confined to regions of Mediterranean climate (Johnson & Briggs, 1978). The topography of Western Australia is much less rugged than in the Cape Region, however, and one might therefore postulate that the unique combination of an equable climate, infertile soils associated with a well-devel-

oped and relatively old (Oligocene ?) sclerophyllous vegetation, a rugged topography, and the multiplying effects of the development of warm season aridity, which by eliminating some kinds of plants allowed others to proliferate extensively, are among the factors responsible for the floristic richness and diversity here.

MODES OF EVOLUTION

There are many books and reviews dealing with plant evolution and speciation in general, but these phenomena have barely been studied in southern Africa. The basic knowledge of the flora is available so the time is ripe for biosystematic and evolutionary research. Though few such investigations have been undertaken, patterns of species distribution and relationships and what is known about hybridization and chromosome cytology do suggest certain trends.

GEOGRAPHIC SPECIATION

Geographic speciation is undoubtedly of primary importance for the southern African flora, especially for areas in the south and west with dry and Mediterranean climates and dissected topography. It would also appear significant in the montane areas of eastern South Africa. This is evident in the recurring pattern in many genera of allopatry or vicarism in closely related species. Levyns (1954) has proposed such a mode of evolution in *Muraltia* (Polygalaceae), and Rourke (1972) envisages geographic speciation in *Leucospermum*. Other Proteaceae appear to exhibit similar patterns of speciation. Bremer (1976a) also draws attention to geographic speciation in his revision of *Relhania* (Compositae), while Strid (1972) mentions examples in *Adenandra* (Rutaceae).

The mode of evolution operating under conditions such as are found in southern Africa (Axelrod, 1967: 203) could account for much of the diversity of species here (Raven, 1964; Axelrod, 1967). Fluctuations in the climate of the world during the late Tertiary and Quaternary had their counterpart in southern Africa where alternating arid and mesic phases occurred (van Zinderen Bakker, 1974, 1978; Schalke, 1973; Tankard & Rogers, 1978). Evolution under circumstances of increasing aridity in areas of moderate to low precipitation promotes geographic isolation (Stebbins, 1952; Raven, 1964) of populations, with consequent differentiation of races, and then species. Geographic speciation, especially in the arid south and west, is likely to have been rapid, and much of the richness at the species level is of recent origin—hence the high species per genus ratios for arid areas of the world and for southern Africa particularly. Uneven evolution of isolated families and genera under these conditions (Stebbins, 1952; Raven, 1972) typically occurs as an accompanying phenomenon.

HYBRID SPECIATION

Speciation at the diploid level through the formation of hybrid complexes—homogamic complexes of Grant (e.g., 1971: 297)—is known to be important in the California flora (Raven & Axelrod, 1978) which is ecologically comparable to the arid and Mediterranean parts of southern Africa. This process is poorly

known in southern Africa, but important in *Streptocarpus* (Gesneriaceae; Hilliard & Burtt, 1971). Many other genera in the flora exhibit features which suggest that hybridization may be significant. Natural hybrids between species of both woody and herbaceous taxa are known notably in *Protea* (Rourke, pers. comm.) and even between genera of Proteaceae (Rourke, 1976), in *Streptocarpus* (Hilliard & Burtt, 1971), *Euryops* (Nordenstam, 1968a), *Erica* (Oliver, 1977b) and in several genera of Iridaceae: e.g., *Babiana*, *Homeria*, and *Gladiolus*. Artificial hybrids are readily produced and often are fertile: e.g., *Zantedeschia* (Araceae; Horn, 1962) and in *Sparaxis*, *Ixia*, *Watsonia*, *Gladiolus* (Iridaceae; Horn, 1962; T. T. Barnard, pers. comm.) but not always so. In two other genera of Iridaceae, *Romulea* and *Moraea*, intersectional hybrids cannot be produced (de Vos, 1972, Goldblatt, unpubl. data) and even within sections only closely related species seem to hybridize easily. Hybrids are also particularly well known in *Rhus* and in *Aloe*. Studies on southern African genera such as those of Nobs (1963) on *Ceanothus* sect. *Cerastes*, a typical member of the California sclerophyll, or of Lenz (1958, 1959) on Californian species of *Iris*, should yield valuable information on this pattern of evolution for southern Africa. Since woody and perennial plants in general often form interfertile hybrids and since they predominate in southern Africa, it can almost be said with certainty that although hybrid speciation has not been demonstrated and only postulated for one genus, *Streptocarpus*, it will most likely prove significant given the diverse environments and recurring climatic changes.

POLYPLOIDY

Chromosome studies in the southern African flora are many, but widely scattered in the literature. A survey of some data suggests that the incidence of polyploidy may be generally low. As might be expected, the frequency of polyploidy is low in woody and shrubby taxa. There are no recorded polyploids in Proteaceae, *Erica*, or *Aspalathus* (Dahlgren, 1971), for example.

In herbaceous and semiherbaceous groups polyploids are recorded for many families and assume some importance. Of 88 species of Mesembryanthemoideae studied by de Vos (1947), 33 were polyploid, almost 38%, and this pattern is evident in more recent studies in Aizoaceae. In *Pelargonium* a survey of chromosome counts for southern African species indicates a similar level of polyploidy, about 30%. For *Streptocarpus* no polyploids have been found in several species counted (Hilliard & Burtt, 1971). In Compositae few polyploids have been reported: in Calenduleae (Norlindh, 1963) 1 of 17 studied; *Euryops* (Nordenstam, 1968b) only 1 of 36 species examined; *Ursinia* (Haesler, 1967) none of 8 examined; *Felicia* (Grau, 1973) 1 species and 1 subspecies of 20 studied; *Relhania* (Bremer, 1976a) none of 18 examined. In all these taxa there is a range of habit from subshrub to herbaceous perennial to annual. *Othonna*, also Compositae, provides a contrast with 5 polyploids out of 35 species examined, while diploids and polyploids occur in 4 more species (Nordenstam, 1967a). In *Nemesia* (Scrophulariaceae) the only predominantly annual genus of southern Africa well known cytologically, all 16 species examined are diploid (Fedorov, 1969).

Turning to monocots, in Iridaceae 27 species of 295 surveyed by Goldblatt (1971) are polyploid, almost 10%. The level of polyploidy is lower, about 5%, for the winter ranifall area (Cape Region and Namaqualand). In Liliaceae, a low frequency of polyploidy is also apparent in *Ornithogalum* where Pienaar (1963) recorded only 2 polyploids in 30 and in *Aloe* where Riley (1959) reported 5% polyploidy. In *Haworthia* Riley (1960) reports 16% polyploidy in the species and 39% polyploidy if infraspecific taxa are included. Only in Gramineae does polyploidy really assume importance and a survey by de Wet (1960) suggests a frequency of about 50% in one small sample.

Thus from the few examples quoted here frequency of polyploidy in southern Africa seems somewhat lower than for the world, which Stebbins (1971) estimates is in the 30–35% range. This is consistent with Stebbins's observation that frequency of polyploidy is lowest in warm temperate areas, being higher in both tropical and cold temperate regions of the world. Except for scattered families and genera, frequency of polyploidy is unknown for southern Africa, and broad comparisons are not yet possible. Sufficient data are, however, available for the subcontinent, and a thorough literature survey will surely yield much data of interest in a field as yet barely touched.

APOMIXIS

There are no large swarms of species comparable to the northern hemisphere genera *Rubus*, *Crataegus*, or *Hieracium* in southern Africa. In this region, apomixis is well known only in Gramineae (Brown, 1958; Brown & Emery, 1958). Apomixis has long been suspected in *Eragrostis* taxa, and has recently been confirmed in the *E. curvula* complex (de Winter, pers. comm.). This mode of reproduction seems likely also in the large species of *Hypoxis* (Wilsenach, 1967; Wilsenach & Papenfus, 1967), and in some bulbous Liliaceae, especially *Ledebouria* and *Drimiopsis* (Jessop, 1970, 1972). Vegetative apomixis is recorded in several Iridaceae [e.g., *Sparaxis bulbifera* (L.) Ker, *Watsonia vivipara* Mathews & L. Bol., *Homeria bulbillifera* Lewis], and is the only form of reproduction in *Watsonia bulbillifera* Mathews & L. Bol. and *Geissorhiza bolusii* Bak. (Goldblatt, 1971). There are no doubt other scattered examples in herbaceous families, but apomixis in general appears insignificant in southern Africa except for Gramineae.

SALTATIONAL SPECIATION AND ANEUPLOIDY

Saltational speciation resulting from catastrophic selection of individuals with considerable chromosomal mutation, usually including numerical change, an idea developed by Lewis (1962, 1966) (see Raven & Axelrod, 1978: 82 for summary) is usually applied to annuals, which are relatively poorly represented in southern Africa, and have not been studied biosystematically at all. Extensive aneuploid sequences occur in several perennial herbaceous groups, and chromosomal changes are implicated in speciation in these groups. Some examples are *Moraea*, *Galaxia*, and *Romulea* (Iridaceae; Goldblatt, 1976a; de Vos, 1972) and *Lachenalia* (Liliaceae; Ornduff, pers. comm.). In Compositae aneu-

ploidy has been recorded in Calenduleae (Norlindh, 1963) in the *Pentzia-"Matricaria"-Sphaeroclinium* alliance (Nordenstam, 1967b; Mitsouka & Ehrendorfer, 1972), and in *Felicia*, where reduced base numbers are correlated with the annual habit.

Introduced Plants

I have made no attempt to gather comprehensive data on introduced plants in southern Africa, and adventives have been excluded from all statistics provided. Apart from the typical spectrum of cosmopolitan and herbaceous weedy introductions, tropical and temperate, there are some unusual problems, focused mainly in the Cape Region, and these do warrant mention.

Particularly serious introductions now widely naturalized in the Cape Region are a number of woody plants mainly of Australian origin. These include *Acacia longifolia* (Jacq.) Willd., *A. saligna* (Labill.) Wendl., *A. cyclops* Cunn., and *Albizzia lophantha* (Willd.) Benth. [*A. distachya* (Vent.) MacBride] (Leguminosae); *Hakea suaveolens* R. Br. and *H. tenuifolia* (Salisb.) Domin. (Proteaceae); *Leptospermum laevigatum* F. Muell. and *Eucalyptus lehmannii* Preiss (Myrtaceae), all Australian; and the southern European *Pinus pinaster* Ait. (see summary by Hall & Boucher, 1977). All exhibit a pattern of fast regeneration after fire and grow more rapidly than the native flora. The flora in the Cape Region comprises predominantly shrubs or herbs which are often out-competed and excluded in their native habit by these aliens. Dense stands of woody introduced species are now common throughout the Cape Region, and the flora is in danger of complete replacement in many large areas and in the long term perhaps entirely. Kruger (1977) has estimated that some 60% of the fynbos, which is especially affected by this alien element has been replaced. This is an alarming figure as it means that about one quarter of the entire area of the Cape Floristic Region is now dominated to varying degrees by naturalized alien species. These especially serious weeds are mostly native in areas of infertile soils, and their success in Cape fynbos reflects their ability to thrive on such soils in the Cape Region.

Other notable naturalized introductions, also Australian, are *Acacia melanoxylon* R. Br. in forested areas of the south and east coast, again a severe competitor of the native forest flora, and *Acacia mearnsii* D. Wild., widespread in the well-watered parts of the plateau where it is sometimes conspicuous as the only tree in grasslands. The *Lantana camara* complex, introduced species of *Rubus*, *Sesbania punica* (Cav.) Benth., *Canna* species, and *Eupatorium odoratum* L. are among the particularly serious pests in disturbed areas of forest and grassland along the equable eastern coast and interior, while *Opuntia* species (Cactaceae) still cause major problems (Arnold, 1977) in dry parts of the eastern Cape. Stirton (1978) cites 63 invasive plant species, of which approximately 20 are major pests in southern Africa.

Annual and herbaceous weeds are mostly encountered in disturbed sites along roadsides, and in farmed land. Often serious in agricultural areas, they have poor capabilities of becoming permanently established in undisturbed situations and are unimportant at present in relation to the native flora.

CONSERVATION

It follows from the previous section that the floras of the Cape Region and, secondarily, also forests of the eastern part of southern Africa are being seriously affected by alien flora in addition to the usual threats from agriculture, urbanization, and pollution. The situation in the Cape Region is most severe (Esterhuysen, 1966; Taylor, 1978), especially when the other factors affecting the flora besides alien vegetation are considered. This is the part of southern Africa first settled by Europeans, and it has been under intensive cultivation for at least fifty years and much longer in some areas. Probably all sites suitable for agriculture have been or are now in use. Areas once farmed do not revert readily to natural vegetation but are often colonized by alien plants. Farmland may comprise another quarter of the area of the Cape Region, and this in effect means that the area of the Cape Region now occupied by native flora is probably less than half the total. Much of this relatively untouched area is mountainous so that the flora of lowland areas is seriously depleted, with the situation along the south and west coast especially severe.

As this is one of the richest areas floristically in the world, and as there are numerous species of very limited range, it is clear that apart from the flora as a whole, which is endangered, large numbers of species are very seriously threatened with extinction. A. V. Hall (pers. comm.) has suggested that in the Cape Region, and Karoo to the north, including all territory south of the Orange River, there are perhaps some 1,500 species seriously threatened and at least 38 presumed extinct. Taylor (1978) estimates that about 500 species in the Cape Floristic Region are threatened, and some 60 extinct. In Natal there is very little native coastal forest left as a result of the expansion of population, the use of coastal areas for recreation, and intensive agriculture, especially of sugar cane. Although this vegetation type has counterparts to the north and has relatively few endemics in southern Africa, its loss for South Africa would be disturbing. However, several important remaining forests are now conserved.

Other regions have a less vulnerable flora which is reasonably unaffected by moderate animal grazing and can reestablish itself after land is returned from agriculture. Overgrazing is, however, serious in many areas, especially in underdeveloped countries like Lesotho and Botswana (Jacot-Guillarmod, 1968, 1971; Wild, 1968) but elsewhere too, with the accompanying erosion causing irreversible changes in the flora. Changes are of course occurring in some parts of all the floristic regions of southern Africa as a result of man's use of the land, but are more subtle even though equally serious biologically in the Karoo, Kalahari, and Highveld areas. Acocks (1953) has estimated the changes in the South African flora since 1400 AD and suggests massive reduction in forest with increases in fynbos and grassland. More disturbing are his estimates of increasing desertification and spread of the Karoo flora at the expense of grassland. This trend, if continued, would by the year 2050 leave nearly half of southern Africa true desert, and semidesert flora would occupy some presently forested areas.

Southern Africa has the dubious distinction of having in the Cape Region one of the most seriously threatened floras in the world (Raven, 1977). The situation in the rest of the subcontinent is not nearly so severe, but in the Cape

Region conditions continue to deteriorate with the spread of aliens evidently uncontrolled. Much attention is being given to problems of the Cape and elsewhere (Kruger, 1977; Stirton, 1978) and conservation is actively preached though not always practiced. Unfortunately, conservation in Africa generally means conservation of fauna, sometimes even at the expense of the flora. This point of view is being countered gradually. Reserves are now being established in many places by state and local governments, while there are several botanical gardens in South Africa, almost as many as in the rest of Africa combined. Promising signs are the establishment of reserves to protect individual taxa that are seriously threatened or particularly unusual. Innumerable private reserves in the hands of farmers and other large landowners also provide small sanctuaries for native flora. Official and public consciousness of native flora is higher than it has ever been, which offers hope, but the overwhelming floral richness and diversity in southern Africa makes conservation especially difficult.

Stable and strong government is essential for the control and planning for a rapidly expanding population which at present is doubling each 25 years and will reach more than 50 million by the year 2000. Unless stability and order are maintained, pressures could well result in serious overgrazing, careless management of resources, uncontrolled utilization of remaining forests even for fuel, all of which could culminate in biological disaster for this floristically rich and unique area of the world.

Directions for the Future

The southern African flora is relatively well known, and though there are still many more species to be described and some even uncollected, undescribed taxa cannot comprise more than a tiny portion of the known total. The time is now appropriate for the cataloging of the flora, which is already well underway with the *Flora of Southern Africa*, begun in 1957 and now accelerating, with 8% of the species completed (Killick, 1976). There is also a need for more local floras, covering phytogeographic regions as well as political subdivisions, so that comparisons of local areas can be made and differences interpreted and analyzed. Good local floras are already available for Swaziland (Compton, 1976), Lesotho (Jacot-Guillarmod, 1971), Natal (Ross, 1972) and the Cape Peninsula (Adamson & Salter, 1950), and a few more checklists are available. Effective assembling of information on the flora of more than 18,500 species will undoubtedlly be tremendously helped by the current computerization of the National Herbarium in Pretoria. With this facility operative all basic data on the flora and its components would become more easily available and much of the drudgery of plant systematics should be circumvented.

Apart from the recording, cataloging, and describing of the flora by plant systematists, there is a need to begin with biosystematic, evolutionary, and population studies in southern Africa. Little research on these lines has been done as yet, although studies by Pienaar (1963), de Vos (1972), and Rourke (1972, 1976) are a notable beginning. Such work can easily be undertaken with the basic knowledge of plant species and their ranges known, if not always conveniently available in a written flora, and need not be done in conjunction with

revisionary work. In fact, as Raven (1974) has stressed, the uncoupling of evolutionary and revisionary studies would enhance progress in evolutionary and population biology. Only when a range of such studies is available will some basic questions about the flora be answered. We do not know why there should be so few annuals in southern Africa where many more would be expected to occur. Little is known from experimental evidence of the patterns of evolution and speciation in woody, herbaceous, or annual taxa. A start should be made by compiling known data on cytology and hybridization in the flora. An appreciable amount of basic cytology may have already been done but data is widely scattered.

There are also many questions on the origin of endemic and characteristic southern African plants that could be investigated in detail—the relationship and possible ancestry of *Calodendron* to the remaining, all endemic, Diosmeae; the origin and relationships of Thymelaeeae; reasons for the extraordinary richness of succulents in the flora and the evolution and speciation in Mesembryanthemoideae particularly. Equally problematic are questions on the remarkable richness of petaloid monocots in southern Africa. Explanations will remain speculative on many of these subjects until some basic and detailed population studies are made on selected groups. When a pool of such studies is available, overall trends and patterns will begin to be perceived and evaluated.

Finally, a reasonable understanding of the southern African flora will be achieved only with the help of a fossil record which is desperately incomplete at present. There are good reasons why there are fewer plant fossils in southern Africa of Tertiary age, but there are certainly many more than have been studied thus far (Martin, 1953). The assemblage from Banke in Namaqualand (Axelrod & Raven, 1978) illustrates just how valuable even a small fossil flora can be in interpreting age and relationships of the flora. A systematic search for appropriate sites for Tertiary plant fossils should yield exciting results while a reinvestigation of Banke for more material should receive priority. Only with a good understanding of the history of the flora can its present status be properly appreciated.

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Appendix 1

Families of seed plants in southern Africa, with numbers of genera, species and endemism.

Family	Number of Genera	Endemic Genera	Number of Species	Endemic Species
Acanthaceae	41	5	355	236
Achariaceae	3	3	3	3
Aizoaceae	135	113	2,021	1,987
Alismataceae	3	—	3	—
Amaranthaceae	20	3	53	20
Amaryllidaceae	17	10	199	163
Anacardiaceae	10	4	93	67
Annonaceae	8	—	13	—
Apocynaceae	16	1	39	12
Aponogetonaceae	1	—	7	4
Aquifoliaceae	1	—	1	—
Araceae	5	—	13	6
Araliaceae	3	1	11	6
Aristolochiaceae	1	—	1	—
Asclepiadaceae	60	20	605	526
Avicenniaceae	1	—	1	—
Balanitaceae	1	—	3	—
Balanophoraceae	2	1	3	2
Balsaminaceae	1	—	4	2
Basellaceae	1	—	1	—
Begoniaceae	1	—	5	3
Bignoniaceae	6	—	11	2
Bombacaceae	1	—	1	—
Boraginaceae	13	3	81	60
Bruniaceae	12	12	75	75
Burmanniaceae	1	—	1	—
Burseraceae	1	—	31	13
Buxaceae	1	—	2	2
Cabombaceae	1	—	1	—
Cactaceae	1	—	1	—
Callitrichaceae	1	—	2	—
Campanulaceae	18	11	380	350
Canellaceae	1	—	1	—
Capparaceae	8	—	49	15
Caryophyllaceae	8	—	40	30
Celastraceae	12	3	58	29
Ceratophyllaceae	1	—	1	—
Chenopodiaceae	12	2	108	92
Chrysobalanaceae	1	—	2	—
Clusiaceae	1	—	2	1
Combretaceae	5	—	35	7
Commelinaceae	6	—	28	1
Compositae	174	80	2,072	1,801
Connaraceae	2	—	2	—
Convolvulaceae	15	—	94	28

APPENDIX 1. *Continued*

Family	Number of Genera	Endemic Genera	Number of Species	Endemic Species
Cornaceae	1	—	1	—
Crassulaceae	5	2	219	194
Cruciferae	15	8	109	100
Cucurbitaceae	17	—	67	21
Cunoniaceae	2	1	2	2
Cupressaceae	1	—	3	2
Cyperaceae	30	7	421	218
Dichapetalaceae	2	—	3	—
Dioscoreaceae	1	—	17	5
Dipsacaceae	2	—	24	19
Dipterocarpaceae	1	—	1	—
Droseraceae	2	—	19	13
Ebenaceae	2	—	34	19
Elatinaceae	2	—	11	4
Ericaceae	24	19	799	797
Eriocaulaceae	2	—	11	7
Erythroxylaceae	2	—	5	3
Escalloniaceae	1	—	1	—
Euphorbiaceae	41	4	389	310
Flacourtiaceae	13	1	25	9
Flagellariaceae	1	—	1	—
Frankeniaceae	1	—	3	2
Geissolomaceae	1	1	1	1
Gentianaceae	7	1	62	47
Geraniaceae	5	—	271	261
Gesneriaceae	2	1	43	42
Goodeniaceae	1	—	2	—
Gramineae	169	21	743	330
Greyiaceae	1	1	3	3
Grubbiaceae	1	1	3	3
Gunneraceae	1	—	1	—
Haemodoraceae	4	4	12	12
Haloragidaceae	2	—	3	—
Hamamelidaceae	1	—	3	2
Hernandiaceae	1	—	1	—
Hydnoraceae	1	—	3	3
Hydrocharitaceae	4	—	11	—
Hydrophyllaceae	1	1	2	2
Hydrostachyaceae	1	—	1	—
Hypericaceae	1	—	7	4
Hypoxidaceae	6	5	83	79
Icacinaceae	3	—	6	—
Iridaceae	44	27	846	816
Illecebraceae	4	—	9	5
Juncaceae	3	1	19	6
Juncaginaceae	1	—	2	—
Labiatae	31	2	225	161
Lauraceae	4	—	11	7
Lecythidaceae	1	—	1	—
Leguminosae	115	20	1,495	1,114
Lemnaceae	6	—	9	1
Lentibulariaceae	2	—	18	1
Liliaceae	54	21	907	803
Linaceae	2	—	6	4
Loasaceae	1	—	1	1
Loganiaceae	5	—	24	5

APPENDIX 1. *Continued*

Family	Number of Genera	Endemic Genera	Number of Species	Endemic Species
Loranthaceae	12	2	54	23
Lythraceae	7	1	35	15
Malpighiaceae	3	—	13	7
Malvaceae	14	2	122	39
Melastomataceae	4	—	9	1
Meliaceae	6	1	12	1
Melianthaceae	2	1	14	12
Menispermaceae	7	1	13	4
Menyanthaceae	2	—	2	1
Monimiaceae	1	—	1	—
Montiniaceae	1	—	1	—
Moraceae	4	—	27	3
Moringaceae	1	—	1	—
Musaceae	2	—	6	4
Myricaceae	1	—	9	7
Myrothamnaceae	1	—	1	—
Myrsinaceae	4	—	7	4
Myrtaceae	4	—	8	2
Najadaceae	1	—	3	—
Neuradaceae	2	2	7	7
Nyctaginaceae	4	1	10	5
Nymphaeaceae	1	—	4	—
Ochnaceae	2	—	13	3
Olacaceae	2	—	3	—
Oleaceae	5	—	22	12
Oliniaceae	1	—	4	2
Onagraceae	3	—	11	—
Opiliaceae	1	—	1	—
Orchidaceae	54	15	461	371
Orobanchaceae	1	—	1	—
Oxalidaceae	2	—	203	199
Palmae	5	1	6	1
Papaveraceae	5	4	7	7
Passifloraceae	4	—	17	6
Pedaliaceae	8	—	29	12
Penaeaceae	7	7	21	21
Phytolaccaceae	2	—	5	—
Piperaceae	2	—	6	—
Pittosporaceae	1	—	1	—
Plantaginaceae	1	—	10	7
Plumbaginaceae	3	—	21	19
Podocarpaceae	1	—	4	2
Podostemaceae	4	—	4	—
Polygalaceae	4	1	201	176
Polygonaceae	4	—	31	14
Pontederiaceae	3	—	3	—
Portulacaceae	5	1	56	49
Potamogetonaceae	1	—	7	—
Primulaceae	3	—	7	—
Proteaceae	13	10	336	326
Ptaeroxylaceae	1	—	1	—
Rafflesiaceae	1	—	3	3
Ranunculaceae	7	—	25	14
Resedaceae	1	—	3	2
Restionaceae	12	11	316	316
Retziaceae	1	1	1	1

APPENDIX 1. *Continued*

Family	Number of Genera	Endemic Genera	Number of Species	Endemic Species
Rhamnaceae	9	1	156	144
Rhizophoraceae	4	—	8	2
Roridulaceae	1	1	2	2
Rosaceae	9	—	133	125
Rubiaceae	59	8	234	122
Ruppiaceae	1	—	2	—
Rutaceae	23	13	271	255
Salicaceae	1	—	5	3
Salvadoraceae	2	—	3	—
Santalaceae	6	2	144	136
Sapindaceae	13	2	23	7
Sapotaceae	7	—	14	1
Scrophulariaceae	51	16	515	447
Selaginaceae	10	7	210	204
Simaroubaceae	1	—	3	2
Solanaceae	3	—	59	44
Sphenocleaceae	1	—	1	—
Stangeriaceae	1	1	1	1
Sterculiaceae	6	—	169	143
Stilbaceae	5	5	13	13
Tamaricaceae	1	—	1	—
Tecophilaeaceae	2	1	10	9
Thymelaeaceae	8	2	179	170
Tiliaceae	4	—	49	11
Trapaceae	1	—	1	—
Turneraceae	4	—	9	1
Typhaceae	1	—	1	—
Ulmaceae	3	—	5	—
Umbelliferae	32	13	155	140
Urticaceae	11	—	27	15
Vahliaceae	1	—	2	—
Valerianaceae	2	—	2	1
Velloziaceae	2	1	9	3
Verbenaceae	9	—	55	29
Violaceae	3	—	8	3
Vitaceae	5	—	48	20
Welwitschiaceae	1	—	1	—
Xyridaceae	1	—	10	7
Zamiaceae	1	—	25	25
Zannichelliaceae	4	—	5	1
Zingiberaceae	1	—	2	—
Zosteraceae	1	—	1	—
Zygophyllaceae	7	3	46	43
TOTAL	1,859	559	18,327	14,808

Appendix 2

Genera endemic in southern Africa, with numbers of species and general distribution. A total of 559 genera are endemic in southern Africa and 190 are endemic in the Cape Floristic Region. (Abbreviations: Namaq. = Namaqualand; O.F.S. = Orange Free State; Tvl. = Transvaal; S.W. Cape includes the whole Cape Floristic Region).

Acanthaceae

Acanthopsis 8—Namibia to Karoo
Aulojusticia 1—E. Tvl.
Chaetacanthus 3—Tvl., O.F.S., Natal to S. Cape
Glossochilus 2—Tvl., Botswana, N. Cape
Mackaya 1—E. Tvl. to E. Cape

Achariaceae

Acharia 1—S. Cape (van Stadens) to Natal
Ceratosicyos 1—S. Cape (Knysna) to E. Tvl.
Guthriea 1—E. Cape to Natal

Aizoaceae

Acrodon 3—S. Cape
Acrosanthes 5—S.W. Cape
Adenogramma 10—Mainly S.W. Cape to S. Namibia, E. Cape
Aethephyllum 1—S.W. Cape
Aloinopsis 15—Mainly Karoo to N. Cape, Namaq.
Amoebophyllum 1—S.W. Cape
Amphibolia 3—W. Karoo (Tanqua), S. Namaq.
Anisocalyx 1—Namaq. (Kommagas)
Antegibbaeum 1—S. and Little Karoo
Apatesia 4—W. Cape
Aptenia 1—E. Cape coast
Argyroderma 10—S. Namaq.
Aridaria 5—S.W. Cape, Karoo to Namibia
Aspazoma 1—Namaq.
Astridia 10—N. Namaq. to S. Namibia
Bergeranthus 11—E. Cape to O.F.S.
Berrisfordia 1—Namaq. (Kamiesberg)
Bijlia 1—S. Karoo (Prince Albert)
Braunsia 3—S.W. Cape
Calamophyllum 3?—Karoo
Carpanthea 2—S.W. Cape
Carruanthus 2—S. Karoo (Willowmore)
Caryotophora 1—S. Cape (Bredasdorp)
Cephalophyllum 60—S.W. Cape, Namaq. to S. Namibia
Cerochlamys 1—Little Karoo
Chasmatophyllum 6—Karoo, O.F.S., S. Namibia
Cheiridopsis 91—W. Cape, Namaq., S. Namibia
Coelanthum 3—S.W. Cape to S. Namibia
Conicosa 10—S.W. Cape to Karoo
Conophytum 210—S.W. Cape, Namaq., Karoo, S. Namibia
Cylindrophyllum 5—S. and Little Karoo
Dactylopsis 1–2—S. Namaq. (Knersvlakte)
Dicrocaulon 6—W. Cape, Namaq.
Didymaotus 1—Ceres Karoo
Dinteranthus 4—S. Namibia, N. Cape
Diplosoma 1—W. Cape (Piketberg)
Dorotheanthus 10—S.W. Cape to Namaq.
Drosanthemum 90—Mainly S.W. Cape to S. Namibia, Karoo, and E. Cape
Eberlanzia 25—Widespread, mainly arid areas
Ebracteola 3—Namibia
Enarganthe 1—Namaq. (Richtersveld)
Erepsia 36—S.W. Cape to E. Cape
Esterhuysenia 1—S.W. Cape (Worcester)
Eurystigma 1—Ceres Karoo
Faucaria 33—S. Cape to S. Karoo, E. Cape
Fenestraria 2—Namaq. (Richtersveld) to S. Namibia
Frithia 1—Central Tvl.
Gibbaeum 15—Mainly Little Karoo to S. Karoo
Glottiphyllum 56—S.W. Cape, Karoo to E. Cape
Hereroa 34—Cape Prov., O.F.S., Namibia
Herrea 24—S.W. Cape, Namaq., W. Karoo
Herreanthus 1—Namaq. (Steinkopf)
Hymenogyne 2—W. Cape
Jacobsenia 2—S. Namaq. (Knersvlakte)
Jensenobotrya 1—S. Namibia (Lüderitz)
Juttadinteria (incl. *Dracophilus*, *Namibia*) 12—N. Namaq., S. Namibia
Kensitia 1—W. Cape (Piketberg)
Khadia 6—Tvl.
Lampranthus 72—S.W. Cape to Namaq., S. Namibia
Lapidaria 1—S. Namibia (Warmbad)
Leipoldtia 19—S.W. Cape, Namaq., S. Namibia
Lithops 40—Widespread except eastern regions
Machairophyllum 8—S.W. Cape to E. Cape
Malephora 13—S.W. Cape to Karoo, S. Namibia
Maughaniella 1—S. Namaq. (Knersvlakte)
Mestoklema 6—E. Cape, Karoo, N. Cape, S. Namibia
Meyerophytum 4—Namaq.
Micropterum 6—S.W. Cape, Namaq., Karoo
Mitrophyllum 6—S. Namaq. (Knersvlakte)
Monilaria 5—S. Namaq.
Mossia 1—S. Tvl., O.F.S.
Muiria 1—S. Cape (Riversdale)
Namaquanthus 1—Namaq.

APPENDIX 2. *Continued*

Nananthus 9—Karoo, Kalahari
Nelia 4—N. Namaq. (Richtersveld)
Neohenricia 1—Karoo
Octopoma 3—S.W. Cape to Namaq.
Odontophorus 3—Namaq. (Steinkopf)
Oophytum 2—S. Namaq. (Knersvlakte)
Ophthalmophyllum 19—Namaq., S. Namibia
Orthopterum 2—E. Cape
Ottosonderia 2—Namaq.
Pherolobus 1—W. Karoo (Calvinia)
Platythyra 1—E. Cape (Swartkops R.)
Pleispilos 33—Mainly O.F.S., Little Karoo
Plinthus 4—Widespread in arid areas
Polpoda 2—S.W. Cape
Polymita 1—Namaq. (Richtersveld)
Prenia 5—S.W. Cape to S. Namibia
Psammophora 4—N. Namaq., S. Namibia
Rabiea 7—Karoo, N. Cape, O.F.S.
Rhinephyllum 2—Karoo
Rhombophyllum 3—E. Cape, Karoo
Ruschia 326—Widespread except eastern region
Ruschianthemum 1—Namaq., S. Namibia
Ruschianthus 1—S. Namibia (Numeis)
Saphesia 1—W. Cape (Kalbaskraal)
Scletium 22—S.W. Cape, Karoo, N. Cape
Schlecteranthus 2—Namaq. (Richtersveld)
Scopelogena 2—S.W. Cape (Peninsula–Swellendam)
Semnanthe 1—S.W. Cape (Paarl–Stellenbosch)
Skiatophyllum 1—W. Cape
Smicrostigma 1—S.W. Cape
Sphalmanthus 30—S.W. Cape to S. Namibia, Karoo, O.F.S.
Stayneria 1—S.W. Cape (Worcester)
Stoeberia 2—N. Namibia (Lüderitz)
Stomatium 44—Karoo, O.F.S., N. Cape
Synaptophyllum 1—S. Namibia (Lüderitz)
Titanopsis 4—Namaq., N. Cape, S. Namibia
Vanheerdea 4—Karoo
Vanzylia 3—W. Cape to S. Namaq.
Wooley 1—Namaq. coast
Zeuktophyllum 1—S. Cape (Riversdale Karoo)

Amaranthaceae

Arthraerua 1—Namibia (Namib Desert)
Calicorema 2—Central and W. Namibia to N.W. Cape
Leucosphaera 1—Namibia, Botswana, N.W. Cape

Amaryllidaceae

Amaryllis 1—S.W. Cape
Apodolirion 4—S. Cape to E. Tvl.
Carpolyza 1—S.W. Cape
Clivia 4—E. Cape to Tvl., forests
Cybistetes 1—S.W. Cape
Gethyllis 18—S.W. Cape to Namaq.
Haemanthus 9—Widespread
Hessea 12—S.W. Cape–Namibia, Karoo
Nerine 20—Widespread, mainly E. Cape to Tvl.
Strumaria 8—Namibia, Namaq. to W. Cape

Anacardiaceae

Heeria 1—S.W. Cape
Laurophyllus 1—S.W. Cape
Loxostylus 1—S. Cape to S. Natal
Smodingium 1—Tvl. to E. Cape

Apocynaceae

Gonioma 1—S. Cape to Natal

Araliaceae

Seemanaralia 1—Tvl. to E. Cape

Asclepiadaceae

Anisotoma 2—Natal to E. Cape
Astephanus 2—C. and E. Cape to Namaq.
Cordylogyne 1—Widespread mainly in E. Highlands
Dregea 3—Widespread except in S.W. Cape
Ectadium 2—Namibia and Namaq.
Emplectanthus 2—Natal
Eustegia 5—Namaq., S.W. Cape
Fanninia 1—Natal to E. Cape
Hoodia ca. 10—Namibia, N.W. Cape, N.W. Tvl.
Huerniopsis 3—Namibia, Botswana, N. Cape
Macropetalum 1—Tvl., O.F.S.
Microloma 12—Namibia, Namaq., S.W. Cape
Oncinema 1—S.W. Cape
Orbeanthus 2—N. Tvl.–Natal Drakensberg
Parapodium 3—Tvl., O.F.S., N.E. Cape
Pectinaria 5—N.W. and Central Cape
Rhyssolobium 1—Namaq.
Sisyranthus 12—Widespread except in S.W. Cape
Stapeliopsis 2—Namibia to Namaq.
Woodia 3—Tvl. to S. Cape

Balanophoraceae

Mystropetalum 2—S.W. Cape

Boraginaceae

Echiostachys 3—S.W. Cape
Lobostemon 28—S.W. Cape, Namaq., W. Karoo
Tysonia 1—E. Cape, Natal Drakensberg

APPENDIX 2. *Continued*

Bruniaceae

Audouinia 1—S.W. Cape
Berzelia 12—S.W. Cape to E. Cape
Brunia 7—S.W. Cape
Linconia 2—S.W. Cape
Lonchostoma 5—S.W. Cape
Mniothamnea 2—S.W. Cape
Nebelia 6—S.W. Cape
Pseudobaeckia 4—S.W. Cape
Raspalia 6—S.W. Cape, Natal
Staavia 10—S.W. Cape
Thamnea 7—S.W. Cape
Tittmannia 4—S.W. Cape

Campanulaceae

Grammatotheca 1—S.W. Cape (? introd. to Australia)
Merciera 4—S.W. Cape
Microcodon 4—S.W. Cape
Namacodon 1—Namib Desert
Prismatocarpus 30—Mainly S.W. Cape to Namaq., E. Cape
Rhigiophyllum 1—S.W. Cape
Roella 24—Mainly S.W. Cape to E. Cape
Siphocodon 2—S.W. Cape
Theilera 1—S.W. Cape
Treichelia 1—S.W. Cape
Unigenes 1—S.W. Cape

Celastraceae

Hartogia 1—Tvl. to S.W. Cape
Maurocenia 1—S.W. Cape
Pseudosalacia 1—S. Natal

Chenopodiaceae

Exomis 1—Namaq., Karoo, Namibia
Manochlamys 1—Namibia, Namaq., S.W. Cape

Compositae

Adenanthemum 1—E. Tvl. highveld
Adenoglossa 1—Namaq.
Alatoseta 1—S. Karoo (Laingsburg)
Alciope 2—S.W. Cape
Amellus 12—S.W. Cape to Namibia, Karoo
Amphiglossa 4—S.W. Cape to Namibia
Anaxeton 9—S.W. Cape
Anisochaeta 1—Transkei to Natal
Anisothrix 1—S.W. Cape (Montagu)
Antiphiona 2—Namibia
Antithrixia 1—Namaq.
Arrowsmithia 1—E. Cape (King Williams Town)
Asaemia 2—Margin of S.W. Cape to Namibia
Brachymeris 6—Tvl., Swaziland
Bryomorphe 1—S.W. Cape
Cadiscus 1—W. Cape (Malmesbury)
Callilepis 5—Tvl. to E. Cape
Castalis 3—S.W. Cape, Tvl.
Comptonanthus 3—S.W. Cape (Witteberg) to Karoo and Namibia
Corymbium 10—Mainly S.W. Cape to E. Cape
Cullumia 15—S.W. Cape to Karoo
Cuspidia 1—S. Cape to Karoo, E. Cape
Cymbopappus 3—S.W. Cape, Natal, E. Tvl.
Didelta 2—W. Cape, Namaq., Namibia
Disparago 7—Mainly S.W. Cape to E. Cape
Dymondia 1—S. Cape (Bredasdorp)
Elytropappus 8—Mainly S.W. Cape to Namaq., S. Karoo, E. Cape
Engleria 2—Namibia
Eremothamnus 1—S. Namib Desert
Eriosphaera 1—Karoo and O.F.S.
Eroeda 6—Mainly S.W. Cape to E. Cape
Eumorphia 5—Karoo Mts. to Drakensberg
Garuleum 8—Widespread except S.W. Cape
Gibbaria 2—S.W. Cape
Gorteria 3—Namibia to S.W. Cape
Gymnodiscus 2—Namaq. to S.W. Cape
Gymnopentzia 1—Drakensberg
Gymnostephium 7—S.W. Cape
Heterolepis 3—S.W. Cape
Heteromma 3—Drakensberg
Heterorhachis 1—W. Cape
Hippia 6—Mainly S.W. Cape to E. Cape
Hoplophyllum 2—Namaq. to Karoo
Inezia 1—E. Tvl., Swaziland
Lachnospermum 2—S.W. Cape to Namaq.
Lamprocephalus 1—S.W. Cape
Leontonyx 6—Widespread
Lepidostephium 1—E. Cape
Leucoptera 3—S.W. Cape to Namaq.
Lidbeckia 2—W. Cape
Mairia 21—S.W. Cape
Marasmodes 5—S.W. Cape
Metalasia 33—Mainly S.W. Cape, E. Cape to Natal
Minurothamnus 1—S.W. Cape (Caledon)
Oldenburgia 4—S.W. Cape to E. Cape
Oligothrix 1—W. Cape
Ondetia 1—Namibia (Damaraland)
Osmitopsis 9—S.W. Cape
Oxylaena 1—S. Cape
Pentatrichia 3—Namibia, Karoo, N. Tvl.
Perdicium 2—W. Cape
Petalacte 2—S.W. Cape
Peyrousea 1—S.W. Cape
Phaenocoma 1—S.W. Cape
Phaeocephalus 1—S.W. Cape (Swartberg and Witteberg)
Phaneroglossa 1—S.W. Cape
Philyrophyllum 1—Tvl.

APPENDIX 2. *Continued*

Phymaspermum 6—Karoo to Namaq.
Platycarpha 3—Namibia to N. Cape, Karoo, Natal
Poecilolepis 2—Cape Peninsula to E. Cape
Polyarrhena 4—S.W. Cape
Printzia 7—S.W. Cape to Drakensberg
Psednotrichia 1—S.W. Cape to Namaq.
Pterothrix 4—Namibia to Karoo
Relhania 29—S.W. Cape, Karoo, Namaq., Natal
Rhynea 1—E. Cape to Tvl.
Rosenia 4—S.W. Cape, Karoo, Namaq.
Stilpnogyne 1—S.W. Cape
Stilpnophytum 4—S.W. Cape
Thaminophyllum 3—S.W. Cape

Crassulaceae

Andromischus 30—Widespread
Tylecodon 26—Widespread

Cruciferae

Aplanodes 2—Natal, E. Cape, Lesotho
Brachycarpaea 1—S.W. Cape to Namaq.
Chamira 1—S.W. Cape
Cycloptychis 2—W. Cape
Heliophila 71—Mainly S.W. Cape to Tvl.
Schlecteria 1—W. Cape (Cedarberg)
Silicularia 1—W. Cape (Ceres)
Thlaspeocarpa 2—Namaq., W. Karoo, W. Cape

Cunoniaceae

Platylophus 1—S. Cape

Cyperaceae

Chrysithrix 2—S.W. Cape
Epischoenus 8—S.W. Cape to E. Cape
Hellmuthia 1—S. Cape
Macrochaetium 2—S.W. Cape to Natal
Neesenbeckia 1—S.W. Cape
Trianopteles 3—S.W. Cape
Volkiella 1—N. Namibia

Ericaceae

Acrostemon 12—S.W. Cape
Anisérica 2—S.W. Cape
Anomalanthus 10—S.W. Cape
Coccosperma 4—S.W. Cape
Coilostigma 4—S. Cape
Eremia 7—S.W. Cape
Eremiella 1—S. Cape (Outeniqua Mts.)
Grisebachia 9—S.W. Cape
Lepterica 1—S.W. Cape
Nagelocarpus 2—S.W. Cape
Platycalyx 1—S. Cape (Riversdale)
Salaxis 8—S.W. Cape
Scyphogyne 18—S.W. Cape
Simocheilus 21—S.W. Cape
Stokoeanthus 1—S.W. Cape
Sympieza 8—S.W. Cape
Syndesmanthus 19—S.W. Cape
Thamnus 1—S. Cape
Thoracosperma 12—S.W. Cape

Euphorbiaceae

Ctenomeria 1—S. Cape to E. Mts.
Hyenanche 1—W. Cape (Clanwilliam to Nieuwoudtville)
Lachnostylis 2—S.W. Cape
Seidelia 3—E. Cape, Karoo, O.F.S.

Flacourtiaceae

Pseudoscolopia 1—S.W. Cape to Natal

Geissolomaceae

Geissoloma 1—S. Cape (Langeberg)

Gentianaceae

Orpheum 1—S.W. Cape

Gesneriaceae

Charadrophila 1—W. Cape (Stellenbosch distr.)

Gramineae

Catalepis 1—Drakensberg to E. Tvl.
Chaetobromus 4—S.W. Cape to Namaq.
Dregeochloa 2—S. Namibia to Karoo
Harpochloa 1—E. Mts. and highveld
Kaokochloa 1—Namibia
Karoochloa 4—S.W. Cape, E. Cape, Karoo
Lasiochloa 5—Mainly S.W. Cape to Karoo
Leucophrys 4—Central Namibia
Lophacme 1—Tvl. highveld
Mosdenia 1—N. Tvl.
Pentameris 6—S.W. Cape
Plagiochloa 5—S.W. Cape
Poagrostis 1—S.W. Cape
Polevansia 1—Drakensberg
Prionanthium 3—S.W. Cape
Prosphytochloa 1—E. Cape to Tvl.
Pseudopentameris 2—S.W. Cape
Psilochloa 1—N. Namibia
Tarigidia 1—Namibia, N. Cape, O.F.S.
Tetrachne 1—Drakensberg
Urochlaena 1—S.W. Cape, Karoo

Greyiaceae

Greyia 3—Tvl. to E. Cape

APPENDIX 2. *Continued*

Grubbiaceae

Grubbia 3—S.W. Cape

Haemodoraceae

Barberetta 1—E. Cape, Natal
Dilatris 5—S.W. Cape
Lanaria 1—S.W. Cape, E. Cape
Wachendorfia 5—S.W. Cape

Hydrophyllaceae

Codon 2—Namaq. to Namibia

Hypoxidaceae

Empodium 9—Tvl. to S.W. Cape
Pauridia 2—S.W. Cape
Rhodohypoxis 6—Drakensberg
Saniella 1—Drakensberg
Spiloxene 30—S.W. Cape to Namaq.

Iridaceae

Gen. nov. 1—W. Karoo
Anapalina 7—S.W. Cape to E. Cape
Anomalesia 3—S.W. Cape to Namibia
Antholyza 2—S.W. Cape to Namaq.
Barnardiella 1—Namaq.
Bobartia 15—Mainly S.W. Cape to S. Natal
Chasmanthe 4—Mainly S.W. Cape to Namaq.
Duthieastrum 1—W. Tvl. to N.W. Cape
Engysiphon 10—Mainly S.W. Cape to Namaq.
Freesia 19—S.W. Cape, E. Cape, Karoo to W. Tvl.
Galaxia 12—S.W. Cape to Namaq.
Geissorhiza 60—Mainly S.W. Cape to Namaq.
Hexaglottis 4—S.W. Cape to Namaq.
Homeria 30—Widespread, mainly S.W. Cape and Namaq.
Homoglossum 10—Mainly S.W. Cape to E. Cape
Ixia 45—S.W. Cape to Namaq. and E. Cape
Klattia 2—S.W. Cape
Micranthus 3—S.W. Cape
Nivenia 8—S.W. Cape
Pillansia 1—S.W. Cape (Caledon distr.)
Sparaxis 6—S.W. Cape
Synnotia 5—Mainly S.W. Cape to S. Namaq.
Syringodea 8—Arid parts of S.W. Cape, Karoo, S. Tvl.
Thereianthus 7—S.W. Cape
Tritoniopsis 14—S.W. Cape
Watsonia 70—S.W. Cape to Namaq., E. areas
Witsenia 1—S.W. Cape

Juncaceae

Prionum 1—S.W. Cape to Natal

Labiatae

Syncolostemon 9—Transkei to Tvl.
Thorncroftia 3—E. and N. Tvl.

Leguminosae

Amphithalea 16—Mainly S.W. Cape to E. Cape
Aspalathus 255—Mainly S.W. Cape to Namaq., E. Cape, Natal
Bolusafra 1—S.W. Cape
Buchenroedera 20—S.W. Cape, S. Tvl., Natal, E. Cape
Chrysoscias 6—S.W. Cape to Tvl.
Coelidium 15—S.W. Cape
Cyclopia 20—S.W. Cape
Dipogon 1—S.W. Cape to E. Cape
Hypocalyptus 3—S.W. Cape
Lebeckia 39—S.W. Cape to Namaq., Namibia, Natal
Liparia 2—S.W. Cape
Melolobium 20—Widespread, mainly arid areas
Podalyria 22—Mainly S.W. Cape to E. Cape
Priestleya 20—S.W. Cape
Rafnia 22—S.W. Cape to S. Natal
Sutherlandia 5—Widespread
Umtiza 1—E. Cape coast
Virgilia 2—S.W. Cape mainly in south
Wiborgia 10—S.W. Cape to Namaq. and W. Karoo
Xerocladia 1—Namaq., Namibia

Liliaceae

Agapanthus 10—S.W. Cape, E. Cape to Tvl.
Amphisiphon 1—S.W. Cape (Nieuwoudtville)
Androsiphon 1—S.W. Cape (Nieuwoudtville)
Baeometra 1—S.W. Cape
Daubenya 1—W. Karoo (Sutherland)
Dipidax 3—S.W. Cape
Galtonia 3—Transkei to Drakensberg
Gasteria prob. 15—S.W. Cape to Namaq., E. Cape
Hexacyrtis 1—Namib Desert
Lachenalia 80—Mainly S.W. Cape to Namaq., Karoo
Litanthus 1—Widespread
Massonia 8—S.W. Cape to Namaq., Karoo
Neodregea 1—S.W. Cape to E. Cape
Neopatersonia 3—S.W. Cape to Namaq.
Poellnitzia 1—S.W. Cape (Worcester to Robertson)
Polyxena 2—S.W. Cape to E. Cape, Namaq., Karoo

APPENDIX 2. *Continued*

Rhadamanthus 9—S.W. Cape, Namaq., Namibia
Sandersonia 1—E. Cape to E. Tvl.
Schizobasis 1—Widespread except S.W. Cape
Veltheimia 2—S.W. Cape to Namaq., E. Cape
Whiteheadia 1—Namaq., Namibia

Loranthaceae

Moquiniella 1—S.W. Cape, Karoo, E. Cape
Septulina 2—S.W. Cape, Namaq., S. Namibia

Lythraceae

Rhynchocalyx 1—Natal S. coast

Malvaceae

Anisodontea 19—Mainly S.W. Cape to Namaq., O.F.S., Natal
Radyera 1—Namibia, Namaq., Karoo, O.F.S.

Meliaceae

Nymania 1—S. Cape (Little Karoo) to Namibia

Melianthaceae

Melianthus 8—Widespread, mainly arid regions

Menispermaceae

Antizoma 3—Widespread

Neuradaceae

Grielum 6—Widespread in arid areas
Neuradopsis 1–2—N. Cape, Namibia, Botswana

Nyctaginaceae

Phaeoptilum 1—Namibia to N. Cape

Orchidaceae

Acrolophia 7—Mainly S.W. Cape, Natal
Amphigena 2—S.W. Cape
Anochilus 3—S.W. Cape to E. Cape
Bartholina 2—S.W. Cape to E. Cape
Ceratandra 3—Mainly S.W. Cape to E. Cape
Corycium 17—Mainly S.W. Cape to E. Tvl.
Evota 3—S.W. Cape
Forficaria 2—S.W. Cape
Huttonaea 4—E. Cape to Tvl.
Monadenia 21—Mainly S.W. Cape to E. Cape, E. Tvl.
Orthopenthea 12—S.W. Cape
Pachites 2—S.W. Cape
Penthea 2—S.W. Cape
Satyridium 1—S.W. Cape
Schizodium 5—S.W. Cape

Palmae

Jubaeopsis 1—Pondoland

Papaveraceae

Cysticapnos 1—S.W. Cape to Namaq.
Discocapnos 1—S.W. Cape
Phacocapnos 3—S.W. Cape to Natal
Trigonocapnos 1—W. Cape to W. Karoo

Penaeaceae

Brachysiphon 4—S.W. Cape (Peninsula to Swellendam)
Endonema 2—S.W. Cape (Riviersonderend Mts.)
Glischrocolla 1—S.W. Cape (Hottentots Holland)
Penaea 3—S.W. Cape
Saltera 1—S.W. Cape (Peninsula to Bredasdorp)
Sonderothamnus 2—S. Cape (Caledon to Bredasdorp)
Stylapterus 8—S.W. Cape

Polygalaceae

Nylandtia 1—S.W. Cape to Namaq., E. Cape

Portulaceae

Portulacaria 2—S.W. Cape, Namaq., Karoo, E. Cape

Proteaceae

Aulax 3—S.W. Cape
Brabeium 1—S.W. Cape
Diastella 7—S.W. Cape
Leucadendron 80—Mainly S.W. Cape to Natal
Mimetes 12—S.W. Cape
Orothamnus 1—S.W. Cape (Caledon)
Paranomus 18—S.W. Cape
Serruria 50—S.W. Cape
Sorocephalus 11—S.W. Cape
Spatalla 20—S.W. Cape

Restionaceae

Anthochortus 1—S.W. Cape
Calopsis (non *Leptocarpus*) 27—Mainly S.W. Cape to Natal, Namaq.
Cannomois 9—Mainly S.W. Cape, E. Cape
Chondropetalum 23—Mainly S.W. Cape to E. Cape
Elegia 36—Mainly S.W. Cape to E. Cape

APPENDIX 2. *Continued*

Hypodiscus 14—S.W. Cape
Mastersiella (non *Hypolaena*) 31—S.W. Cape
Phyllocomos 1—S.W Cape
Staberoha 9—S.W. Cape
Thamnochortus 31—Mainly S.W. Cape to Namaq., E. Cape
Willdenowia 7—S.W. Cape to Namaq.

Retziaceae

Retzia 1—S.W. Cape (Stellenbosch to Bredasdorp)

Rhamnaceae

Noltia 1—S.W. Cape to Natal

Roridulaceae

Roridula 2—S.W. Cape

Rubiaceae

Burchellia 1—S. Cape to E. Tvl.
Carpacoce 4—S.W. Cape to E. Cape
Crocyllis 1—Namibia, Namaq.
Dinocanthium 1—Tvl. to N. Natal
Eriosemopsis 1—Natal, Transkei
Galopina 3—S.W. Cape to Natal, E. Tvl.
Nenax 4—S.W. Cape to Namaq., Karoo, Namibia
Plectroniella 2—Tvl. to Natal

Rutaceae

Acmadenia 22—Mainly S.W. Cape to E. Cape
Adenandra 18—S.W. Cape
Agathosma 137—Mainly S.W. Cape to Natal
Coleonema 7—S.W. Cape
Diosma 27—Mainly S.W. Cape, Namaq.
Empleuridum 1—S.W. Cape (Caledon)
Empleurum 2—S. Cape
Euchaetes 27—S.W. Cape
Macrostylis 11—S.W. Cape
Phyllosma 2—W. Cape (Cold Bokkeveld)
Gen. nov. 1 1—W. Cape
Gen. nov. 2 4—W. Cape
Gen. nov. 3 1—S.W. Cape

Santalaceae

Rhoiacarpos 1—S.W. Cape to Transkei
Thesidium 8—Mainly S.W. Cape to E. Cape

Sapindaceae

Hippobromus 1—S. Cape to Natal, Tvl.
Smelophyllum 1—S. Cape forests

Scrophulariaceae

Antherothamnus 1—N. Cape to Namibia, Tvl.
Bowkeria 3—E. Cape to S.E. Tvl.
Colpias 1—Namaq. to W. Karoo
Diascia 53—Widespread
Dermatobotrys 1—Natal to Transkei
Dintera 1—N. Namibia (Otjiwarongo)
Glumicalyx 6—Drakensberg
Hemimeris 4—S.W. Cape to Namaq., Karoo
Hyobanche 7—S.W. Cape to Namaq., Namibia, Natal
Ixianthes 1—W. Cape
Manuleopsis 1—Namibia
Oftia 3—S.W. Cape to Namaq.
Phygelius 2—E. Cape to Tvl.
Polycarena 42—Widespread, mainly S.W. Cape
Strobilopsis 1—Drakensberg
Teedia 2—S.W. Cape, Namaq., E. Cape

Selaginaceae

Agathelpis 3—S.W. Cape
Cromidon 1—S. Karoo (foot of Witteberg)
Dischisma 11—Mainly S.W. Cape to Namaq., S. Namibia
Globulariopsis 1—S.W. Cape (Witteberg)
Gosella 1—S.W. Cape
Microdon 5—S.W. Cape
Tetraselago 4—Natal to E. Tvl.

Stangeriaceae

Stangeria 1—S.E. coast

Stilbaceae

Campylostachys 1—S.W. Cape (Peninsula to Hermanus)
Eurylobium 1—S.W. Cape (Riversonderend Mts.)
Euthystachys 1—S.W. Cape (Franch Hoek)
Stilbe 8—S.W. Cape
Xeroplana 2—S. Cape (Caledon to Riversdale)

Tecophilaeaceae

Cyanella 8—Mainly S.W. Cape to W. Karoo, Namaq., Namibia

Thymelaeaceae

Cryptadenia 5—S.W. Cape
Lachnaea 25—Mainly S.W. Cape to Namaq., Natal

Umbelliferae

Arctopus 3—S.W. Cape to Namaq.
Annesorrhiza 8—Widespread
Chamarea 1—Widespread in South Africa
Choritaenia 1—Karoo, Kalahari

APPENDIX 2. *Continued*

Glia 1—S.W. Cape
Hermas 6—S.W. Cape
Heteroptiles 1—S.W. Cape to Natal
Marlothiella 1—Namib Desert
Phlyctidocarpa 1—N. Namibia
Polemannia 3—S.W. Cape to Natal
Rhyticarpus 3—S.W. Cape to E. Cape
Sonderina 5—S.W. Cape to Namibia, Natal
Thunbergiella 1—S.W. Cape

Velloziaceae

Talbotia 1—E. Tvl., Natal

Zygophyllaceae

Augea 1—Namaq., Karoo
Neoleuderitzia 1—S. Namibia
Sisyndite 1—Namaq. to S. Namibia

APPENDIX 3

Checklist of genera of seed plants shared between tropical Africa (-S. Arabia) and southern Africa. Asterisk indicates genera with very limited ranges outside southern Africa.

Acanthaceae
Angkalanthus
Crabbea
Duosperma
Macrorungia
Megalochlamys
Ruelliopsis
Ruspolia
Ruttya
Sclerochiton
Aizoaceae
**Aizoanthemum*
Delosperma (also Reunion)
Galenia
Hypertelis
**Pharnaceum*
**Psammotropha*
**Psilocaulon*
Tribulocarpus
Alismataceae
Burnatia
Amaranthaceae
Achyropsis
Centema
Centemopsis
Cyphocarpa
**Hermbstaedtia*
Marcelliopsis
Nelsia
Pandiaka
Sericocoma
Amarylllidaceae
Ammocharis
Boophone
Brunsvigia
Cyrtanthus
Scadoxus
Anacardiaceae
**Harpephyllum*
Ozoroa
Annonaceae
Monodora
Apocynaceae
Acokanthera
Adenium
Diplochynchus
Ephippiocarpa
Araceae
Gonatopus
Stylochiton
**Zamioculcas*
Zantedeschia
Araliaceae
Cussonia
Asclepiadaceae
Curroria
Duvalia
Echidnopsis
Fockea
Huernia
Kanahia
Mondia
Orbea
**Orbiopsis*
Pachycarpus
**Pachycymbium*
Pentarrhinum
Periglossum
Piaranthus
Raphionacne
Schizoglossum
Sphaerocodon
Stapelia
Stigmatorhynchus
Stomatostemma
Tacazzea
Tavaresia
Tenaris
Xysmalobium
Balanophoraceae
Sarcophyte
Bignoniaceae
**Catophractes*
Kigelia
**Podranea*
Tecomaria
Boraginaceae
Wellstedia
Canellaceae
Warburgia
Campanulaceae
Cyphia
Monopsis
Capparaceae
**Bachmannia*
Cladostemon
Caryophyllaceae
Krauseola
Celastraceae
Allocassine
Catha
**Putterlickia*
Pterocelastrus
Chenopodiaceae
Lophiocarpus
Combretaceae
Pteleopsis
Compositae
Arctotheca
Arctotis
Artemesiopsis
Berkheya
Bothriocline
Calostephane
Chrysanthemoides
**Chrysocoma*
Denekia
**Dimorphotheca*
Eriocephalus

APPENDIX 3. *Continued*

Erlangea
Euryops
Felicia
Gazania
Geigeria
Gerbera
Gongrothamnus
Haplocarpha
Hirpicium
Kleinia
**Leontonyx*
Lopholaena
Macowania
Nicolasia
**Othonna*
**Pechuel-loeschea*
Pentzia
Pleiotaxis
Pteronia
Schistostephium
**Sphaeroclinum*
Stomatanthes
Tarchonanthus
Ursinia

Convolvulaceae
Astripomoea
Falkia

Cornaceae
**Curtisia*

Crassulaceae
Cotyledon

Cucurbitaceae
Acanthosicyos
Gerrardanthus
Trochomeria

Cupressaceae
Widdringtonia

Cyperaceae
Ficinia

Dipterocarpaceae
Monotes

Ebenaceae
Euclea

Ericaceae
Blaeria
Ericinella

Erythroxylaceae
Nectaropetalum

Escalloniaceae
Choristylis

Euphorbiaceae
**Adenocline*
Cavacoa
Clutia
Erythrococca
Heywoodia
Leidesia
Monadenium
Pseudolachnostylis
Pterococcus
Ricinodendron
Spirostachys
Synadenium

Flacourtiaceae
Gerrardina
Kiggelaria
Oncoba
Rawsonia
Trimeria
Xylotheca

Geraniaceae
**Sarcocaulon*

Gramineae
Beckeropsis
Bewsia
Cleistachne
Cymbosetaria
Cypholepis
Danthoniopsis
Diheteropogon
Dinebra
Ehrharta
Elymandra
Entolasia
Entoplocamia
Fingerhuthia
**Heterocarpha*
Lintonia
Megaloprotachne
Melinis
Miscanthidium
Monelytrum
Monocymbium
Odontelytrum
Odyssea
Oryzidium
Oxytenanthera
Pogonarthria
Rendlia
Sartidia
Schmidtia
Stiburus
Stereochlaena
Streblochaete
Styppeiochloa
Urelytrum
Urochloa

Hamamelidaceae
Trichocladus

Illecebraceae
Pollichia

Iridaceae
Anomatheca
Babiana
Crocosmia
Dierama
Ferraria
Hesperantha
Lapeirousia
Moraea
Oenostachys
Radinosiphon
Schizostylis
Tritonia

Labiatae
Acrotome
Aeolanthus
Becium
Englerastrum
Hemizygia
Holostylon
Hoslundia
Iboza
Tinnea

Leguminosae
**Adenolobus*
Amblygonocarpus
Baikiaea
Bolusia
Bolusanthus
Brachystegia
Burkea
Colophospermum
Craibia
Dichilus
Elephantorrhiza
Julbernardia
Lablab
Lessertia
Neorautanenia
Otoptera
Ptycholobium
Requienia
**Schotia*
Tylosema
Xeroderris

Lemnaceae
Pseudowolffia

Liliaceae
Albuca
**Behnia*
**Bowiea*
Bulbine
**Camptorrhiza*
Drimiopsis
Eriospermum
**Eucomis*
**Haworthia*
Littonia
Ornithoglossum
Pseudogaltonia
Schizobasis
Trachyandra
Tulbaghia

APPENDIX 3. *Continued*

Loganiaceae
**Gomphostigma*
Loranthaceae
**Actinanthella*
Erianthemum
Odontella
**Pedistylis*
Plicosepalus
Tapinanthus
**Tieghemia*
**Vanwykia*
Lythraceae
**Galpinia*
Hionanthera
Malpighiaceae
Triaspis
Melastomataceae
Dissotis
Melastomastrum
Meliaceae
**Entandrophragma*
Pseudobersama
Melianthaceae
Bersama
Menispermaceae
Epinetrum
Montiniaceae
**Montinia*
Moraceae
Cardiogyne
Musaceae
Strelitzia
Monimiaceae
Xymalos
Myrtaceae
Heteropyxis
Oliniaceae
Olinia
Orchidaceae
Ansellia
Bolusiella
Bonatea
Centrostigma
Cystorchis
Diaphananthe
Herschelia
Holothrix
Mystacidium
Neobolusia
Pterygodium
Rangaeris
Schizochilus
Stenoglottis
Passifloraceae
Basananthe
Schlechterina
Pediaceae
Ceratotheca
Dicerocaryum
Holubia
Harpagophytum
Pleurodiscus
Rogeria
Sesamothamnus
Plumbaginaceae
Dyerophytum
Podostemaceae
Leiothylax
Sphaerothylax
Polygalaceae
Muraltia
Portulacaceae
Ceraria
Proteaceae
**Leucospermum*
Protea
Ptaeroxylaceae
Ptaeroxylon
Ranunculaceae
Knowltonia
Rosaceae
Cliffortia
**Leucosidea*
Rubiaceae
Amphiasma
Ancylanthus
Conostomium
Crossopteryx
Fadogia
Ferretia
Heinsia
Kraussia
Lagynias
Leptactinia
Mitrocarpum
Mitriostigma
Neorosea
Oxyanthus
Pachystigma
Pentanisia
Plectroniella
Pygmaeothamnus
Rothmannia
Tapiphyllum
Vangueriopsis
Zygoon
Rutaceae
Calodendrum
Citropsis
Oricia
Toddaliopsis
Santalaceae
Colpoon
Osyridiocarpus
Sapindaceae
Blighia
Pancovia
Pappea
Sapotaceae
Bequaertiodendron
Inhambanella
Vitellariopsis
Scrophulariaceae
Aptosimum
**Anastrabe*
Buttonia
Cycnium
Freylinia
Gerardiina
Hiernia
Ilysanthes
Manulea
Nemesia
Peliostomum
Stemodiopsis
Sutera
Zaluzianskya
Selaginaceae
Selago
Simaroubaceae
Kirkia
Sterculiaceae
Cola
Tecophilacaceae
Walleria
Thymelaeaceae
**Passerina*
Struthiola
Turneraceae
Streptopetalum
Tricliceras
Umbelliferae
Alepidia
Lefeburea
Steganotaenia
Welwitschiaceae
**Welwitschia*
Zamiaceae
Encephalartos