ENVIRONMENTAL AND BIOGEOGRAPHIC INFLUENCES ON THE DISTRIBUTION AND COMPOSITION OF THE SOUTHERN CAPE FORESTS (VELD TYPE 4)

by

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CONTENTS

ABSTRACT

This study aims at explaining the distribution and composition of the southern Cape forests, the largest forest complex in southern Africa. These are the only forests in southern Africa which are actively and scientifically managed for their products and values. Population growth due to forestry, agricultural and economic development and a growing tourism industry exerts increasing pressures on the natural environment of the southern Cape coast and therefore affect the dynamics and conservation of the forests.

Conservation and sustained utilization of the forests require a sound knowledge of the composition, structure and dynamics of the forests. This study was aimed at an understanding of the biogeography of the forests at the landscape level in order to isolate those variables which contributed to the present distribution and composition of the forests.

Determinants of the forest location pattern in the southern Cape were identified as rainfall above 500 mm, which determines the potential limits of the forests, and the bergwind fire pattern, which determines the actual forest distribution. Fires driven by the hot, dry, northwesterly, föhnlike bergwinds interacted with the terrain physiography since prehistorical times and the forests persisted in topographic shadow areas. The largest forests in the area therefore occur on the coastal platform at the foot of the mountains, in the river valleys and on the coastal scarp. Forests in the mountains, with high rainfall, are small and scattered. The results have shown that the bergwind driven fires control the distribution of forests which have important implications for the understanding of forest dynamics and for conservation management of forests in multiple-use management systems.

Forest composition at the landscape level was studied by means of plant species lists. A species list for the southern Cape forests was annotated with information on the growth form, breeding system, propagule type, forest type, moisture tolerance, abundance and spread in the study area, and the distribution range in southern Africa, of each species. Analyses of the list showed that the species/family ratios for the southern Cape forest flora are very low, that woody plants have mostly fleshy propagules and herbaceous plants mostly dry propagules, and that several species have adaptations to adverse conditions.

The species richness and composition, and floristic similarity and relationships were compared between the southern Cape forest flora and the floras of 13 other forests representing particular geographic regions in southern Africa. Forest size explained relatively little of the variation in species richness of the forests. Stepwise multiple regression analyses indicated that the number of dispersal corridors, the proximity to other forests and mean altitude explained most of the variation in number of woody species, whereas the number of landscape types and dispersal corridors explained most of the variation in number of herbaceous species. The high similarity between the southern Cape forest flora and those of the forests along the escarpment from the eastern Cape to northern Transvaal, and the southern attenuation of species suggest that the forests were once continuous. It is suggested that the Sundays river valley east of Port Elizabeth isolated the southern Cape forests from those to the east already during the Pliocene or earlier.

Patterns in species richness of 23 small, isolated forests in the inland mountains of the southern Cape were not explained by habitat preferences, species-area relationships or long-distance dispersal. However, patterns in species richness and composition show definite trends when they are considered in relation to dispersal corridors along the Gouritz and Gamtoos rivers, the only two rivers which connect the coastal forests with the inland mountains. The patterns relate to the geomorphological history of the river systems. The results indicated that at least four floras can be recognized and that relative dates can be attached to their domination of the area and their contribution to the southern Cape coastal forest flora.

The 206 species which reach their distribution limits within the southern Cape forests, or have disjunct distributions within this area and wider distributions outside were found to be mostly concentrated in a few localities within the study area. Biological variables such as growth form and dispersal type, and habitat

variables such as forest type and moisture tolerance did not correlate with the drop-out of species. Species which were concentrated in the western limit of the forests, and in other parts of the high forests, relate to the major forest decline with the onset of the Late Pliocene marine regression. Species tolerant of drier conditions are concentrated in various disjunct localities along the coast and this pattern is attributed to the elimination of coastal dune forest and subtropical transitional thicket on the Agulhas Bank during the marine transgression after the Last Glacial Maximum.

Finally, the distribution ranges of the 465 species of the southern Cape forest flora were used to establish generalized tracks of the flora in order to test the hypothesis that regional speciation of the floral elements of the tropical, subtropical and temperate regions of southern Africa have enriched the older Afromontane forest flora. Log-linear analysis was used to determine the dependence between the biological and ecological characteristics of the species and their geographical categories. The results indicated that the ecological characteristics of the species of each geographical group reflected the environmental conditions and disturbance regimes which prevailed in each source area. The results confirmed that the southern Cape forest flora was made up of elements of a narrower cool, humid Afromontane area, elements of a transition zone between the montane zone and the humid, warm subtropical coastal areas with wide moisture tolerances in the southern Cape, elements which had to adapt to more frequent and extreme droughts and drier conditions of the eastern Cape lowlands, and western Cape elements which are associated with either cool, moist montane areas or with more frequently burnt forest margins.

The southern Cape forest flora is therefore a product of a long period of forest expansion and contraction which in this study is taken back to the Late Cretaceous-Palaeocene. The increasing aridity since that time contributed to the narrowing and fagmentation of the forest belt. Species developed which were tolerant of frequent fires or droughts. Most of the large plant families, and many of the other important families, are shared between the forests and other vegetation types. This sharing suggests that the forests might have been the original gene source for the speciation of many of the families and genera.

The effect of the increasing aridity and disturbance pressure seems to be that the radiation of species occurred in smaller growth forms outside the forests.

ACKNOWLEDGMENTS

I wish to thank the Director-General of the Department of Environment Affairs and the Director of the South African Forestry Research Institute who gave me ample opportunities in an ideal workplace, and provided the funds for this study. They also funded a study visit to the rainforests of Australia, New Zealand and Chile during which I was able to gain a Southern Hemisphere perspective of rainforest dynamics. I became aware of the role of disturbance regimes in shaping the physiognomy and dynamics of the different forests and hence influencing the silvicultural systems applicable in the management of those forests.

My colleagues at the Saasveld Forestry Research Centre and in the wider South African Forestry Research Institute with their varied scientific interests and approaches helped to broaden my view of my field of study. From them I learned the art of questioning the things I observe around me in order to gain a better understanding of the mechanisms operating in the environment. The questions and comments raised during many formal and informal discussions helped me to focus in on relevant aspects of the study and provide better clarity in my presentation of the information.

Through the coordinated activities of the Forest Biome Project of the CSIR I was motivated to maintain a holistic view of the composition, interrelationships, dynamics and values of the South African mixed evergreen forests, and the interaction of these forests with surrounding vegetation types and landuses. I grew up in rural Transkei amongst the Xhosa kids from whom I gathered much appreciation for the interdependence between the biotic and abiotic environment, and also for the dependence of mankind on a healthy environment.

The contributions of various individuals are acknowledged in the specific chapters. However, I thank Linda Stander for her excellent efforts to prepare the final text of the thesis. I also thank Hans van Daalen whom, from time to time, relieved me from official duties to allow me to carry on with my studies.

I am grateful to my supervisor, Prof E J Moll, for his advice and encouragement and that he allowed me a free mind in the completion of the study.

My wife Este, and kids, Careen, Nico, Martjie and Coert, my closest responsibility, and my parents, retained an interest in the completion of the study and motivated me through their continued patience.

Through this study I became more aware of the tremendous order in which the environmental processes operate at different spatial and temporal scales. This strengthens my belief that God created matter and life, set the evolving, dynamic and interactive environment in motion, and continues to maintain the processes of the environment. I therefore believe that as a scientist I share the responsibility to provide means by which the spiritual, social and economic needs of mankind can be met. I realize that this requires a balanced approach towards the conservation and utilization of the resources of the earth.

PREAMBLE

VALUES AND PRESENT USES OF THE FORESTS

The small and fragmented mixed evergreen forests of southern Africa contribute disproportionately to the well-being of the societies in southern Africa (McKenzie 1988). However, only the larger forests in the southern Cape are actively and scientifically managed for their products and values (Seydack et al. 1982; Van Dijk 1987; McKenzie 1988). Resource utilization in the southern Cape forests aims at the sustained production, from selected sites, of quality timbers for the furniture industry, and of fern for florists greenery (Van Dijk 1987; Geldenhuys and Van der Merwe 1988). The growing timber and fern industries are labour intensive and provide job opportunities to both skilled and unskilled labour (Geldenhuys 1983; Geldenhuys and Van der Merwe 1988). Private farmers and individuals hunt bushbuck (Tragelaphus scriptus) and bushpig (Potamochoerus porcus), legally and illegally (Odendaal 1977; A H W Seydack personal communication 1989). Several farmers allow their cattle to graze in private forests. Bark-stripping for medicinal purposes by migrant black labour have occurred in isolated cases and will most probably increase in future.

The forests have many values.

* Forests contribute to the scenic beauty of the area. Tourism is important to the economy of the area and local authorities are well aware of the need to preserve the natural environment and its amenities (Tyson 1971). Recreation facilities are provided at suitable sites in the forests throughout the study area (Geldenhuys 1982, 1983) and contribute to the growing tourism industry (Jooste 1988).

* Forests contribute to conservation of the soil and water as was shown during periods of abnormal heavy rains in 1981 when landslides occurred east of George on steep slopes where forest were previously cleared.

* Forests are a source for society to respond to problems and opportunities in future (Myers 1979) as was demonstrated with the development of the fern industry (Geldenhuys and Van der Merwe 1988).

* Forests are of immense scientific value. Their biota occur in various combinations, and have characteristics which represent adaptions to various

biotic and physical interactions and disturbances (Geldenhuys and MacDevette 1989).

The forests have been used for several thousands of years (Feely 1986; Scholtz 1986) and have survived heavy pressures with the arrival of European woodcutters about two centuries ago (Phillips 1963). However, the growing South African population increases the conflict between different landuse options, especially in the coastal areas. Furthermore, the relative economic and market values of the forests have not been quantified and are considered to be low in comparison with that of surrounding landuses, which yield higher short-term returns. We need a better understanding of the processes involved in the maintenance of the forest ecosystem during pressures of disturbance and stress in order to cope with the demands of the future.

REQUIREMENTS OF MANAGEMENT POLICIES

The management policy for the southern Cape forests aims at ".. the optimal utilization of resources with overriding regard to the maintenance of natural diversity and the protective, scientific and aesthetic value of the indigenous forests." (Seydack et al. 1982).

The concept of species diversity is however complex. Gentry (1988) indicated the effect of different ecological variables on species richness, i.e. the number of species in a particular area. Geldenhuys and MacDevette (1989) reviewed the varied causes for the patterns of species richness observed from preliminary studies in the southern African mixed evergreen forests. Ricklefs (1987) suggested that local diversity cannot be explained solely by local processes of competition between species, predation and disease, or patchworks of natural disturbances. The matrix of processes on larger spatial and temporal scales within which the community occur must also be considered. Regional processes of importance include dispersal, evolutionary adaptation to new habitats, habitat specialization, and speciation.

HIERARCHY OF THE ENVIRONMENT

More and more publications indicate that the ecological community encompasses a hierarchical structure discernable over a range of scales from those within the locality to those of the region and even the globe. In turn, a hierarchy of influences and interactions of environmental constraints, disturbances and biotic processes operate over correspondingly varied spatial and temporal scales (Ricklefs 1987; Urban et al. 1987; Smith and Urban 1988; Kolasa 1989).

The same general phenomena can differ quantitatively when viewed from different spatial and temporal scales (Urban et al. 1987; Smith and Urban 1988). At a fine scale resolution is high whereas at an extensive scale only broad patterns can be discerned. For example at the scale of the forest gap, the elements continuously undergo structural changes. At the next higher scale the forest stand is a steady-state expression of gap dynamics under a given set of environmental conditions. At the landscape and regional scale disturbances such as fires, drought and floods occur infrequently over large areas; demographic processes include species migration, adaptation and evolution; and environmental variables include climatic fluxes over geological time scales.

The different levels of forest pattern are mutually exclusive in any single analysis (Smith and Urban 1988). The multi-layered nature of the influences and interactions has interpretative value because of the relationships between the levels. For example, a mechanistic explanation of gap dynamics invokes the silviculture of trees interacting within the gap. A contextual explanation of gap dynamics considers the edaphic conditions or the disturbance regime under which gap dynamics occur. Both mechanism and context contribute to pattern in gap dynamics.

APPROACH FOR THIS STUDY

In this study I investigate determinants of forest distribution and composition in the southern Cape at the landscape and regional level. My approach stems from the rationale of hierarchy of levels of organization and that the impacts and precision of measurement of the above-mentioned determinants will be different at the different levels of organization. Determinants of forest presence and composition at the landscape level are rainfall regime, geology, physiography of the landscape, and biogeography of the component species. The scale of measurement is forest size in the landscape and species richness of forests. Pattern is deduced from the variation in species richness and composition in forests of different size and location.

I test the hypothesis that the floristic and structural composition of forests of a particular region reflect the characteristics of the physical environment, of the disturbance regime and of the evolutionary history of the taxa. For example, in South Africa the forests of the Cape Peninsula (Campbell and Moll 1977; MacKenzie et al. 1977), the southern Cape (Phillips 1931; McKenzie 1978), the Amatole and Transkei mountains (Story 1952; Phillipson 1988; Cawe 1986), the Natal north coast (Moll 1978, 1980; Venter 1972; Weisser 1980) and Drakensburg (Killick 1963), and of the eastern escarpment in Transvaal (Van der Schijff and Schoonraad 1971; Scheepers 1978; Deall 1985) all reflect differences in overall physiognomy although they share a large component of the total species. I maintain that it is necessary to understand the make-up of the forest in order to make a useful interpretation of the composition and dynamics of the component communities. This information is basic to the understanding of the structure, functioning and dynamics of forest communities and therefore for their management.

The overall hypothesis is tested by means of several sub-hypotheses in the following chapters. The thesis has been written as a series of independent chapters in the form that they are to be submitted for publication. Therefore, there is a degree of repetition.

BRIEF RESUME OF THE THESIS AND CONTENTS OF EACH CHAPTER

In Chapter 1 I firstly test the hypothesis that the physical limit to the persistence of forest in the southern Cape is rainfall below 525 mm. In this study it means that forest in the southern Cape is only limited by the most extreme conditions under which forest persists today. Secondly, I test the hypothesis that forest size increases with increasing rainfall where altitude is used as an index of rainfall. Thirdly, I test the hypothesis that forests in private ownership are smaller, i.e. more fragmented, than forests in public ownership. In order to test the hypotheses, I use existing information on the size and ownership of 908 forest patches and characterize them according to their altitude and landscape type.

In Chapter 2 I test the hypothesis that the environmental factors (rainfall intensity, geology, soils) determine the potential limits of forest distribution, but that the bergwind fire pattern determines the actual distribution of forest in the southern Cape landscape. The study is performed in an area with known historical utilization of the forests. I analyze forest shape in relation to the surrounding terrain physiography and use data on rainfall and soils inside and outside forests on homogeneous terrain.

Chapter 3 presents a floristic and structural analysis of the annotated species list of the flora of the southern Cape forests. I characterize each species by means of its growth form, breeding system, propagule type, forest type, moisture tolerance, abundance and spread in the study area, and distribution range in southern Africa. I analyze the data in terms of number of species in different growth forms, breeding systems, propagule types, and special adaptations to adverse conditions, and calculate species/family ratios for different growth forms and habitat types.

In Chapter 4 I compare the southern Cape forest flora with the floras of 13 other forests representing particular geographic regions in southern Africa, in particular their species richness, floristic similarity and floristic relationships. I test hypotheses which relate floristic richness, similarity and relationships to size and spatial separation of the individual forests, the role of dispersal corridors and barriers, the climatic gradient between the forests, and habitat diversity within a forest. I compile species lists from published and unpublished sources for each of the forests. I use stepwise multiple regression analyses to test the hypotheses and calculate similarity indices to determine the relationship between the forests.

In <u>Chapter 5</u> I determine the patterns in species richness of the small, isolated forests in the inland mountains of the southern Cape and relate the patterns to habitat preferences, species-area relationships, long-distance dispersal, and dispersal corridors in relation to the geomorphological history of the area, in order to aid interpretation of vegetation changes in the coastal forests. I compile species lists for each of 23 forests in different mountain complexes. I use stepwise multiple regression to determine the factors controlling species richness and compile tables to compare patterns in species composition between the different mountain complexes.

In <u>Chapter 6</u> I firstly list the species of the southern Cape forests which have a disjunct distribution or which reach the limit of their distribution within the area. Secondly I use Log-linear analysis of contingency tables to establish which common biological, habitat and distributional characteristics of the species determine their specific distribution patterns. Thirdly I interpret their distribution in relation to the known geomorphological and climatological history of the region.

In <u>Chapter 7</u> I test the hypothesis that regional speciation of the floral elements of the tropical-subtropical Afromontane and Tongaland-Pondoland, and the temperate Cape Regions have enriched the historic Afromontane forest flora. I follow the biogeographic approach and use the ranges of all the species to establish generalized tracks. I use the Log-linear analysis of contingency tables to determine the dependence between the biological and ecological characteristics of species and their geographic categories.

Finally, in the synthesis I attempt to present a scenario of the origin and evolution of the distribution and floristic composition of the forests of the southern Cape.

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Chapter 1

DISTRIBUTION, SIZE AND OWNERSHIP OF FORESTS IN THE SOUTHERN CAPE

CONTENTS

ABSTRACT

Indigenous forest of the southern Cape as delimited on 1:50 000 maps was analyzed for distribution, size and ownership in six landscape zones: mountain, foothill, coastal platform, river valley, coastal scarp and dunes. I tested the hypothesis that forest distribution in the study area was limited by annual rainfall below 500 mm and not by geology. A total of 908 forest patches with size ranging from 0,3 ha to 25 706 ha covering a total area of 60 561 ha were analyzed. Annual rainfall in areas where forest persists ranges between 500 and 1 220 mm, but the size and distribution of forest shows no relationship to total rainfall (above 500 mm), or to geology. The largest forests cover the foothills, coastal platform, river valleys and coastal scarp. The Goudveld-Diepwalle-Harkerville forest is the largest single, continuous forest in southern Africa and covers all landscape zones except dunes. By contrast the mountains have the largest number of forests but these are of relatively small mean area. Prehistorical natural and anthropogenic fires caused the fragmentation and current distribution pattern of the forests. The fragmentation was increased in some areas by historical fires, grazing, and forest exploitation and clearing. Ownership (state versus private) differs in different landscapes and different parts of the study area, but does not determine forest size or fragmentation. Currently the Department of Environment Affairs (Forestry Branch) and other conservation authorities control 72,7% of the high and scrub forest in all landscape zones. In contrast to most other tropical and temperate forests in the world, the southern Cape forests are small in area but differ in having a secure conservation status. A relatively small area is scientifically managed for timber and fern production, and for recreation. The remainder is totally protected. Utilization of private forests is guided by forest scientists of the Department of Environment Affairs. Plantation forestry ensures fire protection of the region and thereby the expansion of forest.

INTRODUCTION

The largest forest complex in southern Africa, the Knysna Forest (Phillips 1931; Acocks 1953), occurs in the southern Cape (Anonymous 1987a). It includes both high and scrub forest (3 m to >20 m in height) and is similar to Australian rainforests in its composition of growth forms (Phillips 1931; Von Breitenbach 1974; Webb 1978). It is the only forest in southern Africa which has been intensively utilized for timber almost continuously since its discovery by European settlers by 1750 (Phillips 1963; Geldenhuys 1982). The forest has a fragmented distribution on the seaward side of the coastal mountain ranges. Acocks (1953) suggested that much of the forested area from the Cape Peninsula to Port Elizabeth have been cleared since the arrival of the European settlers in 1652.

Forest height, structural organization and floristic composition reflect the physiographic, geological, climatic and disturbance factors of the environment (Phillips 1931; Von Breitenbach 1974). Rutherford and Westfall (1986) suggested that forest in the all-year rainfall area occurs where rainfall is $\geq$525 mm. The question is whether the distribution and size of the southern Cape forests reflect these environmental factors, or whether they have been cleared to the extent that natural patterns are not readily evident today.

Forest size has relevance for the conservation of biota (MacArthur and Wilson 1967). Larger forests are more suitable for sustained utilization and for the development of a suitable infrastructure to ensure quality management. Persistence of small forests, i.e. which have a large ratio of forest margin to forest area, is threatened by the relatively extreme disturbance regimes and landuse practices of surrounding vegetation. The most recent estimates of forest size for southern Africa are that of Cooper (1985) for forests of 50 ha and larger in Transvaal, Natal and Orange Free State, and that of Scriba (1984) for forests of 18 ha and larger in the southern Cape. The Forest Map (Anonymous 1987a) shows the distribution of all forests of 30 ha and larger for the Cape Province, Ciskei and Transkei. The data emphasize the small size and scattered nature of the forests.

Ownership determines the type and quality of management and possible impacts on the vegetation (Phillips 1963; Cooper 1985; McKenzie 1988). Concern is often expressed over the decline of the rainforests of the world because of the indiscriminate clearing by man (Myers 1979; Winter et al. 1987).

In this study I firstly test the hypothesis that forest distribution in the southern Cape is limited by total annual rainfall of less than 525 mm and not by geology. The hypothesis suggests that the fragmentation of the Knysna Forest is determined by disturbances such as human clearing or other environmental factors. In order to test the hypothesis, I assume that the forests are limited by those variables, or types or levels of variables, which consistently limit forest establishment and growth. In this study it means that forest in the southern Cape is only limited by the most extreme conditions under which forest persists today. Secondly, I test the hypothesis that forest size increases with increasing rainfall, where altitude is used as index of rainfall. Thirdly, I test the hypothesis that forests in private ownership are smaller than forests in public ownership.

DESCRIPTION OF STUDY AREA

The study covers the area between the Gouritz River in the west and Kromme River in the east, and the Indian Ocean coastline in the south and crests of the east-west trending coastal Cape Folded Mountains in the north (Figure 1). Few and only very small forests occur north of the crests. The mountains separate the moister coastal region from the drier Little Karoo inland. Acocks (1953) recognised the following vegetation types in the area: warm-temperate evergreen Knysna Forest (Veld type 4; Phillips 1931), the subject of this study; a large area of False Macchia or Mountain Fynbos (Veld Type 70) along the mountains and coastal foreland; and relatively small areas of Coastal Macchia (Veld Type 47), Coastal Renosterbos (Veld Type 46) and Valley Bushveld or subtropical transitional thicket of Cowling (1984) (Veld Type 23) towards the western and eastern extremes of the area.

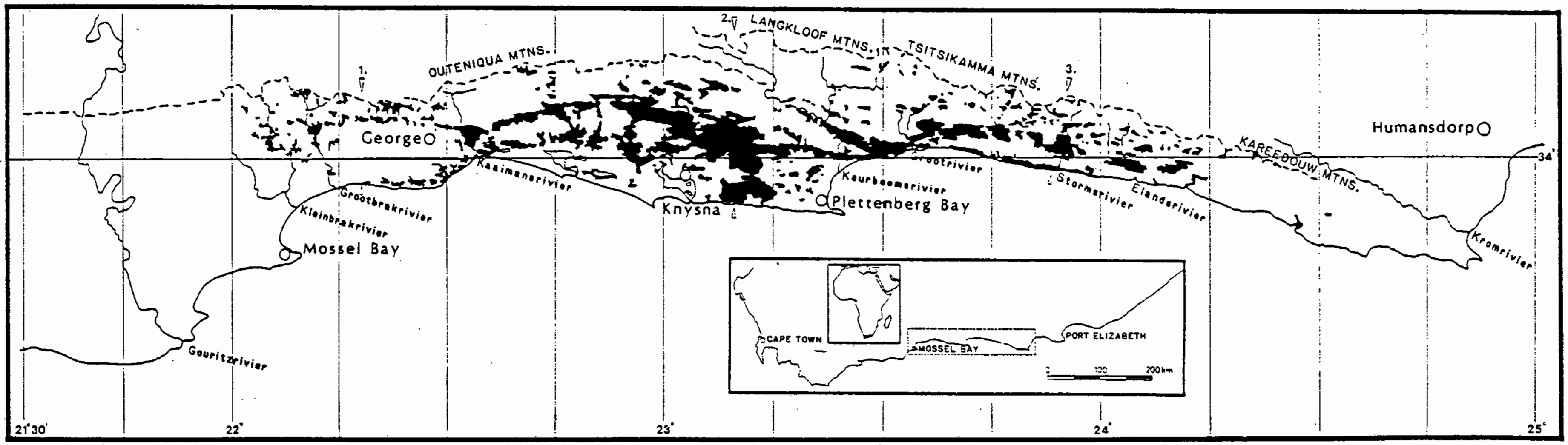

Figure 1 Distribution of forests in the southern Cape study area. The position of landscape profiles 1 to 3 (Figure 2) is indicated.

The mountains, coastal foreland with coastal scarp, and frequent north-south orientated river incisions are the outstanding physiographic features of the southern Cape (Figure 2; Tyson 1971; Jacobs and Thwaites 1988; G N Schafer personal communication 1988). The mountain ranges vary in altitude, width and in distance from the coast (Figure 1, Table 1). Small isolated ridges occurnorth of Knysna. Many secondary ridges with intermontane valleys run south from the main east-west ridges. South of the mountains undulating, to steeply rolling foothills rise up sharply above the coastal platform (Profile 2 of Figure 2). The foothill zone is particularly narrow west of George and is absent in the Tsitsikamma, i.e. east of the Keurbooms River. It reaches its maximum extent north and northwest of Knysna. The coastal platform at 180 to 240 m a.s.l. is level to gently seaward dipping, and is particularly prominent between George and Great Brak River and in the Tsitsikamma (Profiles 1 and 3 of Figure 2). The platform ends in a steep coastal scarp. Tyson (1971) described an upper plateau or plateau remnant at altitudes between 335 to 396 m which occur to the north of Knysna (De Vlugt Plateau of Phillips 1931). Sandy coastal lowlands or embayments occur south of the coastal scarp between Mossel Bay and Great Brak River, between George and Knysna, and around the Keurbooms River estuary. These

TABLE 1 Characteristics of the coastal mountain ranges in the southern Cape

Map	Range	Distance (km) from main mountain ridge to			Altitude (m)	
		coast	northern foot	southern foot	Main ridge	Highest peak
22°00'E	Outeniqua	36,8	4,8	8,3	1000	1621
22°15'E	Outeniqua	18,0	10,5	5,0	1000	1579
22°30'E	Outeniqua	16,8	3,3	11,3	1000	1301
22°45'E	Outeniqua	26,7	4,5	9,3	1100	1487
23°00'E	Outeniqua	29,0	2,8	13,8	950	1059
	Langkloof	37,0	1,3	3,3	1200	1234
23°15'E	Langkloof	34,0	6,3	15,2	1350	1618
23°30'E	Tsitsikamma	14,8	4,7	9,0	1150	1675
23°45'E	Tsitsikamma	13,2	5,0	6,0	1100	1497
24°00'E	Tsitsikamma	12,2	2,9	4,5	900	1251
24°15'E	Kareedouw	10,6	0,6	0,7	700	918
24°30'E	No mountains					

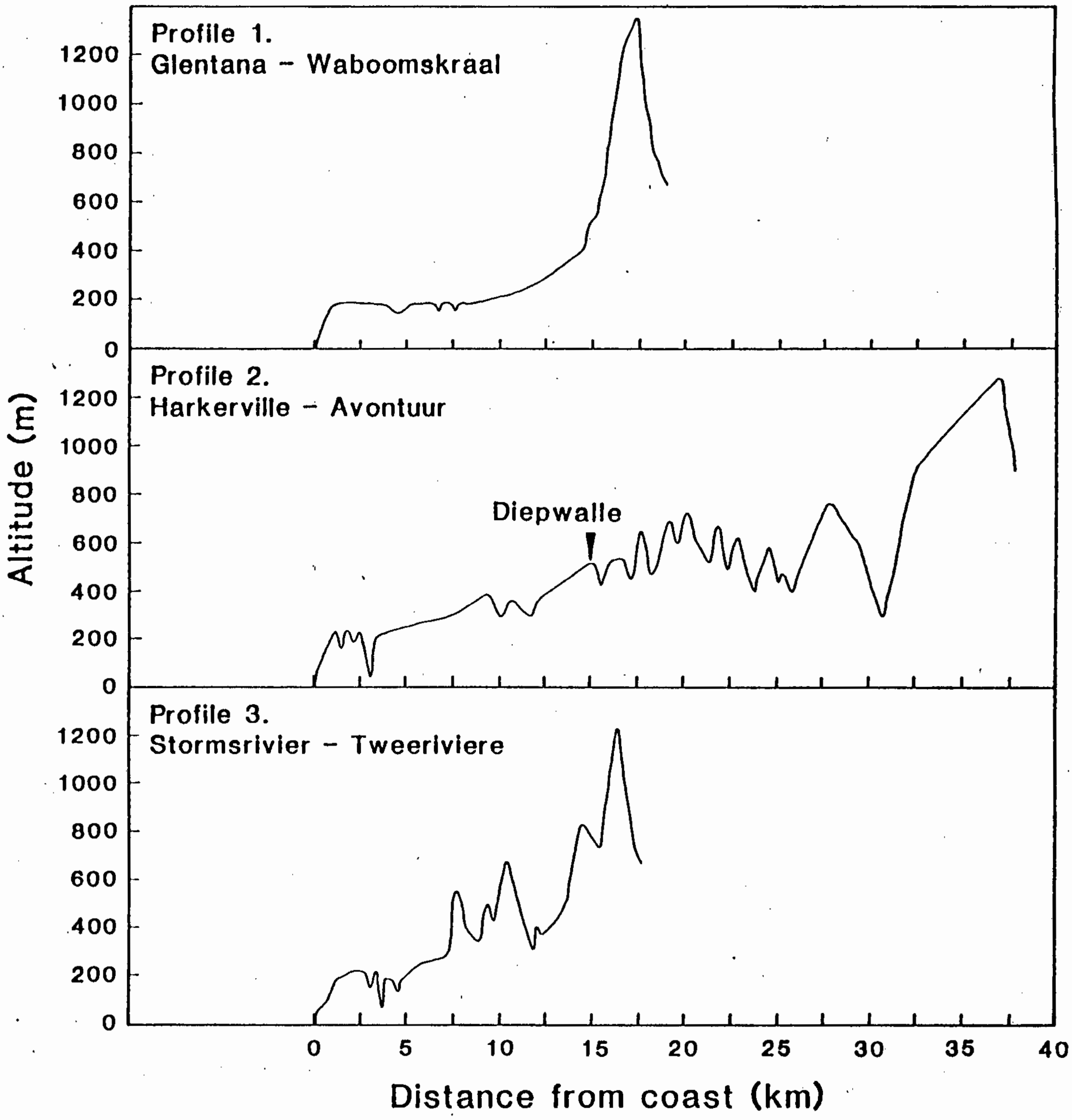

Figure 2   Landscape profiles for three north-south transects through the study area (see Figure 1 for the position of the transects).

comprise the Wilderness lakes system, and estuaries at Klein Brak River, Great Brak River and Keurbooms River, with calcareous sand ridges and unconsolidated superficial deposits on the coast.

Two rivers, the Gouritz and Kromme, cut through the coastal mountains. The Keurbooms river cuts through the coastal mountains but a low ridge separates it from the Little Karoo to the north. Many other rivers have their source south of the mountain ranges, and have eroded deep, narrow valleys (ravines) through the coastal foreland. West of Great Brak River the platform remnants are small and scattered. The valley slopes of these rivers and of the Bitou River east of Plettenberg Bay are generally convex with an irregular surface. In several places, east-west tributaries form wider valleys on softer geological substrates (Profile 3 of Figure 2).

Rocks of the Cape Supergroup underlie most of the area, wheras Pre-Cape and Cretaceous rocks, and unconsolidated deposits of recent age occupy smaller areas (Toerien 1979). The pre-Cape rocks comprise the Maalgaten Granite to the west and east of George which are separated by a variety of sedimentary and metamorphic rocks of the Kaaimans Formation, with east-west strike. The seven members of the latter formation include phyllite, quartzite, grit, hornfels and schist. Strata of the pre-Cretaceous Table Mountain Group, which consist mainly of supermature quartz sandstones, with subordinate shales, were subjected to severe north-south orientated compressive stresses. This produced the Cape Fold Belt with the more resistant strata of the Table Mountain Group, the Peninsula and Skurweberg (=Kouga) Formations, forming the prominent east-west trending mountain ranges. Softer sandstones of the Goudini (=Tchando) Formation, and shales of the Cedarberg and Baviaanskloof Formations, have weathered to form the intermontane and platform valleys. Cretaceous conglomerates of the Enon Formation crop out on the coastal plain at Mossel Bay, Knysna and Plettenberg Bay. Silcrete terraces occur in the foothill zone west of George. Aeolian sands which were deposited during the Quaternary cover the coastal platform between Knysna and Plettenberg Bay. A narrow coastal strip of migrating and vegetation-settled dunes occur in the embayments.

The soils are generally acid, leached, low in nutrients (with phosphate and manganese deficiencies in places), have a poor buffering capacity, have poor internal drainage, and the effective depth is almost invariably shallow (G N Schafer personal communication 1988). Six major soil types occur in the area (Schafer 1984; Schloms and Ellis 1984). Unconsolidated soils and exposed rock cover a large part of the area, mainly the mountains, and are shallow and acid with organic accumulation. Lithosols and lithocutanic soils occur on mountain footslopes, the steeper river incisions and the coastal scarp, and are well-drained. Duplex soils are typical of the coastal platform, have a permeable top soil overlying a clay subsoil at 300 to 500 mm, and are poorly drained. Podzols occur mainly in higher rainfall areas, and are locally associated with recent colluviation of Table Mountain Sandstone material and aeolian sand drifts. Red Apedal Soils occur in a narrow strip between George and Great Brak River, and are well-drained. Regic sands are unconsolidated, deep, of medium texture and frequently calcareous.

The weather of the southern Cape is particularly influenced by the succession of east-moving subtropical low-pressure cyclones interacting with subtropical high-pressure anticyclones located over the oceans (Tinley 1985). The mountains profoundly affect the local weather pattern by barring the inland penetration of shallow weather systems and by invoking typical orographic precipitation (Tyson 1971). The warm Agulhas current flowing southwesterly along the coast further moderates the climate. Climate diagrams (after Walter 1979) show the temperature and rainfall patterns for several sites in the area (Figure 3; Weather Bureau 1986, personal communication). The proportion of winter rainfall (April to September) varies between 42 and 54%. This places the forests in the very humid subzonobiome of the warm-temperate humid climate region, with all-year rainfall (Walter 1979). It is a transitional zone between the tropical-subtropical and the typical temperate regions.

Mean annual rainfall in the study area ranges from 400 mm around Mossel Bay to about 1 200 mm in three localities (Scriba 1984; Weather Bureau 1986): Jonkersberg-Geelhoutboomberg on the foothills of the mountains west of George; Diepwalle in the main forest north of Knysna; and on the platform at Storms

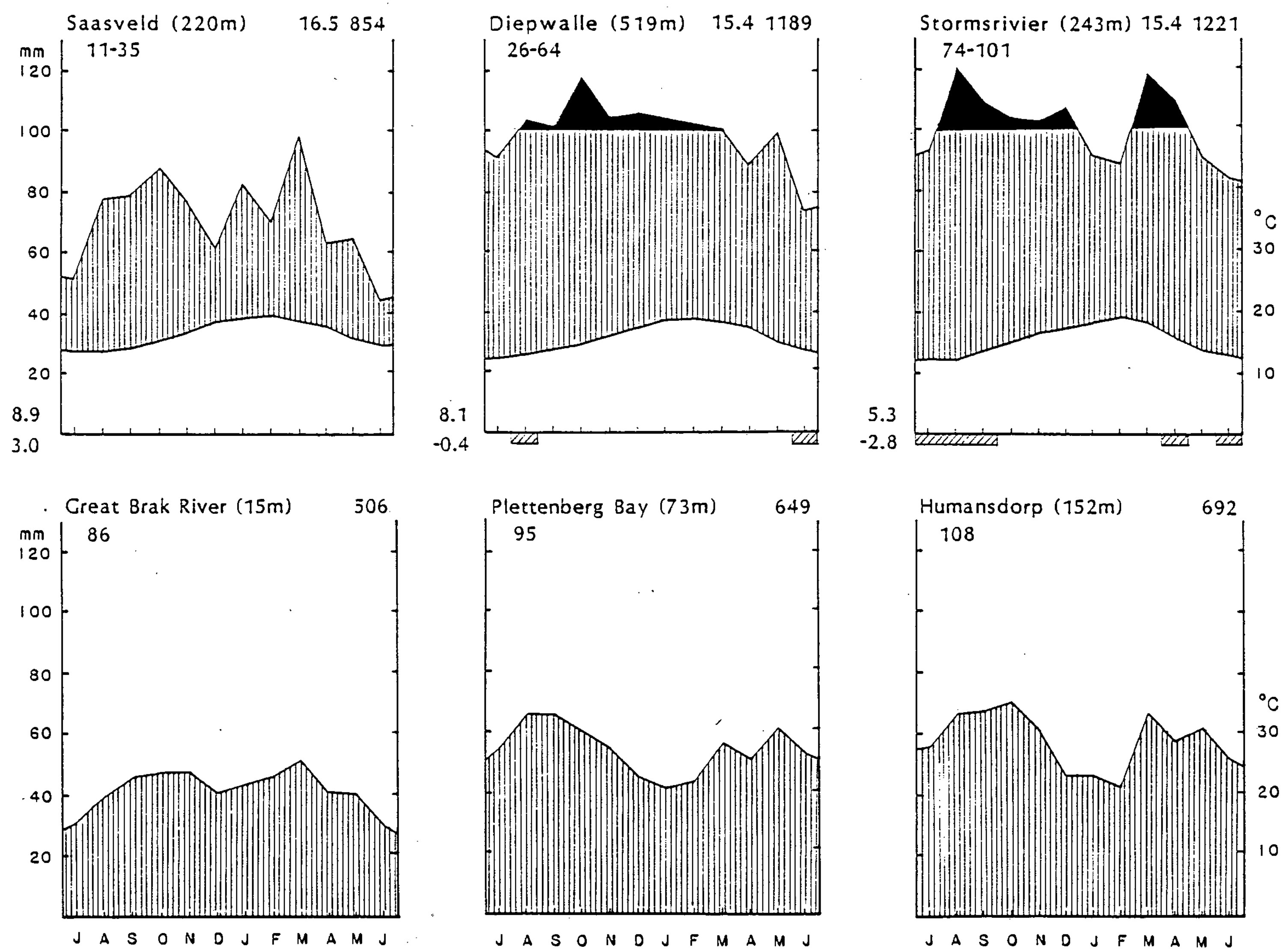

Figure 3 Climate diagrams (after Walter 1979) and rainfall figures for the wetter and drier sites in the study area.

River. Various weather types favour precipitation in the area (Wellington 1955). In summer rain falls when the summer low pressure system (normally situated over northern Botswana) shifts south, or when a low pressure trough extends far enough south to feed in moist air which then precipitates as thunderstorms (with lightning). In winter, rainfall is associated with an east-moving coastal Low together with an inland High located over the eastern sub-continent, i.e. weather following bergwinds (Tyson 1964). The highest rainfall occurs in spring and autumn. It is induced by cold fronts which originate in the South Atlantic and move across the southern coast-line in an easterly to north-easterly direction (Tyson 1971). Scriba (1984) recognized four seasonal patterns in rainfall, based on seasons with above-average rainfall: spring dominance (September and October) for the area from north of Knysna to the Tsitsikamma coastal platform; spring to autumn dominance for the area on the platform from north of Sedgefield to the west; early winter to early spring dominance for the area on the coast around Sedgefield and Plettenberg Bay; and overall above-average rainfall for the northern part of the platform north of Knysna. Rainfall cycles of three, 10 and 30 years between above and below average annual intensity are evident in this area (Tyson 1971; McNaughton and Tyson 1979). Deficits in annual rainfall (i.e. drought severity ranging from moderate to extreme) occur regularly in various parts of the southern Cape at three year intervals (Zucchini and Adamson 1984). Exceptional droughts have been recorded for the following years: 1869, 1881, 1891, 1895, and 1899 (Phillips 1931).

Temperature data are sparse and available for relatively short and sometimes intermittent periods only (Weather Bureau 1986). For Saasveld east of George on the coastal platform, for the period 1973-1984, the mean daily maximum temperature ranged between 23,8°C for February to 18,2°C for August, and the mean daily minimum between 19,7°C and 8,9°C for the same months. The maximum and minimum temperatures for Diepwalle are slightly lower. Frost occurs infrequently and is confined to depressions. Hail occurs infrequently and usually with little impact (Phillips 1931), except for almost complete defoliation and severe bark damage during November 1987 over small areas of forest at Bergplaas and Buffelsnek (personal observation). One to a few snowfalls per year occur on the mountain peaks, but very infrequently lower down. A heavy snowfall on the foothills and coastal platform between George and Knysna during August 1972 damaged many small trees and branches of large trees (personal observation).

Thunderstorms are rare (Phillips 1931). Occasionally portions of the forest are struck by lightning, leaving dead trees standing on small portions of ground on which the ground vegetation is usually dry. Very infrequently the lightning may ignite a fire (Phillips 1931; Geldenhuys unpublished data).

The prevailing winds blow from the southeast and southwest in summer and from the northwest (bergwinds) and southwest in winter. Spring and autumn experience relatively calm conditions (Weather Bureau 1975). Bergwinds during winter and cold fronts during spring and autumn further contribute to the very equable climate.

METHODS

I used data compiled by Grewar (1979) on size and ownership of forests of one hectare and larger which he mapped on 1:50 000 topographic maps of the study area. A number of forests smaller than one hectare were included when they formed part of a cluster of forests in a particular area. Grewar (1979) obtained details from aerial photographs (Job 499/6 of 1966) and 1:10 000 maps in management plans of forests on state forest land. Some forests had more than one owner and individual properties, whether entire forests or parts thereof, were numbered on the maps and listed separately. Ownership was indicated as "state" for all forests on land controlled by the Department of Environment Affairs (Forestry Branch) before transfer of land to the Cape Provincial Department of Nature and Environmental Conservation and to National Parks Board early in 1988. "Other" designates all forests under the control of other bodies such as private individuals, private companies, municipalities and divisional councils, National Parks Board and Cape Department of Nature and Environmental Conservation, before 1988. Grewar (1979) determined forest area for each property by using a "dot planimeter" with each dot representing 0,25 ha, or used area values on planning maps of state forests which were determined by planimeter.

For each forest property I recorded map reference, ownership, altitude, landscape zone and area. I used six landscape zones: mountains, foothills (including De Vlugt Plateau), coastal platform, river valleys through coastal platform, coastal escarpment, i.e. facing the ocean, and recent sand dunes. I used the original data for subdivision by ownership, but combined data for analysis of forest complexes. Some larger forest complexes cover different zones and for these I used the zone covered by the larger part of the forest.

RESULTS

DISTRIBUTION AND SIZE OF FORESTS IN THE LANDSCAPE

A total of 908 forest patches with total area of 60 561 ha occur in the southern Cape. In Figure 4 the frequency distribution of forest size in the southern Cape is compared to that of Natal and Transvaal (Cooper 1985). The latter included forests of 50 ha and larger. Forest size in the southern Cape ranges from 0,3 ha to 25 706 ha, with average size of 66,7 ha and a very skew distribution (Figure 4). Table 2 gives a breakdown of the number, total size and largest forests in the different landscape zones.

The forests are concentrated around Knysna between the Harkerville coast in the south and Yzernek Nature Reserve in the north, and between the Homtini-Goukamma forests in the west and the Bitou River valley north of Plettenberg Bay in the east. In this area the forests cover all the landscape zones except the coastal dunes, and all the geological formations in the region except the granites, schists and recent dunes. Rainfall is highest at Diepwalle in the center of the area (1189 mm; Figure 3). It declines to the north (512 mm at De Vlugt), to the east in the Bitou River valley (649 mm at Plettenberg Bay), to the southwest (748 mm at Knysna), and to the west (833 mm at Goudveld). Other large complexes occur east of George and in the Tsitsikamma between Keurbooms River and Storms River. Forest area declines sharply west of 22°30′E and east of 24°15′E, and also north of Plettenberg Bay relative to the large areas west and east thereof.

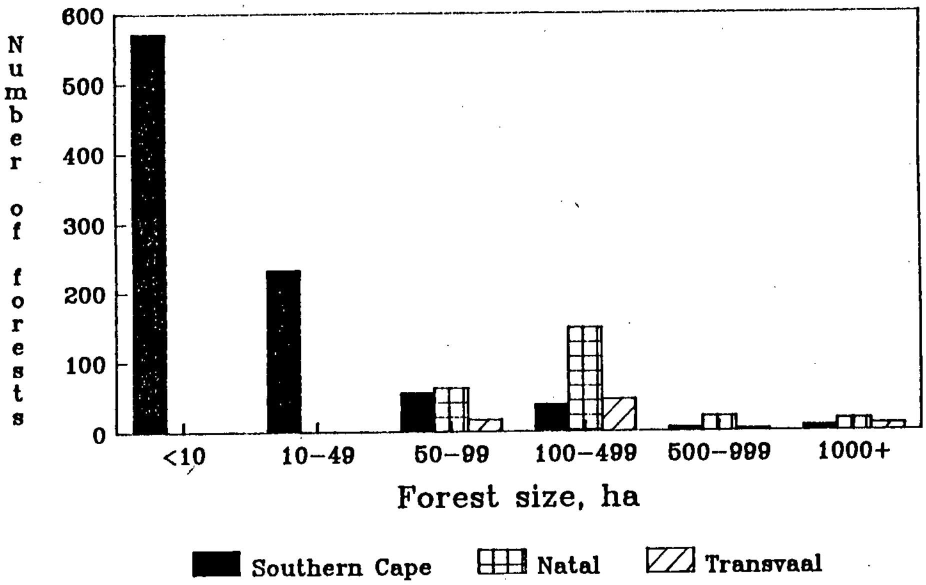

Figure 4 Frequency distirbution of patch size of southern Cape forests compared to forest patch size (≥50 ha) in Natal and Transvaal (data from Cooper 1985).

Foothill forests are the largest forests, cover the largest area and are particularly prominent in the area north of Knysna (Table 2). Their small area west of George and in map zone 23°15′E corresponds to very narrow zones of foothills. This zone is absent east of 23°25′E. Platform forests are particularly extensive in western Tsitsikamma (23°35′E to 23°55′E) and immediately east of George. East of 24°E the area of platform forest is small relative to the large area of coastal platform. These forests are absent west of George. Foothill and platform forests, in most cases, join river valley forests and include relatively large areas of the latter (see Tables 6 and 7). Consequently river valley forests are larger than what the figures indicate. They are particularly extensive in east-west orientated valleys. Coastal scarp forests are large relative to the small area of coastal scarp. They join onto both platform and river valley forests. The scarp forests are particularly prominent between George and Mossel Bay, and in the Tsitsikamma. Dune forests

TABLE 2 Number and area of forests in different map (Figure 1) and landscape zones

Map zone	Landscape zone						Total
	Mountain	Foothill	Coastal Platform	River Valley	Coastal Scarp	Dune	
(i)	Number of forests						
22°00'E	12	20	-	45	-	-	77
22°15'E	38	29	-	7	8	-	82
22°30'E	43	4	4	10	11	2	74
22°45'E	40	10	3	14	-	13	80
23°00'E	42	44	10	33	6	-	135
23°15'E	16	42	2	105	6	-	171
23°30'E	73	-	13	14	7	-	107
23°45'E	62	-	19	3	15	-	99
24°00'E	28	-	19	10	11	-	68
24°15'E	9	-	3	-	-	1	13
24°30'E	-	-	-	2	-	-	2
Total	363	149	73	243	64	16	908
(ii)	Total area (ha)						
22°00'E	315,3	251,7	-	883,2	-	-	1450,2
22°15'E	709,5	524,2	-	451,0	132,0	-	1816,7
22°30'E	373,2	2995,7	1960,8	855,1	789,1	13,5	6987,4
22°45'E	583,9	1269,2	13,3	1019,2	-	275,9	3161,5
23°00'E	942,3	26834,0	64,1	775,0	63,4	-	28678,8
23°15'E	184,7	256,5	62,5	3171,0	110,9	-	3785,6
23°30'E	757,2	-	5370,6	382,5	220,6	-	6730,9
23°45'E	1240,6	-	3179,7	64,1	695,0	-	5179,4
24°00'E	216,0	-	623,9	1725,1	19,0	-	2584,0
24°15'E	138,0	-	11,6	-	-	14,5	164,1
24°30'E	-	-	-	22,4	-	-	22,4
Total	5460,7	32131,3	11286,5	9348,6	2030,0	303,9	60561,0
(iii)	Largest forest (ha)						
22°00'E	66,9	54,3	-	387,1	-	-	387,1
22°15'E	104,1	87,5	-	115,8	45,3	-	115,8
22°30'E	51,9	2965,8	1474,8	509,5	427,8	10,5	2965,8
22°45'E	260,3	1021,9	7,0	808,3	-	120,5	1021,9
23°00'E	334,8	25706,1	31,8	161,0	30,3	-	25706,1
23°15'E	53,3	53,0	49,5	942,7	67,3	-	942,7
23°30'E	104,5	-	5198,2	177,8	72,8	-	5198,2
23°45'E	144,3	-	1331,6	56,1	402,7	-	1331,6
24°00'E	36,2	-	358,6	1066,2	2,5	-	1066,2
24°15'E	54,1	-	7,5	-	-	14,5	54,1
24°30'E	-	-	20,2	2,2	-	-	20,2

are small in area and are confined to the large dune complex between George and Knysna. A small area of dune forest occurs in eastern Tsitsikamma. Mountain forests constitute 40% of the number of forests but only 9% of the forest area. A large number of forests occur in mountain valleys running to the east or west from long ridges running south from the main east-west Tsitsikamma mountains. Very few of the mountain forests join the other forest zones.

The most extreme conditions under which forest still persist today were found near Great Brak River. There I have sampled short regrowth forest growing under extreme conditions, i.e. on conglomerates on a steep southerly upper slope below a dense Pinus radiata stand behind Great Brak River with annual rainfall of 506 mm. West of this forest rainfall declines to 400 mm at Mossel Bay. In this area only thicket vegetation persist which contain stunted trees of forest species.

The relationship between altitude and number and mean area of forests show high values between 150 and 350 m a.s.l., i.e. the river valley, platform and foothill forests (Figure 5). The relatively small number and high mean area of

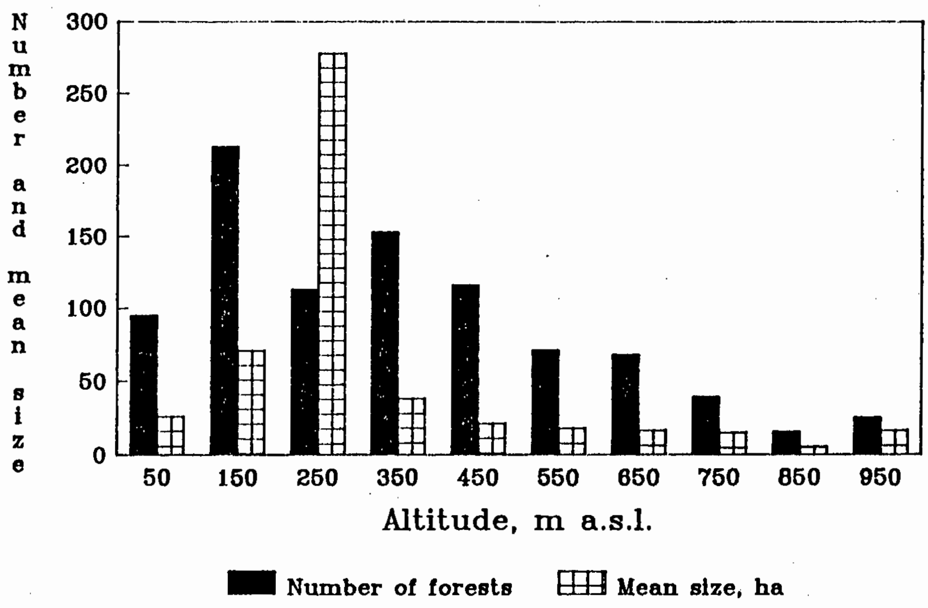

Figure 5 Frequency and mean size of southern Cape forests in relation to altitude.

forest at 250 m constitute the large areas of the river valley-platform-foothill complexes. Several coastal scarp forests occur in places down to almost spring tide sea level. In the mountains forests occur up to 1 220 m a.s.l. although individual trees have been found at higher altitudes.

OWNERSHIP

Ownership is an important factor in different landscapes and map zones, but not in determining forest fragmentation. The Department of Environment Affairs (Forestry Branch) currently controls 69,3% of the forest area or 41 957 ha (Table 3 and 4). This department controls 87,1% of the mountain forests,

TABLE 3 Number and area of forests in different landscape zones according to ownership

Ownership	Landscape zone	Number of forests	Total area ha	Largest forest ha
State	Mountain	303	4770,0	324,7
	Foothill	106	23536,6	14621,3
	Platform	55	10439,3	4333,8
	River valley	69	2702,5	826,9
	Coast scarp	18	508,9	159,3
	Dune	-	-	-
	TOTAL	551	41957,3	14621,3
Other	Mountain	69	706,3	82,1
	Foothill	64	4003,7	1985,6
	Platform	28	628,6	223,6
	River valley	208	11318,0	2494,4
	Coast scarp	60	1635,2	427,8
	Dune	17	311,9	120,5
	TOTAL	446	18603,7	2494,4

85,5% of the foothill forests, 94,3% of the platform forests, 19,3% of the river valley forests (additional area included in platform forest area), 23,7% of coastal scarp forests, but none of the dune forests. It controls a large proportion of the Tsitsikamma forests, of the forests around Knysna and of the forests east of George. West of George and north of Sedgefield it controls about half the area of forests, but none of the river valley, coastal scarp and dune forests. In the map zone north of Plettenberg Bay it controls 35% of the area, mainly on Keurboomsrivier State Forest, but very few of the forests along the Bitou and Keurbooms rivers. East of 24°15'E it controls very few forests and only along the mountain.

TABLE 4 Number and area of forests in different map zones (Figure 1) according to ownership

Ownership	Map	Number of forests	Total area ha	Largest forest ha
State	22°00'E	34	700,7	223,6
	22°15'E	62	938,9	104,1
	22°30'E	53	3774,4	1248,0
	22°45'E	49	5968,8	4198,3
	23°00'E	86	16573,0	14621,3
	23°15'E	48	1488,1	826,9
	23°30'E	81	5544,5	4333,8
	23°45'E	85	4531,0	1097,5
	24°00'E	45	2371,0	1066,2
	24°15'E	8	66,9	30,0
	24°30'E	-	-	-
Other	22°00'E	47	749,5	139,5
	22°15'E	27	877,8	115,8
	22°30'E	29	2219,4	509,5
	22°45'E	38	5716,7	2494,4
	23°00'E	66	4483,2	1985,6
	23°15'E	143	3175,8	701,8
	23°30'E	36	400,3	88,8
	23°45'E	24	648,4	246,2
	24°00'E	28	213,0	46,5
	24°15'E	6	97,2	54,1
	24°30'E	2	22,4	20,2

Ownership other than the state is divided between Provincial Administration, local authorities (divisional council and municipalities), National Parks Board and private companies or individuals (Table 5). Private companies and individuals own the largest area of non-state forest.

TABLE 5 Importance of forest ownership categories other than the state, in the southern Cape

Category	Number of forests	Total area ha	%	Largest forest ha
Cape Provincial Nature and Environmental Conservation	19	286,3	1,5	120,5
Municipality and Divisional Council	13	981,4	5,3	509,5
National Parks Board	35	779,9	4,2	243,4
Private individuals and companies	379	16556,1	89,0	2494,4

DISTRIBUTION AND OWNERSHIP OF THE LARGER FORESTS

The 30 largest forests cover 77,7% of the total forest area, occur in all but three map zones, and all landscape zones, including a very small dune (Table 6). Of this area 73,5% is under control of the Department of Environment Affairs.

The three largest forests cover 55,9% of the total forest area (Table 7). The Goudveld-Diepwalle-Harkerville forest covers all landscape zones except dunes. Forest on foothills and river valleys dominate. Private individuals or companies own 26,8% of the forest. The Soutrivier-Bloukrans-Lottering forest covers mostly the platform, river valleys and coastal scarp. Private individuals or companies and National Parks Board own 16,5% of the forest. The Woodville-Beervlei-Hoogekraal forest covers the foothills (mostly owned by the State) and river valleys (mostly owned by one private company).

TABLE 6 The ownership and landscape zones of the 30 largest forests in the southern Cape

Ownership	Zone	Map	Area ha	Rank	Remarks
State	F/V/P/S	23°00'E	25706,1	1	See Table 4 (26,8% other)
	V/P/S/D	23°30'E	5198,2	2	See Table 4 (16,5% other)
	F/V/P	22°30'E	2965,8	3	See Table 4 (34,1% other)
	P/V	22°30'E	1474,8	4	Groeneweidebos (26,2% other)
	P/V	23°45'E	1331,6	5	Plaatbos, Goesabos (16,8% NPBoard, 0,8% private)
	V	24°00'E	1066,2	6	Koomansbos, Kwaaibrandbos
	F/V	22°45'E	1021,9	7	Vanderwattsbos, Langbos (6,4% private)
	V/P	23°15'E	942,7	8	Keurboomsrivier (12,3% other)
	P	23°45'E	857,5	9	Elandsbos
	P	23°45'E	512,2	11	Witteklipbos
	P/V	22°30'E	481,4	13	Collinshoek (35,6% other)
	V/F	22°00'E	387,1	16	Langbos (42,2% other)
	P	24°00'E	358,6	17	Witelsbos
	M	23°00'E	334,8	18	Millwood, Bloubos (3% private)
	V	24°00'E	331,5	19	Skuinskraal, Leliehoek, Besemgoedkraal
	M	22°45'E	260,3	20	Church Millwood Bush
	F	23°00'E	195,3	21	Platbos, Kruisrivierbos
	V	23°15'E	189,5	22	Landshoogte (38,8% other)
	V	23°30'E	177,8	23	Keurvlaktebos (5,6% private)
	F	23°00'E	177,2	24	Maraisbos
	F	23°00'E	157,4	27	Groot Grysbos
	M	23°45'E	144,3	29	Koutjiesbos
	F	22°45'E	135,8	30	Kaagiesbos
Other	V	22°45'E	808,3	10	Karatararivier
	V/S	22°30'E	509,5	12	Wilderness (also Divisional Council)
	S/V	22°30'E	427,8	14	Duiwerivier, Bo-Langvlei
	S	23°45'E	402,7	15	Stormsrivier NPB (39,6% State)
	V	23°15'E	174,8	25	Doukamma, Wittedrift
	V	23°00'E	161,0	26	Soutrivier (Municipality)
	V	23°15'E	147,2	28	Wittedrift

*M = mountain; F = foothill; P = coastal platform; V = river valley, S = coastal scarp; D = dune.

TABLE 7 Subdivision of the three largest forests in the southern Cape according to ownership, landscape zone and map

State Forest	Zone*	Area	Other Forest	Zone*	Area
(i) Goudveld-Diepwalle-Harkerville Forest (22°45'E to 23°15'E, 25 706,1 ha)					
Kraaibos	P	492,4	Homtini/Goukamma	V	2494,4
Platbos	F	240,6	Portland	V	803,7
Goudveld	F/V	3465,3	Charlesford	V	34,0
Skuinsbos	F	183,7	Gouna Commonage	V	178,3
Gouna	F/P/V/M	3115,5	Parkes Forest A	F	820,8
Klein Gouna	V	123,7	Parkes Forest B	F	1490,3
Gounarivier	V	59,9	Parkes Forest C	F	495,3
Skuinskraal	V	432,7	Thesen Brackenhill	F	346,4
Harkerville	P/V/S	3451,6	Die Poort	F	13,3
Kaffirkop	F/P	3539,7	Skuinsbraak	F	6,5
Diepwalle	F/V	3075,4	Kafferkop	F	6,0
Peerbos	F	223,6	Parkes Noetzie	V	87,0
Ysternek	F	413,2	Mount Nelson	V	18,3
Plantation	P	2,3	Stofpad	V	83,1
			Klipivierspruit	V	5,8
			Kaffersdriftkloof	V	3,3
(ii) Soutrivier-Bloukrans-Lottering Forest (23°15'E, 23°30'E, 5 198,2 ha).					
Soutrivierbos	V/S/P/D	958,9	Keurboomstrand	S	63,3
Kalanderkloof	V	35,5	Forest Hall	P/V	21,0
Grootrivier	V	15,8	Buffelsrivier to Kirbydale	V/P	701,8
Grootrivierpasbos	V	44,9			
Grootkloofbos	V	492,8	Varinghoek	P	25,3
Nommertwaalfbos	V	141,7	Apiesrug National Parks Board	S	31,0
Covie	P	144,3			
Platbos	P	912,0	Soutstrand/Helpmekaar-mond National Parks Board	S	14,0
Bloukransrivier	V	17,3			
Rooistinkhoutbos	V	54,4			
Halifaxbos	V	30,0			
Oosthuizen-se-bos	V	144,3			
Lottering Coldstream	V/P	1349,9			
(iii) Woodville-Beervlei-Hoogekraal Forest (22°30'E, 22°45'E, 2 965,8 ha).					
Woodville	F	705,5	Woodville	P	18,7
Beervlei	F/V	1248,0	Hoogekraal, Eastbrook	V	993,6

* M = mountain; F = foothill; P = coastal platform; V = river valley, S = coastal scarp; D = dune.

DISCUSSION

FOREST SIZE

Several estimates of the indigenous forest area in the southern Cape were published in the recent past: 72 000 ha (Von dem Bussche 1973), 65 000 ha (Von Breitenbach 1974), and 65 713 ha (Scriba 1984, based on Von Breitenbach 1974). This study, based on the detailed mapping exercise of Grewar (1979), with minor adjustments, estimate the area as 60 561 ha. Scriba (1984) used the western and eastern limits of his study area as 22° 05'E and 24° 15'E. This study area extends slightly further to the east and west, but adds only a few small forests. The total land area under study is 736 470 ha, which means that 8,2% of the study area is covered with indigenous forest. Scriba (1984) indicated that the George forests (west of George) represent 4,5% of the forests on 18,5% of the total land area, the Knysna forests (George to Plettenberg Bay) represent 65,8% of the forests on 49,7% of the area and the Tsitsikamma forests (east of Plettenberg Bay) represent 29,7% of the forests on 31,8% of the area. The southern Cape forests are more concentrated than the Natal or Transvaal forests. For forest size of 50 ha and larger, the southern Cape has 105 forests with total area of 53 142 ha, compared to 248 forests of 90 506 ha for Natal and 76 forests of 35 028 ha for Transvaal (Cooper 1985; this study). Natal and Transvaal have more forests of size larger than 100 ha (Figure 4). However, the largest single forest in South Africa occurs in the southern Cape (25 706 ha; Table 2 and 7). This is the only mappable unit of the Forest Biome in southern Africa (Rutherford and Westfall 1986). The largest forest in Natal is the Dukuduku forest of 3 500 ha, and in Transvaal is the Woodbush-De Hoek complex of 6 626 ha (Henkel et al. 1936; Scheepers 1978; Cooper 1985).

ENVIRONMENTAL LIMITS OF FOREST

Scriba (1984) reported considerable variation in the relative influence of climatic, geological, topographic and human factors on the spatial pattern of the George, Knysna and Tsitsikamma forests (Table 8). Of all the factors investigated, none excluded forest, and only extreme conditions or factor levels impeded forest development. Forests occur on all geological formations, but sandstones, shales and schists carry above-average forest cover, and granites, conglomerates and unconsolidated sands carry limited forest cover. The effects of altitude, topography, and aspect are all integrated in the importance of forest in the different landscape zones of this study (Tables 2 and 8). The mountains, with high altitude, high proportion of both northern and southern aspects and steep slopes, have a high number of small forests but low total forest area. By contrast, the river valleys, also with steep slopes and a high proportion of northerly and southerly slopes, but with lower rainfall and physiologically drier sites on shales, schists and conglomerates, carry proportionately large forests. The foothill zone, with generally high rainfall, moderate slopes, southerly aspects and suitable geology also carry large forests. The platform generally only carry large forests on the border with the foothills or with the mountain footslopes where the foothills are absent. The more exposed southern part of the platform is generally devoid of forest. The coastal scarp, with steep slopes and low rainfall, and exposed to salt-laden cold winds, carry a proportionately large forest area.

The extent of the southern Cape forests have often been attributed to the relatively high, well-distributed rainfall, which in turn had been attributed to the close proximity of the mountains to the ocean (Sim 1907; Phillips 1931; Laughton 1937; Tyson 1971). Forest vegetation is generally more prominent in higher rainfall areas (Webb 1978; Rutherford and Westfall 1986) and Scriba (1984) also showed an increase in forest cover with increase in rainfall. However, Grey (1987) calculated a significant increase in rainfall with increasing altitude in the study area. The larger forests occur in the 800 to 1 000 mm zones with altitude around 250 m and not in the mountains which contradicts the general worldwide pattern. The rainfall data for Great Brak River, i.e. the lower extreme, give 45,2% winter half-year rainfall and 3,8 Summer Aridity Index (SAI) for the months of December to March. This point falls below the upper SAI limit for forest patches of Rutherford and Westfall (1986) who suggested that forest or forest patches are limited to areas with mean annual rainfall >525 mm with strong winter rainfall and >725 mm with

TABLE 8 Forest cover as percentage of total land area under a particular variable in three local study areas and in the southern Cape region as a whole (Scriba 1984)

Forests	George	Knysna	Tsitsikamma	southern Cape	
Total land area, ha	82 964	222 287	142 328	447 579	
Total forest area, ha	2 960	43 225	19 528	65 713	
<u>Rainfall</u>, mm/annum					*
501- 600	0	0,7	0	0,4	0,2
601- 700	4,8	1,0	1,5	2,0	2,2
701- 800	1,5	12,9	19,8	13,3	21,5
801- 900	5,7	21,3	6,2	15,4	22,2
901-1000	7,0	38,3	12,7	23,2	17,9
1001-1100	6,7	65,2	14,8	29,8	21,7
1101+	17,4	67,2	23,1	30,5	14,3
<u>Geology</u>					
Cape granite	0,4	14,5	-	3,3	1,7
Table Mountain Sandstone	6,5	22,0	11,2	16,0	72,9
Malmesbury shales	6,5	30,8	-	21,6	12,9
Bokkeveld shales	-	0,3	45,2	21,3	7,8
Enon conglomerates	0	12,1	8,8	8,1	2,6
Superficial deposits	1,4	5,9	2,2	4,7	2,1
<u>Topography</u> (number of 50 m contours on 0,5 minute grid square)					
0-1 (level)	0,9	18,8	15,1	12,1	25,0
2 (gentle slopes)	6,8	33,4	29,5	27,7	43,5
3 (moderate slopes)	6,6	23,8	19,4	20,5	18,9
4-5 (foothills)	3,5	9,0	5,3	7,0	9,6
6-8 (mountains)	9,7	1,7	3,0	3,4	2,7
9+ (very steep slopes)	-	-	5,2	3,8	0,3
<u>Aspect</u>					
Level (0-3,5° slope)	0,9	18,8	15,1	12,1	24,6
North	1,9	11,5	7,3	9,5	7,8
East	8,6	21,3	8,5	15,1	11,1
South	8,1	23,1	17,1	18,8	46,3
West	4,4	21,1	7,7	14,0	10,2
<u>Altitude</u>, m a.s.l.					
0-150	3,2	23,8	23,7	18,2	19,7
151-300	1,9	24,8	23,0	18,9	43,5
301-450	6,5	35,4	12,9	24,7	21,9
451-600	1,5	13,2	8,1	10,8	8,3
601+	7,2	4,1	2,4	3,8	6,6
<u>Accessibility</u> (2 km from all major old roads, 7 km radius from towns)					
Accessible	2,3	17,4	22,7	14,6	50,1
Inaccessible	6,6	21,6	8,9	14,7	49,9
<u>Rural settlement</u> (buildings per 282 ha, i.e. per 1 minute grid square)					
0	5,2	21,0	11,8	15,7	62,6
1- 5	4,9	18,9	25,8	17,6	17,7
6-10	3,5	18,1	12,2	12,1	7,5
11-20	1,8	19,8	12,8	13,0	7,7
21-30	0	11,9	13,5	8,8	1,8
31+	0,4	10,4	14,5	7,5	2,7

* Forest area for variable value as percentage of total forest area

strong summer rainfall. Thicket vegetation dominated by forest species, and not included in this study, occurs scattered west of Great Brak River.

All of this suggest that the only true limit to the potential establishment and growth of forest in the southern Cape is annual rainfall below 500 mm. Above 500 mm annual rainfall the terrestrial temperature, moisture and nutrient regimes and levels do not limit the development of forest. Rutherford and Westfall (1986) indicated that forest occur as unmappable patches in the higher rainfall areas of the Fynbos, Savanna and Grassland Biomes. Fire is an important disturbance factor in all three these biomes, and also in the mountains of the study area. Disturbance factors, therefore, must have eliminated and fragmented forest in many areas of the southern Cape. Furthermore, disturbance of forest would be more severe and recovery more slow with more extreme climatic, edaphic and topographic conditions such as drier or exposed sites.

There is similarity in the distribution of mixed evergreen forests in southern Africa and rainforest distribution in Australia (Goldstein 1977; Webb 1978; Bell et al. 1987). However, the recorded climatic-edaphic limits are higher in Australia. In New South Wales and southeast Queensland warm-temperate rainforest occurs from sea level to above 1 600 m. On soils derived from igneous rocks or calcareous sediments with annual rainfall below 1 000 mm forests occur in topographically sheltered sites. On soils derived from siliceous rocks forest occur if the annual rainfall exceeds 1 300 mm with >25 mm for the driest month (Baur 1953, 1962; McDonald and Whiteman 1979). Scrub forest (Australian thicket) limits fall between the 600 mm and 800 mm rainfall isohyet (Webb 1978). In cool temperate Victoria and Tasmania rainforest is the predominant forest type where rainfall exceeds 1 400 mm and summer rainfall exceeds 50 mm per month, even on low-nutrient soils (Gilbert 1959; Howard and Ashton 1973; Ogden and Powell 1979). However, disturbance by fire is recognized as an important determinant of rainforest distribution (Goldstein 1977; Ogden and Powell 1979). Protection from fire result in rainforest expansion into Eucalyptus stands, whereas regular fires cause the advance of Eucalyptus stands into rainforest.

FRAGMENTATION OF FORESTS BY DISTURBANCE FACTORS

The principal large-scale disturbance factors of forest are exploitation and clearing, grazing and fire (Sim 1907; Phillips 1931, 1963; Laughton 1937; Scriba 1984). Forest exploitation before the advent of the European must have been minimal (Laughton 1937). The San (Bushmen) were mainly hunters, occasionally dwelled and settled in the forests, and did not exploit the forests. The Knoi (Hottentots) were pastoralists who burned the veld to obtain grazing for their cattle. The Nguni people (black tribes), who still utilize forests to the east extensively, are not known to have occupied the southern Cape forests.

Forest exploitation and clearing

The forests west of George were discovered by the Dutch by about 1711. Settlement by the Europeans started about 1778 when woodcutter posts were established at George and Plettenberg Bay (Phillips 1931, 1963). The settlers exploited timber from the forest, and cleared portions of forest, bush and shrubland for crops and grazing. Through gradual evolution of policy between 1778 and 1939 an adequate system of conservation was introduced since 1874 (Phillips 1963). This culminated in the single tree selection system of Laughton (1937). Several proclamations since 1801 were aimed at preventing the waste, destruction or burning of the forests, or the injury of the young trees of the forests. By 1856 the George forests were cut-out and nearly destroyed by fires. Prior to 1856 exploitation damage to forest was common in eastern Tsitsikamma, i.e from Blueliliesbush eastward. But even by 1872 the western Tsitsikamma between the Keurbooms River and Storms River was relatively unoccupied. Exploitation had been responsible for the removal of varying degrees of the upper and lower canopies. Removal of many of the dominant trees stimulated succession and the appearance of dense communities of useful nurse crops such as Halleria lucida, Rhamnus prinoides and Burchellia bubalina. Under these most of the canopy species regenerated, but they required considerable periods to recover adequately. By 1939 the forests were closed for exploitation. By 1965 the forests had recovered and were re-opened for exploitation by the state under control of forestry scientists (Von Breitenbach 1974).

Some forests that were cleared of valuable timber were sold (Phillips 1963). Between 1826 and 1876 "several thousand acres of valuable timber land" were sold to private owners, but the practice was stopped. The larger private forests listed in this study were obtained through these sales. The fate of lots sold often were that forest made way for "mealie gardens". Today clearing of forest still continues, but only at a very low level. It was estimated from aerial photographs that a private company cleared 140 ha of its forest (part of the Diepwalle-Kaffirkop complex) between 1958 and 1966 for conversion to Eucalyptus diversicolor plantations (Von dem Bussche 1973). During the period 1970-1980 a minimum area of 218 ha of forest in the southern Cape was cleared for agriculture, forestsry and roads (46 ha), powerlines (19 ha) and for conversion (of private forests) to Eucalyptus plantations, agriculture and dams (153 ha) (Geldenhuys 1982; Geldenhuys et al. 1988).

Scriba (1984) suggested that the Knysna forests have persisted in a moderate to dense rural environment, but that most of the George forests on the relatively dry coastal foreland had been cleared of forest by humans during recent historical times. However, suggestions of clearing of forest from all open areas adjacent to forest during historical times must be viewed with caution. Clearing and conversion to agricultural land of large areas of forest with modern equipment and methods is a formidable task today. During the 18th and 19th centuries only relatively small areas of forest would have been cleared on the margin of forests to enlarge existing openings. Clearing for agriculture was confined to the foothills and coastal platform and would not explain the intense fragmentation of the mountain forests. Furthermore, grazing and fire were the two most persistent factors which have led to reduction of forest and extension of fynbos (Phillips 1931).

Grazing

Inskeep (1987) produced various pieces of evidence to suggest that the pattern of forest and open country around Plettenberg Bay existed long before European tree-felling started. A mosaic of grassland (fynbos?), scrub, and forest, similar to the present, is pictured in the writings of survivors of the wreck of the ship San Gonzales during June 1630 and early travellers (Raven-Hart

1967; Le Vaillant 1780; Lichtenstein 1812; Thunberg 1814; all from Inskeep 1987). The bay was inhabited by pastoralists with herds of sheep and cattle. Sheep seems to have been present between 900 and 1000 years BP (Inskeep 1987). Forest regulations issued in 1856 entitled each holder of a timber licence to take 16 oxen to the forests and to graze them for ten days on the adjacent government or other lands under servitude of grazing (Phillips 1963). Phillips (1963) mentioned that plenty of buffalo and elephant were still present by 1875. Both these animals occur in herds and favour more open vegetation such as woodland, shrubland and grassland (Smithers 1983), although they may shelter and feed in the forest. The area west of George is known amongst the farmers as "grasveld", i.e. grassland, and was favoured in earlier times for seasonal grazing (personal communication with older farmers).

Fire

Man has used fire since 1,0-1,5 million years ago (Brain and Sillen 1988) and for some form of veld management in the fynbos area for at least the last 100 000 years (Deacon 1983), i.e. long before pastoralism. Diaz, Da Gama and others have recorded in the fifteenth century great smoke bands over the land (Phillips 1963; Inskeep 1987). The greatest fire on record in the area occurred during a bergwind during February 1869 after three months of drought and much dead material accumulated in the forest (Phillips 1963). Forest and other vegetation were destroyed from the mountains to the coast throughout the study area. However, many forests escaped the fire. Phillips (1963) suggested that fires originating in the Little Karoo and Langkloof, driven southward by bergwinds, destroyed the margins of the main forests of the platform. Fires driven by the hot, dry bergwinds exerted a specific pattern on the distribution of forests in the study area (Chapter 2). Phillips (1931) noted evidence of forest presence in extensive areas of fynbos such as charred roots and stems, incinerated layers at depths of 300 to 450 mm, presence of floral elements of bush, scrub forest and forest in tall fynbos, and actual relict trees or small relict tree communities at distances of several kilometers from the forest. During the historical past fire reduced forest in area and, in part, structure, until about 1900 (Phillips 1963). Today fire is largely controlled below the foothills. The mountain catchments are burnt in blocks on a 10 to 15 year cycle during the relatively moist summer months (Seydack 1986).

Fires within the forests were far fewer than fires ravaging from outside. Their ignition are attributed to various causes. Some were ignited by forest-dwelling parties of the now extinct semi-nomadic San (Phillips 1963). Islands of fire-prone sclerophyll fynbos shrublands in the large forest around Diepwalle, ranging in size from 0,5 ha to 670 ha, commonly occur on broad ridges or north-facing slopes (Cameron 1980; Inskeep 1987; Bond et al. 1988). Phillips (1931) attributed the origin of the islands to the use of fire by the San and not to lightning. Lightning is an important small-scale disturbance factor in the forest in both killing trees and by causing fires (Geldenhuys unpublished data). Inskeep (1987) regarded the islands as an ancient and possibly entirely natural feature, kept open in part by the grazing of buffalo. However, Bond et al. (1988) attributed the islands to their isolation by forest expansion from a few centuries to several thousand years ago. The islands were later expanded by European and coloured hunters by setting forest alight to smoke out elephant, buffalo and bees, and by reckless burning for grazing (Phillips 1963). Furthermore, the severe exploitation of the forests created much debris and exposed them to the drying effects of wind and rendered them inflammable (Sim 1907; Phillips 1931, 1963). Fires used for clearing land and improving grazing on land adjoining forest made most headway in heavy disturbed forest.

Plantation forestry

Conservationists often maintain that plantation forestry threatens the indigenous forests (Campbell and Moll 1977; Stirton 1978; Cooper 1985). In the study area the government started in 1876 to establish stands of alien trees, mainly of *Pinus*, *Eucalyptus* and *Acacia*, in fynbos along the forest margins and into opened areas in the forests (Phillips 1931). Van Daalen (1981) attributed the lack of forest regeneration in the adjoining fynbos of the islands around Diepwalle to the inability of forest trees to withstand regular burning and the unfavourable macro- and microclimate of the fynbos. However, Geldenhuys et al. (1986) and Knight et al. (1987) indicated that plantation forestry provided protection to the forests in different ways: an alternative and more economic timber source; an effective means of fire reduction; and a nurse stand for the expansion of forest. Plantation forestry therefore provide indirect evidence that forest is limited in the area due to uncontrolled fires of the past.

PRESENT STATUS AND FUTURE CONSERVATION OF THE FORESTS

This study has shown that even on steep, well-drained slopes, slopes exposed to salty winds from the sea and on recently stabilized sand dunes, forest can establish, although rather slowly. The only true physical limit to forest is annual rainfall below 500 mm. Disturbance by fire, grazing and historical forest exploitation and clearing appear to be the main factors which have caused the fragmentation of the forests. Although one may deduce that the disturbance would be more severe, and thereby permanent, on marginal sites, many parts of the study area with high rainfall, suitable geology and deep soils do not carry forest. However, plantations on these sites encourage the establishment of forest species. I therefore conclude that potentially forest can grow throughout the study area if disturbances through uncontrolled fire, grazing and forest clearance and exploitation can be prevented. It is also clear that private ownership, mostly through economic incentives, has important implications for conservation of the forests.

The intensity and quality of forest management practices differ amongst different owners, different landscape zones and different management classes (Phillips 1963; Geldenhuys 1982, 1983; Van Dijk 1987). In the study area indigenous and plantation forests occur as a mosaic in the landscape, mainly on the foothills and coastal platform. The total plantation area is 76 750 ha of which 75,3% belong to the state (Anonymous 1987b). Of the total indigenous forest area 72,7% is under the control of public conservation and local authorities, and 19,4% is conserved in proclaimed nature reserves and national parks which cover all the landscape zones. Most of the mountain catchments is managed by the Cape Department of Nature and Environmental Conservation. This suggests that most of the forests are under good management which will ensure their future welfare.

The Forestry Branch of the Department of Environment Affairs practices a most comprehensive, scientifically based multiple-use management system (Van Dijk 1987). Management classes provide for production (timber and fern), protection (dry, wet and ecologically sensitive forests), nature reserves, recreation and research. The classes represent 19,7%, 55,8%, 23,0%, 0,4% and 1,1% respectively of the forests on state land. Timber and fern are harvested from ecologically acceptable areas of the foothills, coastal platform and river valleys, excluding nature reserves and recreation areas. It is practiced with minimum interference of the structure, composition and functioning of the ecosystem. A single tree selection system for timber is operated by departmental staff until the timber is delivered on timber auction depots outside the forest. Removals are based on nett growth during the felling cycle (Von dem Bussche 1975; Geldenhuys 1982; Van Dijk 1987). Forest margins are actively re-established with forest species (Von dem Bussche 1975; Van Daalen 1988). Timber harvesting from private forests is controlled through the Forest Act. For larger private forests, officials of the Forestry Branch assist the owners in enumeration surveys and the planning of management activities to control the harvesting of timber and promote conservation of the forest (Parks and Thesen indigenous forest management plans). Many private forests are too small to be managed for timber production. The issue of permits to cut the protected valuable trees of <u>Ocotea bullata</u> and two <u>Podocarpus</u> species is subject to both ecological principles and an acceptable conservation attitude of the owner (Geldenhuys 1983). Fern harvesting is practiced by private contractors on both state and private forests (Geldenhuys and Van der Merwe 1988) and in state forests it is controlled by a monitoring system. Tourism and recreation is operated by all public authorities and facilities include camping sites, forest walks, view points and picnic sites.

These practices ensure that the present forest distribution in the southern Cape is maintained. No quantitative data exist but indications are that the gains in forest area through active re-establishment of forest and natural regrowth, exceed the loss of forest through necessary clearing for the development of infrastructure (Van Daalen and Geldenhuys 1988). This is in sharp contrast to the large-scale clearing of forest in tropical and temperate areas (Myers 1979; Winter <u>et al</u>. 1987).

Several forests in private ownership contain groups of species whose distribution limits or whose disjunct localities in the study area are found only in those forests. These are the river valley, coastal scarp and dune forests west of George and around Sedgefield, forests along the Bitou and Keurbooms rivers and along the coast and river valleys in eastern Tsitsikamma (Chapter 6). In most cases the owners are unaware of the importance of their forests in terms of the ecological importance of those species. Special measures should be taken by the relevant authorities to ensure the conservation of those private forests.

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Chapter 2

BERGWIND FIRES AS DETERMINANTS OF FOREST PATCH PATTERN IN THE SOUTHERN CAPE LANDSCAPE, SOUTH AFRICA

CONTENTS

ABSTRACT

A hypothesis is tested that forest location pattern is determined by the fire pattern, which in turn is determined by the interaction between prevailing winds during dry periods and terrain physiography. The study has shown that the location pattern is not related to clearing by man during historic periods nor to rainfall and geology. The forests persisted in topographic shadow areas of the gusty, hot, desiccating northwesterly föhnlike bergwinds which are common during autumn and winter. Bergwind direction is locally changed due to barriers posed by mountain ridges, and is channelled through valleys running from the mountains. Fires associated with the bergwinds would burn with higher probability in zones in the landscape where forest is currently absent. The wind-fire pattern would furthermore cause calm conditions and a lower probability of fire in localities where the forests have survived. A graphic model is presented to indicate the likelihood of forest persistence in topographic positions in relation to bergwind direction. The historical sporadic, extensive and destructive fires in the area have all been associated with bergwinds. Understorey differences and the presence of charcoal and seed of the legume <u>Virgilia divaricata</u> in the litter layer of Witelsbos forest are related to such a bergwind fire which occurred an estimated 230 years ago.

INTRODUCTION

Arguments on causes of the location pattern of indigenous forests in the southern Cape, and in southern Africa in general, revolve around the clearing of forest and the use of fire by man during the last 300 years (Phillips 1931, 1963; King 1938; Acocks 1953; Granger 1984) and limiting environmental factors, particularly edaphic factors (Rutherford and Westfall 1986). My observations suggested that, in most cases, this pattern does not conform to the edaphic changes (geology and soils) or the clearing practices and history in the southern Cape, although Phillips (1931) indicated that such factors do affect the floristic and structural composition of the forests to some extent. I collected charcoal from the litter and feeding root zone of many seemingly mature forest stands throughout the southern Cape (Geldenhuys 1988). Many sites in the southern Cape landscape are devoid of forest whereas similar nearby but more accessible sites carry tall, diverse and well-structured forest.

From historical records it is known that fires which were driven by bergwinds have devastated large areas in the southern Cape (Le Roux 1969). Bergwinds are gusty, hot, dessicating, northwesterly to northeasterly winds which blow from the arid interior across the coastal mountains onto the coast. They are associated with low pressure cells moving from west to east along the coast (Tyson 1964). The greatest forest fire on record for this region occurred during a bergwind during February 1869 and burnt along the coastal areas from Swellendam to Uitenhage (Phillips 1931, 1963; Edwards 1984). Large fires at Bergplaas (1962) and Witfontein (1964), both near George, and at Longmore near Port Elizabeth (1984) burnt down large areas of pine plantations and entered the indigenous forest in several places (De Ronde <u>et al.</u> 1986; Department of Environment Affairs unpublished reports). During July 1984 a fire burnt down large areas of pine stands on Kromrivier State forest in the eastern Tsitsikamma, burnt through narrow strips of indigenous forest on the southern slopes but did not reach many other forests on the same slopes (personal observation).

In this paper I develop a hypothesis that environmental factors such as rainfall pattern, geology and soils determine the potential limits of forest distribution, but that the bergwind fire pattern determines the actual location pattern of forest in the landscape. The bergwind fire hypothesis is based on the patterns of wind flow around barriers (Barry 1981).

STUDY AREA

The southern Cape forests (Acocks' 1953 Veld Type 4) occur in the area between longitude 22°00'E and 24°30'E and south of the mountain ranges at approximate latitude 33°45'S. The forests occur in distinct landscape zones (Chapter 1) with many small forests in the mountains and few but large forests confined to the coastal platform and river valleys. For several reasons I selected the Tsitsikamma forests between 23°30'E and 24°15'E for the study (Figure 1). In this area the landscape zones are well-defined and run parallel to the coast. Rainfall is high and uniform. A site study area west of Witelsbos is representative of the sites on the coastal platform (Grey et al. 1987). The area was relatively unoccupied by 1870 and a controlled system of forest utilization was in operation by 1870, in contrast to the poor control over forest use and clearing in the George and Knysna area (Phillips 1963).

The mountains form an east-west trending range with elevation between 850 m and 1 300 m. Numerous ridges run south from the main range (Figure 1). The southernmost ridges, i.e. at the junction with the coastal platform, have an east-west orientation. The geomorphology of the area is influenced by the strongly-folded sediments of the Cape Supergroup (Toerien 1979; Grey et al. 1987). This Supergroup is represented by quartzitic sandstones of the Peninsula, Goudini, Skurweberg and Baviaanskloof Formations and shales of the Cedarberg and Gydo Formations. The formations have been folded in one anti- and one syncline in tight to nearly isoclinal folds. Their strike runs parallel to the coastline. The mountains and most of the coastal platform, both near the mountain and inland of the coastal scarp, are underlain by the resistant Peninsula Formation. The coastal platform is a Tertiary wavecut terrace with an elevation between 150 and 260 m. The Gydo shales weathers easily and have been heavily dissected to form east-west orientated rivers with local relief of over 100 m in the coastal

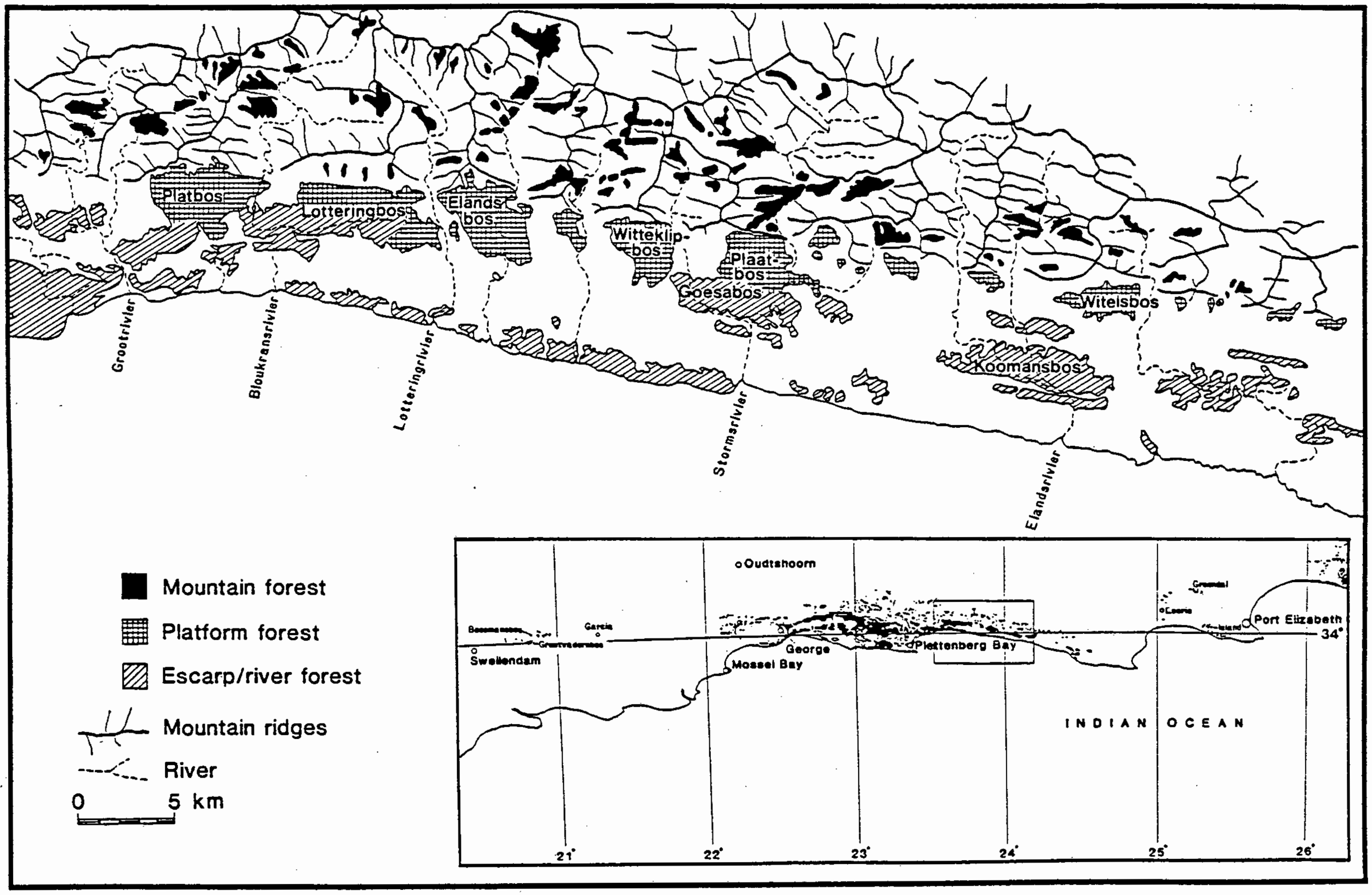

Figure 1 The location pattern of mountain, platform, river valley and coastal scarp forests in the Tsitsikamma area of the southern cape. The insert shows the distribution of forests to the west and east of the southern Cape (adapted from Anonymous 1987)

platform. Numerous rivers flow down wide valleys through the mountains, at right angles to the mountains, and have cut deep, narrow gorges through the coastal platform.

Rain falls all year with means for driest month (February) between 70 and 80 mm and high peaks of 110 to 120 mm during August and October (Grey et al. 1987). Mean annual figures for the rainfall stations from west to east are as follows: Bloukrans 1002 mm; Lottering 1097 mm; Storms River 1221 mm; Blueliliesbush 1134 mm; and Witelsbos 1148 mm (Weather Bureau personal communication 1985). On the platform the annual falls increase by 30 to 84 mm/km northwards (Grey et al. 1987). Bergwinds frequently occur from May to August, but can start from March and continue through to September. Lightning occurs at a density of <2 flashes/km^2/year throughout the year (CSIR 1982).

METHODS

I used forest distribution at different scales to determine forest pattern in relation to different environmental variables.

* Figure 1 was prepared from 1 : 50 000 topographic maps on which the forest was mapped (Chapter 1). From the topographic maps I described the distribution pattern of forest patches in each of the main landscape zones.
* For the platform forests I calculated the probability that forest patches occur in specific positions relative to the topography of the east-west mountain ridge on their northern boundary, and to the river gorges to their east and west. I selected five of the larger platform forests: Platbos, Lotteringbos (northern portion), Witteklipbos, Plaatbos and Witelsbos. Elandsbos was excluded due to the western bend of the river south of the range. I drew five parallel lines from west to east across the forest, from river to river: the first line near the northern boundary, the fifth line near the southern boundary and the other lines at equal espacement in between. I drew a center line from the midpoint of the first line to the midpoint of the fifth line. On each line I measured the distance from

river to river, and from the center line to the western and eastern forest boundary. I used the Chi-square test for goodness of fit to calculate various probabilities about the location pattern of the platform forests (STSC 1986).

* I used results from the site study area west of Witelsbos to determine the site conditions to the east and west of the Elands River and south of the mountains, both inside and outside the forest.
* After I had observed an abrupt change in the density and composition of the understorey near the southern boundary of the Witelsbos forest, I mapped the line of change. Several soil pits were dug and I sampled the forest composition on either side of the change.

RESULTS

LOCATION PATTERN OF FOREST

In landscape zones

The largest forests occur on the coastal platform immediately south of the southernmost mountain ridge and along the east-west trending river valleys in the coastal platform (Figure 1). The platform forests occur west of each north-south river gorge cutting through the platform. Their northern boundary occurs on the steep footslope of the southernmost ridge, near its eastern end. Forest is absent from the platform to the east of each gorge where only fynbos or *Pinus* plantations which were planted into fynbos, grow. Forests in the river valleys occur up to the sharp edges between the coastal platform and the valley, on both the northern and southern sides of the valleys. On ridges running from the coastal platform into the valley, forest occurs at a level much lower than the upper edge of the valley. Forests along the coastal scarp occur in positions very similar to those in river valleys. The smallest forest patches occur in the mountains in several types of situations. Most mountain forests occur west of the streams, near the bottom of the valley, wheras forests are absent east of those same streams, for example the forests north of Plaatbos. A few mountain forests occur immediately below precipitous krantzes on concave slopes. No forests occur near the top of the ridges except where the slope to the north is more gentle than the slope to the south of the ridge, and the southern slope is straight or concave to near the top of the ridge. Near the lower end of some ridges forest occur in the valley of a first-order stream within the forking end of the ridge.

On coastal platform near mountain

The mean forested area of the five studied platform forests (Table 1) is 58,8% and the areas for individual forests (43,5 to 67,3%) do not differ significantly (Chi-square = 7,27, 4 df, P=0,122) from this mean value. However, the Witelsbos forest has made a large contribution to the Chi-square value (4,072) which suggest that its size is significantly smaller than the expected mean.

The gentle slope at the foot south of the southernmost ridge, the uniform topography between the two adjacent north-south river gorges and the parallel east-west strike of the geological formations suggest that the platform forest will have a symmetric distribution on either side of the center north-south line between the two gorges. However, it is clear from Table 1 that the eastern half of the area between two rivers is 84,8% forested whereas the western half is only 31,3% forested. Figure 1 also shows that the shape and size of the open area west of each forest varies. Along several lines in Witteklipbos and Witelsbos the western boundary is situated to the east of the center line. I tested the hypothesis that, for each forest, the open area to the west of the forest was the same along each of the measured lines. The Chi-square value was non-significant for Platbos (except for large value of line five), Lotteringbos and Plaatbos (except for large values of lines four and five) but significant for Witteklipbos (P=1,56E-5) and Witelsbos (P=0,0011). For the eastern portion I tested the hypothesis that the distance from the center line to the eastern margin, expressed as a percentage of the distance to the eastern river, was the same for the five lines of each forest. For all the forests the deviations from the mean were non-significant. Note the relation between the shape of the forest and the orientation of the ridge to its north, particularly the western end, the position of this ridge in relation to the southernmost ridge west of the gorge, the shape of the eastern end of the ridge and its connection with the river, and the presence or absence of east-west river valley to the south of the forest (Table 1; Figure 1).

TABLE 1 The location pattern of five Tsitsikamma platform forests

Forest	Line*	Distance: river to river, km	Forest area as % of distance from center line to river: To west	To east	Comments on orientation and form of mountain ridge to the north of the forest
Platbos	1	7,4	50,0	98,6	[1] Arch concave
	2	7,3	49,7	97,9	[2] WSW to ENE
	3	7,1	46,5	90,1	[3] Precipitous from narrow ridge to river
	4	7,3	35,9	84,1	
	5	7,2	26,4	90,3	
Lotteringbos	1	8,8	53,4	88,6	[1] Straight W to E
	2	8,9	53,1	83,6	[2] W to E
	3	9,1	53,8	75,8	[3] Steep slope of rounded ridge; platform next to river
	4	9,2	53,6	75,4	
	5	9,1	54,1	81,8	
Witteklipbos	1	4,8	46,3	82,1	[1] Straight WNW to ESE
	2	4,7	47,3	86,0	[2] W to E
	3	4,7	31,9	87,2	[3] Narrow steep ridge down to river
	4	5,3	5,7	71,7	
	5	5,4	- 1,9	68,5	
Plaatbos	1	5,9	15,3	84,7	[1] Arch concave
	2	5,5	14,5	90,9	[2] WSW to ENE
	3	5,4	24,3	99,1	[3] Narrow ridge with valley north of ridge
	4	5,2	40,4	100,0	
	5	4,9	36,7	98,0	
Witelsbos	1	7,0	- 2,9	82,9	[1] Arch convex
	2	7,0	- 4,3	81,4	[2] WNW to ESE
	3	7,0	33,1	82,0	[3] Platform next to river. Ridge east of river more south than ridge west of river
	4	7,0	10,1	82,0	
	5	7,0	-10,1	80,6	

* Parallel East-west lines measured from river to river. Line 1 is nearest to mountain and line 5 the furthest away
[1] Orientation of ridge from river to river in relation to forest to the south
[2] Orientation of western end of ridge
[3] Shape of eastern end of ridge and type of connection between ridge and river

EDAPHIC CONDITIONS INSIDE AND OUTSIDE FOREST

The Tsitsikamma site study area covers the coastal platform on either side of the Elands river (see Figure 3). The area shows the typical forest distribution pattern as observed in the rest of the Tsitsikamma. The area has been stratified into mountain footslopes, central plateau next to the mountain, and the coastal plateau. The site survey in the study area, which are in a preliminary stage, produced results which are relevant to this study:

* Effective rooting depth for *Pinus* species ranged between 250 and 1 200 mm (Payn and Clough 1988). The shallower soils are in the northern part of the area and are associated with mountainous terrain. The northern parts of both Puntjiesbos and Witelsbos grow on such soils. Soil depth of the central plateau was between 600 and 800 mm wheras similarly deep soils occur in places on the coastal plateau south of Koomansbos.

* Between Puntjiesbos and Witelsbos on the central plateau and south of Koomansbos on the coastal plateau the soils are deep, hydromorphic and podzolic, both inside and outside the forests. The central plateau soils overlie sandstone wheras the soils of the coastal plateau overlie deep clays. Soils of the incisions into shales of the Koomansbos area are richer in nutrients and have good water holding capacity.

* The *Pinus* stands were established on areas which were covered by fynbos. Various forest species are scattered to common underneath the mature pine stands, both on the central and coastal plateaux (Grey *et al.* 1987; personal observation).

* Earthworm and arthropod dominated mull-humus are sometimes found under the indigenous forest, particularly on shales, but the dominant humus form in the forest is a microbiotic mull. Humus layers on the plateau soils outside forest are highly disturbed due to burning, grazing, cultivation and planting of *Pinus* plantations (Grey *et al.* 1987).

UNDERSTOREY DIFFERENCES IN WITELSBOS FOREST

The area which I studied in Witelsbos is shown in Figure 2. Note the pointed-finger pattern towards the southwest of the southern boundary of many of the platform forests which are not bounded by a east-west river valley (Figure 1). This form of southern boundary is particularly well-developed in Witelsbos although recent road-building has obscured much of it. Inside the forest the abrupt change in the density and composition of the understorey follows a similar

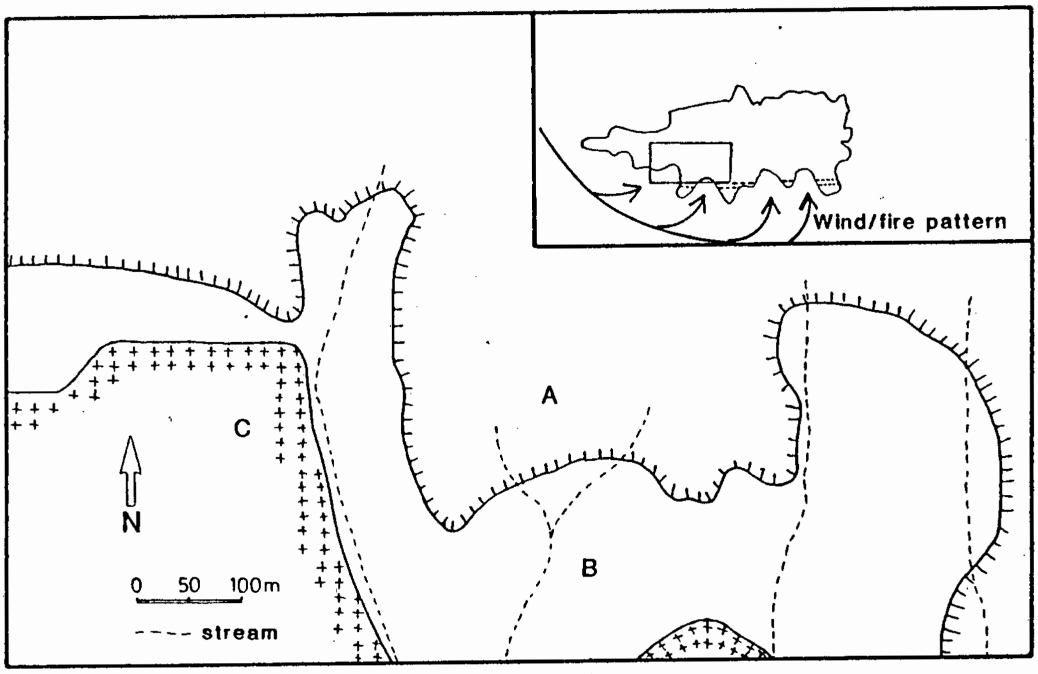

Figure 2. The Witelsbos study area. Areas A and B are indigenous forest of 20 m height. Area C is a pine stand establish into fynbos on the forest margin. The understorey of area A is a tall, dense stand of the shrub *Trichocladus crinitus*, and of area B is a sparse stand of seedlings and saplings of canopy tree species. Abundant charcoal and seeds of the legume pioneer tree *Virgilia divaricata* are present in the feeding root zone of area B.

pattern up to 300 m from the present road. Comparison of various variables north and south of the change showed the following (which will be published separately in more detail):

* The soil profiles on either side of the change were basically similar and do not explain the abrupt understorey change.

* North of the change, the understorey consists of a dense, tall (2 to 3 m) stand of the shrub *Trichocladus crinitus*, which is typical of the platform forests. South of the change the understorey is short and sparse, consisting mostly of seedlings and saplings of 1 to 3 m tall of a range of canopy and understorey tree species. *T. crinitus* occurs scattered, occasionally in small sparse groups.

* Canopy height of the mixed stands on either side of the change is 20 m. The composition of tree species is very similar on either side of the change, but the range of tree diameter classes on the southern side is much wider with many more smaller stems. Species such as *Ocotea bullata*, *Podocarpus falcatus* and *Gonioma kamassi* are particularly common on the southern side.

* South of the change abundant charcoal and seeds of the pioneer legume tree *Virgilia divaricata* are present in the upper 10 cm of the soil, i.e. in the feeding root zone below the litter. The charcoal and legume seeds are absent north of the change. Some *V. divaricata* seed germinated on the sides of the soil pits.

* Stem sections of *Podocarpus falcatus* were collected during forest clearing for building of the road south of the study area. Ring counts showed that the oldest tree was 215 years, allowing for a 5% underestimate in the dendrochronological age determination (McNaughton and Tyson 1979). The age of the other large trees ranged between 108 and 126 years.

DISCUSSION

FOREST LOCATION PATTERN IN RELATION TO CLEARING AND SITE CONDITIONS

The location pattern of forest in the study area is not related to historic clearing of forest. Because many deep gorges cut through the coastal platform the area was very inaccessible before the modern network of roads was built. The first permanent residents settled in the Witelsbos area between 1850 and 1860 (Grey et al. 1987) at a time when relatively good control was enforced on the woodcutter settlers, and most of the area remained relatively unoccupied (Phillips 1963). Plantations of Pinus and Eucalyptus species were established outside the forest in fynbos (unpublished reports).

The pattern is also not related to rainfall, geology and soils. Annual rainfall throughout the coastal platform is high (900 to 1200 mm) and can be expected to be higher in the mountains. In parts of the Tsitsikamma and the larger southern Cape, forest persist in areas with rainfall down to 500 mm (Chapter 1). The strike of geological formations cut across forest patches. Forest grows on both deep and very shallow soils whereas the soils are similar both inside and outside the forest. The incised valleys and coastal scarp with steep slopes carry large areas of forest. The coastal scarp soils are very rocky and shallow and the forests are exposed to the saline winds from the ocean.

FORESTS PERSIST IN BERGWIND SHADOW AREAS

Historical records show that fires are most likely to occur and persist during the hot, desiccating bergwind periods. Fires during bergwinds would most likely follow the flow direction of the wind and would destroy forests along that route. I suggest that forests persisted in bergwind shadow areas where fires are less likely to occur at frequent intervals (Figure 3).

Wind flow across barriers

Flow patterns of air across barriers (Barry 1981) explain most of the location patterns of forests in the study area. The mountains change the flow of northwesterly bergwinds and channel them with greater velocity southwards through the valleys. Their severity is particularly felt in the neighbourhood of a pass or break in a mountain chain, as at George (McNaughton in Sim 1907; personal

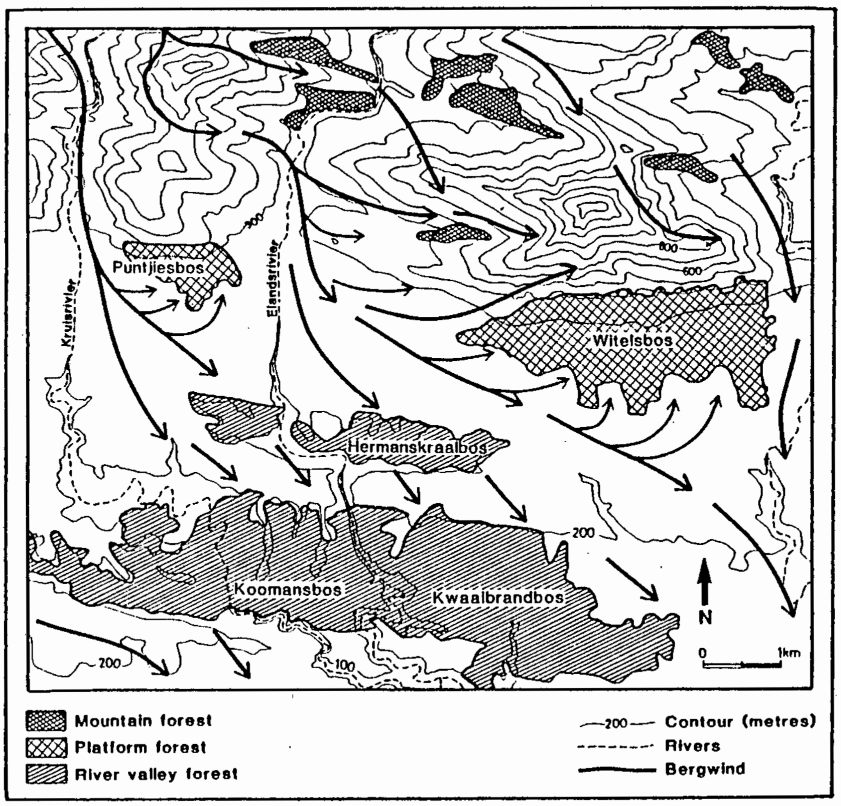

Figure 3 Part of the Tsitsikamma site study area. Note the hypothesized flow patterns of a bergwind in relation to the location pattern of mountain, platform and river valley forest.

observation). South of the mountains they continue in a southeasterly direction across the coastal platform. This explains the absence of forest on the central plateau east of each gorge, but the presence of large forests west of the gorges, and the absence of forest on the coastal plateau (Figure 1; Table 1).

The orientation, position and shape of the crest of the ridges on the western and eastern extremes of the southernmost ridges have a marked effect on the shape of the open areas to the west and east of the platform forests.

* When the western tip of the ridge points to the northwest, or if the ridge tip east of the gorge is situated further north than the ridge tip west of the gorge, the fynbos area between the forest and the western river gorge is large because of the direct flow of the wind onto the platform as at Witelsbos.

* When the western tip of the ridge points towards the southwest, the fynbos area between the forest and the western gorge is small as at Platbos, Lotteringbos, Elandsbos and Witteklipbos.

* When the ridge east of the gorge is situated further south than the ridge west of the gorge, fires burn in a southwesterly direction onto the platform west of the gorge, for a short distance, as at Lotteringbos and Elandsbos.

The orientation of the gorge through the platform has no influence on the location pattern of the platform forest such as the eastern boundary of Elandsbos and Witteklipbos. The gorges are narrow and fires can easily jump a gorge as at Witteklipbos and along the coastal plateau.

On the platform, wind of lesser velocity will branch away from the main southeasterly air flow, to blow in a northeasterly direction. The velocity of the branching wind will depend on the velocity of the main air flow and the velocity gradient between this flow and the wind shadow area in the northeastern corner of the platform. This explains the pointed-finger pattern towards the southwest along the southern boundary of some forests, such as Witteklipbos and Witelsbos (<u>Figure</u> 1 and 3). Occasional fires under extreme bergwinds would destroy the forest beyond the margin of the more regular fires such as in Witelsbos (<u>Figure</u> 2). The southern boundaries of some platform forests would therefore represent development stages which relate to different but long fire intervals. East-west river valleys south of the platform forests affect the flow of the main wind across the platform and prevented the development of the finger pattern south of Platbos, Lotteringbos and Plaatbos.

The shape or profile of obstacles is also important (Barry 1981). Sharp breaks of slope set up more turbulence in the air passing over them than if the slope is gradual. Breaks of slope greatly increase the tendency for the airflow to separate from the ground and to form vertical eddies or rotors, i.e. air flow in a direction opposite to the wind direction across the barrier (Figure 4). The intensity of the eddy increases with wind velocity across the barrier and with abruptness of the change in slope between the windward and leeward sides. Furthermore, air tends to flow round an isolated peak or range of limited length.

* During a bergwind, air will flow upward in a northeasterly direction on the southern slopes of the southernmost ridge above the platform forest. This explains the absence of forest on the southern slopes towards the western tip of the ridge (Figure 3). Towards the eastern tip the wind will be much calmer and the probability of a fire is much smaller. Forest therefore often extends to below the crest of the ridge on the eastern end as in Platbos and Plaatbos.

* With a steeper lee than windward slope, the lee eddy will prevent a fire from burning down the lee slope. Forests persist on such slopes to near the crest. Examples are the northern boundaries of Platbos and Plaatbos, and forests of the coastal scarp and river valleys which extend up to the sharp boundaries with the coastal platform.

* An eddy does not develop with a very gradual change in slope such as a rounded hill. Winds will rather slow down towards the valley because of the rise of hot air at the fire front. Forests in such topographic situations are confined to valley bottoms such as many of the forests in the mountains where the ridges have been eroded to rounded crests near their ends (Figure 5).

The diverse directions of the ridges and valleys in the mountains make wind flow patterns very complex. However, the presence of almost every mountain forest can be explained in terms of the wind flow patterns along the slopes and ridges

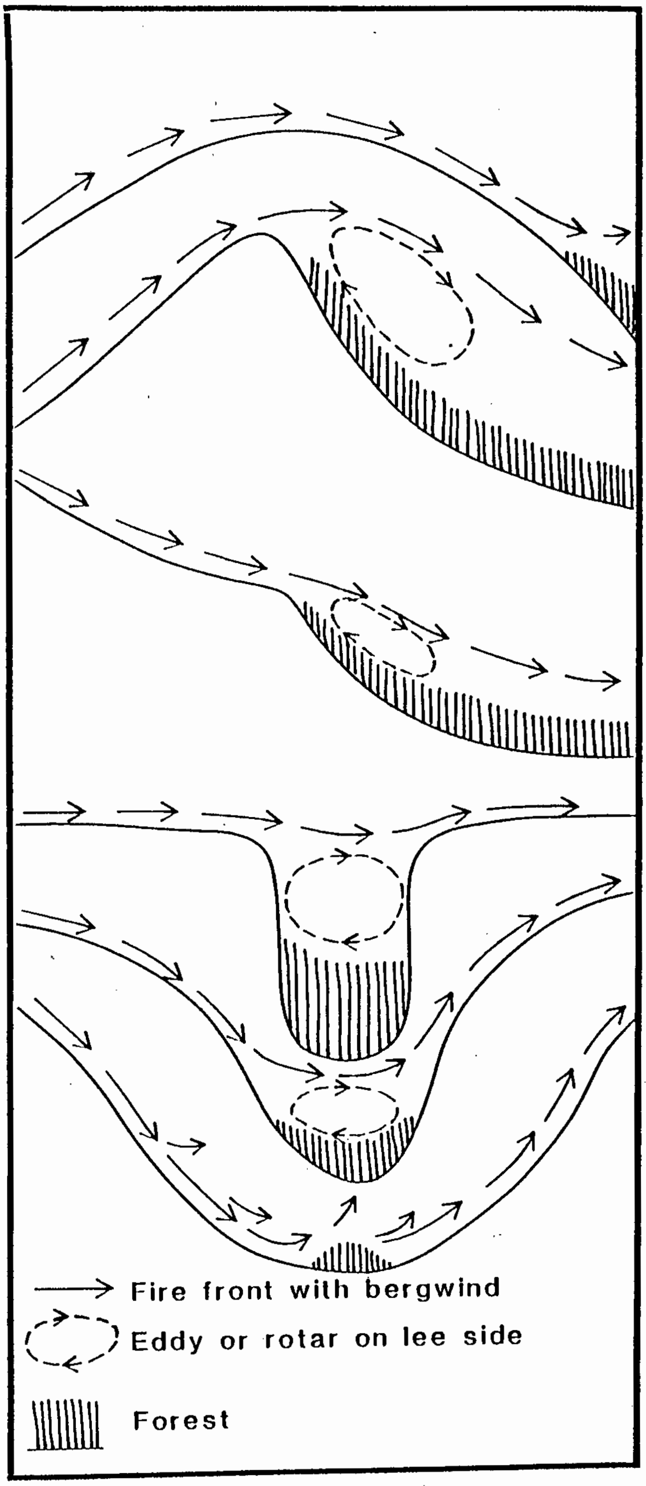

Figure 4 Schematic view of hypothetical air flow across topographic barriers, the development of eddies on the leeside of the barrier and the persistence of forest in wind shadow areas. The figures represent real examples from the study area surrounding the forest.

surrounding the forest. Very often these patterns can be seen as burnt strips in remnants of tall, unburnt fynbos indicating the path of previous natural fires. An example is the flow patterns around Buffelsbos along the Bloukrans river north of Platbos (Figure 5). Sometimes relatively inconspicuous streams on either side of a forest, which grows on a slight ridge between the streams, provide enough protection to the forest in terms of wind flow patterns.

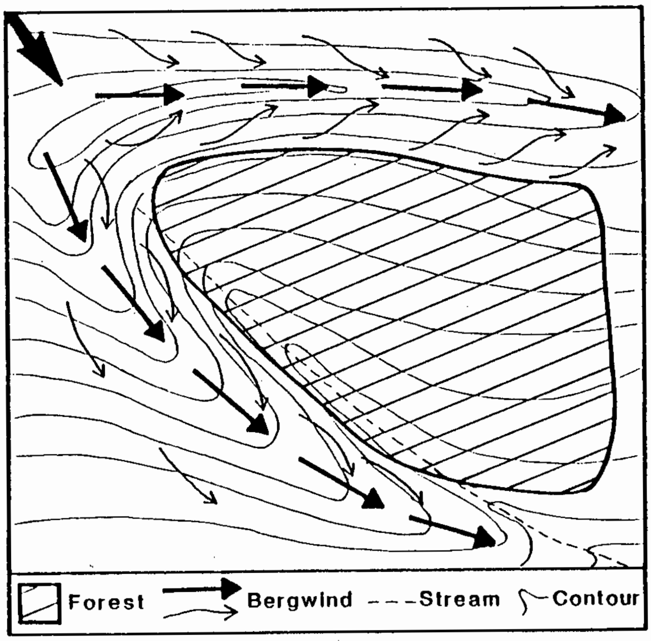

Figure 5 Buffelsbos west of the Bloukrans river north of Platbos. The bergwind fire pattern is based on burnt strips of a natural fire through unburnt old fynbos near the forest margin.

Bergwind fire frequency and rate of forest regrowth

The Witelsbos study area gives some indication of the process and rate of forest recovery. The density of V. divaricata seed which occur mixed with the charcoal suggest that a dense stand of this legume pioneer tree developed after the fire. Virgilia seed requires a very hot fire in order to germinate in large numbers and to develop dense stands (Phillips 1926; personal observation and unpublished data). Although some seedlings of forest canopy species occur in such stands after about five years, they only become established after natural suppression and mortality and consequent thinning of the pioneer stand (C Jacobs personal communication 1989). The mixed stand of 20 m in height in the Witelsbos burnt area must have established during such a succession.

Most of the forest canopy species can recover from fire by root, stem or crown coppices (unpublished data). However, the two Podocarpus species cannot coppice and are killed by fire. The age of the older Podocarpus trees therefore provide a reliable estimate of the minimum period since the fire, i.e. at least 230 years. This suggest that the age of the viable V. divaricata seed is about the same.

Recovery of forest therefore takes a long time. The composition of the canopy in the burnt zone of Witelsbos forest has recovered in terms of species content, but not in the relative density of the different species or the size class distribution of the individual species. The most significant difference is evident in the understorey. In the southern Cape many stands near the forest boundary, and also deeper into the forest, have understoreys which appear similar to the understorey of the burnt zone in Witelsbos and contain many pieces of charcoal (unpublished data). I. crinitus is associated with the mature forest (Geldenhuys and Van Laar 1980). It therefore takes centuries for a forest to recover after fire, to the stage with the tall, dense understorey of I. crinitus.

Evidence of the 1869 fire can be seen in portions of Koomansbos where the forest is shorter with abundant small stems, but not in the studied area in Witelsbos. Harison, conservator of forests in the area at that time, wrote that, except for the forest at Kwaaibrand, Koomansbos and Robbehoek near the coast, the forest escaped lightly (Phillips 1963). The evidence of a fire at least 230 years ago and the historical record of the 1869 fire suggest that forest can persist with a fire interval of about 100 years. More frequent fires would cause forest to disappear and fynbos to persist. Fynbos would then increase the chances of frequent fires because of the density of flammable material (Van Daalen 1981; Van Wilgen et al. in prep). The periodic, extreme and devastating fires, such as the 1869 and earlier fires, caused great destruction of the forest and established their location pattern. More frequent but less intensive bergwind fires, such as the Kromrivier fire of 1984, must have maintained the open areas next to forest. These were repeatedly burnt by the local tribes and the early European settlers during hunting and for grazing (Phillips 1963).

CAUSES OF BERGWIND FIRES

Bergwinds act in two ways. Firstly, they desiccate the vegetation, particularly along their flow route through a valley and on ridges (Story 1952). As such they affect the growth of the plants and increase their flammability. This effect is particularly severe on the more exposed ridges. The 1869 fire followed a hot dry period of six weeks that reached a climax on the day of the fire with a scorching hot dry northerly bergwind and high temperatures that attained 34°C at 08h00 and 45°c at 14h00 (Edwards 1984). The gusty nature of the wind caused the breaking of branches and leaves from tree canopies. On 2 June 1986, after a long period of successive bergwinds, a strong bergwind of mean speed of 32 km/hour over a 6-hour period caused a litter fall of 138 g/m^2 for June compared to the mean of 20 g/m^2 for May and July (Geldenhuys 1988). Leaves of trees on the forest margins were scorched by the wind. The dry conditions which existed would have favoured the rapid spread of a fire if an ignition event occurred.

Secondly, if associated with an ignition, bergwinds drive the fire front to eliminate the desiccated forest vegetation. Usually the moist conditions of the forest site and closed community restrain the advance of fire originating outside the forest (Sim 1907; Van Wilgen et al. in prep).

Lightning and humans are the main ignition sources for fires in the southern Cape (Le Roux 1979; Horne 1981). Lightning is the most significant natural ignition source of veld fires in South Africa, although opinions differ on the frequency and importance of lightning induced fires (Edwards 1984). During the period 1966 to 1975 lightning caused 23 fires (27% of total) in the fynbos of the southern Cape with mean burnt area of 243 ha/fire, whereas unknown causes started 13 fires with mean area of 1 735 ha/fire. Fifty-eight percent of all the fires occurred in the summer-autumn period from December to May (Le Roux 1979). In the inland Swartberg range lightning caused 81 (48%) compared to 65 (38%) human induced fires from 1951 to 1977. Most natural fires occurred from November to March although lightning fires occurred during all months except June (Horne 1981). Lightning induced fires burn relatively small areas because they usually strike near the ridges (Le Roux 1979; Horne 1981). Horne (1981) has shown that lightning fires occur in cycles and that human induced fires increased during periods of few lightning fires. Lightning ignited a fire in the Lottering forest on 19 March 1984 during a relatively dry period. The fire burnt until 12 May and cleared a small area of 0,4 ha on a ridge above a steep slope (unpublished data).

Edwards (1984) suggested that in pre-colonial times with low population densities, lightning-induced fires could have burned extensive areas, especially when they occurred under conditions favourable for fire. At present an effective fire prevention and combatting system in the plantation areas and the different landuse systems on the coastal platform reduce the chances of extensive fires.

Conditions for lightning and bergwinds do not usually coincide (P D Tyson, personal communication 1987). However, I have observed such conditions to overlap during March 1989. But a lingering fire such as at Lottering can be swept out of proportion if followed after some time by severe bergwinds. In the Diepwalle forest north of Knysna, most of the hilltops are either covered in fynbos, or carry sparse forest with fern understorey and contain scattered charcoal. Lightning frequently strike these ridges during thunderstorms (W J Cooper, resident forester, personal communication 1988). The fynbos "islands" (Phillips 1963; Cameron 1980; Bond et al. 1988) have a northwest-southeast orientation which suggest that they have been created or maintained through a combination of lightning and bergwinds. Although the peak periods of lightning and bergwind occurrence are widely separated, the time of the 1869 fire indicate the presence of severe bergwind conditions during February. I have observed a succession of lightning and bergwind periods around George during late summer.

Anthropogenic fires are considered as the most important cause of bergwind fires (Sim 1907; Phillips 1963). Man has used fire in southern Africa since 1,0-1,5 million years ago (Brain and Sillen 1988). Quartzite flakes of pre-Acheulean handaxe makers suggest hominid occupation around Plettenberg Bay during early Pleistocene (Butzer and Helgren 1972). Although fire was used by communities of the Early Stone Age, it is possible that it was not widely employed until the succeeding Middle Stone Age (Hall 1984). Some form of fire management of the vegetation for honey hunting, improvement of pastures for game hunting and the farming of geophytes was practised for the last 125 000 years (Deacon et al. 1983). It is most probable that many intentional and accidental fires occurred during bergwind periods, as they occur under the modern use of fire in the management of vegetation (Le Roux 1979; Horne 1981).

WIND-RELATED FOREST LOCATION PATTERN IN SOUTHERN AFRICA

Most large-scale natural fires are associated with prevailing winds of a particular direction during the fire-prone periods. I suggest that the prevailing wind-fire pattern will explain much of the present location pattern of forests in southern Africa. In particular, the hot, dry bergwinds blowing from the interior are a phenomenon along the mountains and escarpment of the southern African coast (Tyson 1964).

Forests to the west of Mossel Bay and east of eastern Tsitsikamma are small, few and far between (Figure 1). These areas coincide with a much wider and drier coastal plain. I have experienced, while driving through these areas, that southwesterly winds in the west and southeasterly winds in the east are relatively hot and dry whereas those same winds are cool and moist between Mossel Bay and eastern Tsitsikamma. I suggest that during pre-colonial times fires occurring in these areas were often driven towards the mountains from the coastal plains and eliminated forests except for sheltered valleys and gorges. This would also explain the relative absence of forest south of the foothills between Mossel Bay and George, and east of Witelsbos (Figure 1). In the forested area the southwesterly and southeasterly winds often cause misty or cloudy weather with rain and reduce the probability of extensive fires. The Langeberg range west of Mossel Bay and the Kareedouw range east of Witelsbos are relatively narrow with very few southerly valleys running from the mountains. The strong bergwinds blowing across these ranges would cause an overturn of air on the lee side to form a deep, standing eddy (Barry 1981). Fires originating in the valleys on the lee side would eliminate much of the forest on the exposed southern slopes. Between eastern Tsitsikamma and Port Elizabeth most mountain ranges reach the coast at an angle. The ranges are separated by wide valleys which form channels for the bergwinds or southeasterly winds which would carry winds (and fires) up and down those valleys and mountains.

Many forests along the eastern escarpment of southern Africa show location patterns which are typical of the bergwind shadow patterns of the southern Cape. Examples are Gudu forest in Natal Drakensberg and forests in Collins Pass area of northern Natal and in the Wolkberg/Serala area (Edwards 1967 Photo 110, 116; Acocks 1975 Figure 77; Cooper 1985 several photographs; personal observation).

BERGWINDS AND CLIMATIC CHANGE

Palaeoecological studies relate warm and moist periods with forest expansion and cool and dry periods with forest regression (e.g. Van Zinderen Bakker 1978; Deacon 1983; Deacon et al. 1983). Forests do however persist in areas of relatively low rainfall (Rutherford and Westfall 1986; Chapter 1). This study has shown that forest persistence is mostly related to sheltering from regular fires, in particular bergwind fires. I suggest that because bergwinds are associated with particular atmospheric circulation patterns, they provide a useful key to the correlation of changes in forest area with climate changes.

Bergwinds conform to the general circulation over the sub-continent (Tyson 1964). They occur in the region of increased pressure gradient between a high-pressure cell over the interior (plateau), and a depression or frontal system moving round the south coast of southern coast. The high temperature and low humidity of bergwinds appear to be due to dynamic heating of subsiding upper air from the semi-permanent high pressure cell over the interior of southern Africa. Bergwinds are present in the winter months and absent in the summer months due to the different circulation patterns during the different seasons (Tyson 1986). From casual observation of local weather data, I have noticed that some years experience frequent and intense bergwinds whereas during others bergwinds are almost absent. I suggest that this may also occur over longer time intervals with climatic change that will lead to periods of frequent bergwinds and retreating forest, and periods of absence of bergwinds with expansion of forest.

CONCLUSIONS

The topographic configuration of plateau, escarpment and coastal plain has a major influence on the persistence of forest. It confines the flow of the hot, dry bergwinds, and fires driven by them, and as such allows forest to persist in bergwind shadow areas. It compliments the findings of Feely (1986). He has shown that the forest-grassland mosaic of mountain and coastal areas and the grasslands of the central plateau in Transkei existed before the arrival of Iron Age farmers about 300 AD.

Forests can recover from episodic, extreme bergwind fires. Most forest species are adapted to low-frequency fires. The large platform and river valley forests contain large areas which are probably never disturbed by fire. By contrast most of the small mountain forests are probably sometimes destroyed by fire and are as such regrowth forests. This is suggested by the few tree species in the canopy, and only those which are able to survive fires. Their understoreys resemble the understoreys of platform forests which have been burnt, such as at Witelsbos, and they contain charcoal pieces. Geldenhuys and MacDevette (1989) used this gradient of fire frequency to explain the low richness of woody plants, the high richness of ferns, and the almost absence of epiphytes and vines in mountain forests, and the high richness of woody plants, vines and epiphytes in the platform and river valley forests of the southern Cape. This relation between disturbance and species richness should be considered in a phytosociological study of the southern Cape forests.

Results from this study suggest that a gradient exists of high fire frequency (and probably lower intensity) along the ridges and northern slopes, with a low frequency (and probable high intensity, see Kruger and Bigalke 1984) in the valleys. It can be expected that fynbos plants and other biota are ordered along these gradients according to their adaption to different fire frequencies and intensities. In the current practice of block burns in the mountain catchments, fires are initiated along the upper ridges around a catchment (personal observation). Once these fires have progressed some distance down the slope, the circle of fire is closed by lighting fires in the bottom of the valley in order to burn upslope towards the ridges. I suggest that it is possible that this practice breaks down the diversity of species along the gradients to a more uniform composition throughout the catchment. The block burn system should be revised in order to achieve the management objective of maintaining the patterns of species diversity.

The results also have implications for the fire protection plans of the plantations. Plantations of pines and eucalypts have been planted in fynbos, i.e. mostly fire-prone sites. The current practice is to establish wide fire breaks in the mountains north of the plantations which are burnt on a short rotation. The fire breaks often threat the survival of rare fynbos plants. They are also very expensive to maintain. This study suggest that only a few key points need intensive protection against fire, i.e. where the valleys emanate from the mountains.

The intensive fire protection systems for plantations and the intensive agricultural use of the coastal foreland reduced the frequency and extent of fires. This elimination of fire and the shade provided by plantation stands favour the spread and wider establishment of forest species (Geldenhuys <u>et al.</u> 1986). This succession process under plantation stands should provide keys to the control of plantation weeds.

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Chapter 3

COMPOSITION OF THE SOUTHERN CAPE FOREST FLORA, WITH ANNOTATED CHECKLIST

CONTENTS

ABSTRACT

An annotated list of species was compiled to enumerate the species which have been collected in the forests of the southern Cape. The flora contains 465 species which belong to 280 genera and 107 families, 52 monogeneric families, 33 monospecific families and 196 monospecific genera. The species/family ratios of 3,1 for woody plants and 4,5 for herbaceous plants are very low when compared to other forests in Africa and to the surrounding fynbos shrublands. Bisexuality predominates all growth forms and dioecy and unisexueality are almost confined to trees, woody shrubs and vines. Sixty nine percent of the woody plants have fleshy propagules, predominately of small size, whereas 85% of the herbaceous plants have dry propagules of which 41% are wind-dispersed (mainly ferns and orchids). Several species other than geophytes and ferns have conspicuous adaptations to adverse conditions such as spines or prickles, deciduousness and water and/or food storage organs. Very few endemics are entirely confined to the area. Several statistics suggest that due to pressures of fire frequency and aridity speciation occurred outside forest in shrubby and herbaceous growth forms. Families shared with surrounding shrublands and thickets have few but widespread species inside forests and many species with limited distribution ranges in the surrounding vegetation types.

INTRODUCTION

The southern Cape forests have several features which stimulate a study of the flora. The forests form the largest forest complex in southern Africa and it is the most southerly situated large forest complex in Africa (Anonymous 1987). The forests cover a wide altitudinal range over a very short distance, i.e. from the Indian Ocean coastline to near the top of the mountains at 1 220 m above mean sea level (a.s.l.) and 10 to 37 km away (Chapter 1). The forests occur relatively isolated from the larger forests to the east and west, and the very small forests in the inland mountains to the north (Anonymous 1987; Chapter 5).

Several authors included the forest flora of the southern Cape in their studies. Phillips (1931) listed the species of "the principal stages of the four seres - hydrosere, halosere, psammosere and lithosere - in order of the plant succession" as well as the species of scrub forest and high forest. Fourcade (1941) compiled a checklist of all flowering plants of the forest, fynbos and Little Karoo (dry shrublands) between George, Uniondale and Humansdorp. Von Breitenbach (1974) provided a general account of the forest flora and listed the more common woody and herbaceous plants. Goldblatt (1978) and Bond and Goldblatt (1984) included the southern Cape forests in their discussions of the flora of the Cape Floristic Region, one of only six Floral Kingdoms of the world. In recent years several other forests in southern Africa have been studied in relative detail (Chapter 4). Species collected during recent studies in the southern Cape forests have produced some new species and have extended the distribution ranges of several known species.

The objectives of this study were to enumerate the species which have been collected in the forests of the southern Cape, to analyse the flora in terms of floristic and structural plant groups, and to determine the composition of breeding, dispersal and survival systems within the flora. These analyses would allow comparison with floras of other forests and vegetation types which could improve the understanding of the ecological significance of the southern Cape forest flora. The knowledge of the flora will be used in biogeographical analyses of the forest floras of the southern Cape and southern Africa (Chapters

4, 6 and 7). Finally, it is declared policy of the Department of Environment Affairs to maintain the species diversity of the vegetation types under its jurisdiction. This study will provide the baseline information for the southern Cape forests.

STUDY AREA

The study covers the area between the Gouritz River in the west and Kromme River in the east, and the Indian Ocean coastline in the south and crests of the east-west trending coastal Cape Folded Mountains in the north (Figure 1; Chapter 1). The mountains, up to 1600 m a.s.l., separate the moist coastal region from the dry Little Karoo inland. To the south undulating foothills separate the mountains from the level coastal platform at 180 to 240 m a.s.l. The platform ends in a steep coastal scarp. Many rivers run south from the mountains to form deep, narrow incisions through the coastal foreland. In several places, east-west tributaries form wider valleys along softer geological substrates. Rocks of the Cape Supergroup (mainly of supermature quartzitic sandstones, with subordinate shales) underlie most of the area. Pre-Cape and Cretaceous rocks (granite, quartzites, shales and schists), and unconsolidated deposits of recent age occupy smaller areas (Toerien 1979). The soils are generally acid, leached, low in nutrients (with phosphate and manganese deficiencies in places), have a poor buffering capacity, have poor internal drainage, and the effective depth is almost invariably shallow (G N Schafer personal communication 1988).

The forests occur in areas where the mean annual rainfall, mainly orographic, ranges from 500 mm to about 1200 mm (Chapter 1). Rain falls all year with maxima in early and late summer. The mean daily maximum temperature ranges between 23,8°C for February to 18,2°C for August, and the mean daily minimum between 19,7°C and 8,9°C (Chapter 1). Frost is infrequent to absent. Bergwinds during winter and cold fronts during spring and autumn further contribute to a very equable climate.

Acocks (1953) recognised several vegetation types in the area. Knysna Forest (Veld type 4; Phillips 1931), the subject of this study, comprises both high and

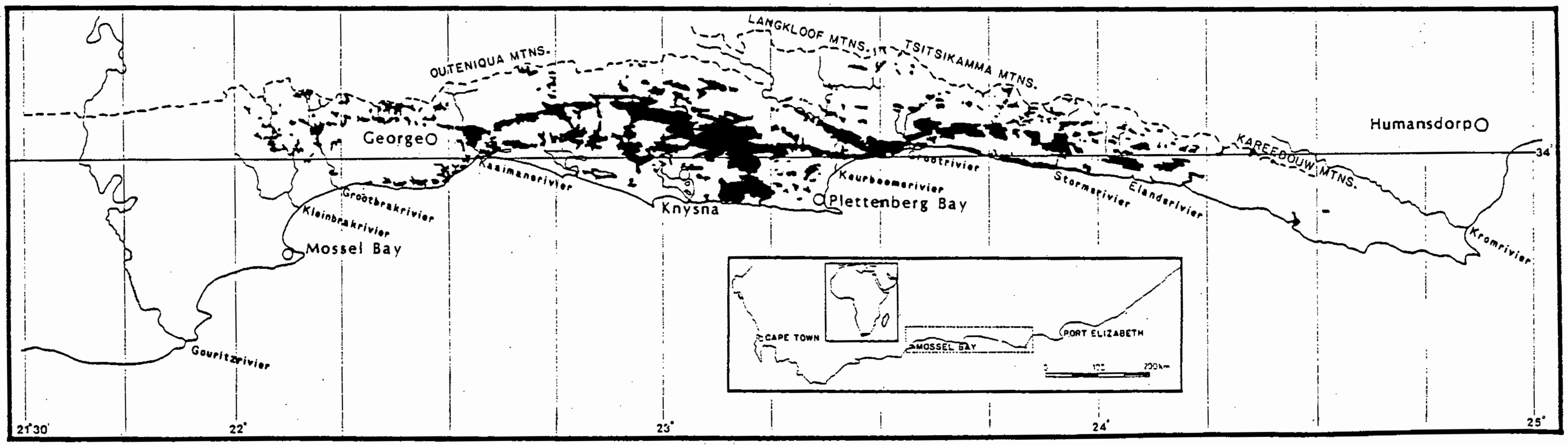

Figure 1 Distribution of indigenous forests in the southern Cape.

scrub forest and a total area of 60 561 ha (Chapter 1). It is surrounded by several types of shrubland: a large area of False Macchia or Mountain Fynbos (Veld Type 70) along the mountains and coastal foreland; and relatively small areas of Coastal Macchia (Veld Type 47), Coastal Renosterbos (Veld Type 46) and Valley Bushveld (Veld Type 23) towards the western and eastern extremes of the area. Taylor (1955), McKenzie (1978) and Cowling (1983, 1984, 1986) studied forest and other vegetation to the west and east of the study area.

METHODS

I compiled a species list for high and scrub forest, forest gaps and forest edges of the study area (Appendix 1). Recurring fynbos-related edge species are included in the list, but were excluded from most analyses. Most of the species are housed in the Saasveld Herbarium, George. I screened various checklists (Phillips 1931; Fourcade 1941; Stewart et al. 1982; Bond and Goldblatt 1984; Schelpe and Anthony 1986; Von Breitenbach 1986), and checked the Fourcade (1941) collection in the Bolus Herbarium and other collections at the Bolus (Pteridophyta) and Compton herbaria in Cape Town and the National Herbarium in Pretoria for additional species. I observed most included species in the field during sampling for forest classification. Where field or herbarium checking of unfamiliar species was not possible, a reference indicate the information source. It is possible that some species have been ommitted from the list and additions will continue in future.

The definition of the different variables and categories and the source references are given in the Appendix. Information on growth form, breeding and dispersal system, deciduosity and spinescence are based on the literature, but also on personal observations in the study area. Information on moisture requirements, forest type, geographic spread in the study area and abundance is based on my extensive observation of species in the study area. The geographic range in southern Africa of each species is based on distribution maps, and accounts of floras and taxa.

RESULTS

SIZE AND COMPOSITION OF THE FLORA

Composition of the flora is summarized by taxonomic groups in Table 1, and by growth forms in Table 2. Appendix 1 includes four families and 12 genera of the fynbos-related edge species which are unique to fynbos. The families are Bruniaceae, Ericaceae, Penaeaceae and Gentianaceae, which represent five genera and 13 species. The genera, *Protea*, *Leucadendron*, *Phylica*, *Empleurum*, *Agathosma*, *Struthiola*, *Euryops*, *Peyrousea*, *Anapalina*, *Ixia*, *Brownleea* and *Schizodium*, belong to seven forest-shared families and represent 17 species. The remaining nine entirely fynbos species belong to five forest-shared genera (and families), i.e. *Myrica*, *Silene*, *Crassula*, *Lobelia* and *Holothrix*. The fynbos species represent four growth forms: woody shrubs (23 species); soft shrubs (1 species); geophytes (5 species) and forbs (10 species). The rest of the analyses cover forest-related species only.

TABLE 1 Composition of the southern Cape forest flora by main taxonomic groups

	Forest species	Fynbos-related edge species
Families	107	15
Genera	280	22
Species	465	39
Pteridophyta	67	-
Gymnospermae	3	-
Monocotyledones	80	5
Dicotyledones	315	34

NUMBER OF SPECIES AND GENERA PER FAMILY

The frequency distribution of families or genera with specific numbers of genera or species follows the typical negative exponential curve, i.e. with relatively few large families or genera and many small families or genera (Table 3). The flora contains 52 monogeneric families, 33 monospecific families and 196

TABLE 2 Number of families, genera and species in each growth form, and the species/family ratio by growth form and forest type*, excluding fynbos-related edge species

Growth form	Number of Families	Number of Genera		Number of species and species:family ratio Total	Hf*	Sf*	Df*
Canopy trees	27	40	Number	47	34	11	2
			Ratio	1,74	1,4	1,2	2,0
Subcanopy trees	17	27	Number	39	22	12	5
			Ratio	2,29	2,4	2,4	1,0
Woody shrubs	25	40	Number	54	14	14	26
			Ratio	2,16	1,3	1,8	1,9
Soft shrubs	15	22	Number	28	3	7	18
			Ratio	1,87	1,0	1,2	1,8
Lianes	11	12	Number	15	8	6	1
			Ratio	1,36	1,3	1,0	1,0
Vines	17	30	Number	46	15	20	11
			Ratio	2,71	1,4	1,8	1,2
Ferns: erect+	10	13	Number	34	29	4	1
			Ratio	3,40	3,2	1,3	1,0
Ferns: creeping+	7	6	Number	18	15	-	3
			Ratio	2,57	2,5	-	1,0
Epiphytes	9	15	Number	25	24	1	-
			Ratio	2,78	2,7	1,0	-
Geophytes	6	25	Number	28	10	13	5
			Ratio	4,67	1,7	4,3	1,3
Graminoids	3	20	Number	33	15	2	16
			Ratio	11,00	5,0	2,0	8,0
Forbs	31	58	Number	98	31	36	31
			Ratio	3,16	1,7	2,3	2,2

* Hf=high forest; Sf=scrub forest; Df=disturbed forest (gaps and margin)
+ referring to rhizomes

monospecific genera. Large families (number of genera and species repectively between brackets) are Asteraceae (12, 22), Orchidaceae (13, 18), Poaceae (11, 17), Celastraceae (5, 17), Liliaceae (10, 15), Fabaceae (12, 14), Euphorbiaceae (10, 14), Cyperaceae (8, 14), Acanthaceae (6, 14), Aspleniaceae (2, 14), Asclepiadaceae (8, 13), Rubiaceae (7, 13), Adiantaceae (3, 11), Crassulaceae (2, 11), Anacardiaceae (3, 10) and Lamiaceae (3, 10). Of these only the Celastraceae and Rubiaceae are prominent in the high forest. The larger genera by number of species are _Asplenium_ (13), _Crassula_ (10), _Rhus_ (8), _Cassine_ (7), _Senecio_ (7), _Cheilanthes_ (6), _Isoglossa_ (6), _Maytenus_ (6), and _Thelypteris_ (6).

TABLE 3 Frequency distribution of families or genera with a specific number of genera or species for the southern Cape forest flora

Number of genera per family, or species per genus or family	Frequency distribution for		
	Genera/family	Species/family	Species/genus
1	52	33	196
2	20	25	46
3	15	10	15
4	6	7	7
5	3	9	7
6	2	2	4
7	-	2	2
8	3	1	1
9	-	2	-
10	2	2	1
11	1	2	-
12	2	-	-
13	1	2	1
14	-	5	-
15	-	1	-
16	-	-	-
17	-	2	-
18	-	1	-
22	-	1	-

The genera/family (g/f) and species/family (s/f) ratios vary between the growth forms and forest types (Table 2). The s/f ratio is 3,1 for woody plants and 4,5 for herbaceous plants. Amongst woody plants subcanopy trees and shrubs have the highest s/f ratios. Amongst herbaceous plants graminoids have the highest s/f ratio followed by geophytes, ferns with erect rhizome and forbs. Plants of the high forest, scrub forest and forest gap have very similar s/f ratios, higher than the 1,6 for the forest edge. The s/f ratio is relatively high for subcanopy trees in high and scrub forest, for soft shrubs in disturbed forest, for ferns and epiphytes in high forest, for geophytes in scrub forest, and for graminoids in high forest and forest gaps.

BREEDING SYSTEMS

The importance of different breeding systems varies amongst the growth forms (Table 4). Bisexuality predominates all growth forms except woody shrubs. Dioecy and unisexuality are almost confined to trees, woody shrubs and vines, and spores are confined to ferns. Dioecy runs in families or genera. The

TABLE 4 Relationship between growth form and breeding system in the southern Cape forest flora

Growth form	Breeding system			
	Dioecy	Unisexual	Bisexual	Spores
Trees				
Canopy	12	6	29	-
Subcanopy	10	2	27	-
Shrubs				
Woody	20	7	27	-
Herbaceous	1	3	24	-
Lianes	-	-	15	-
Vines	9	4	33	-
Ferns	-	-	-	52
Epiphytes	-	-	10	15
Geophytes	-	1	27	-
Graminoids	-	4	29	-
Forbs	-	8	90	-
TOTAL	52	35	311	67

families are Anacardiaceae (Laurophyllous, Loxostylis and Rhus), Asteraceae (tree genera Brachylaena and Tarchonanthus), Cucurbitaceae (Kedrostis and Lagenaria), Dioscoreaceae (Dioscorea), Ebenaceae (Diospyros and Euclea), Euphorbiaceae (Adenocline, Clutia, Excoecaria and Lachnostylis), Flacourtiaceae (Dovyalis, Kiggelaria, Scolopia and Trimeria), Myricaceae (Myrica), Menispermaceae (Cissampelos), Meliaceae (Ekebergia) and Podocarpaceae (Podocarpus). Dioecious genera of larger families are Dodonea (Sapindaceae), Myrsine (Myrsinaceae), Pyrenacantha (Icacinaceae) and Vepris (Rutaceae). The unisexual families are Achariaceae (Ceratiosicyos), Aquifoliaceae (Ilex), Cupressaceae (Widdringtonia), Euphorbiaceae (Acalypha, Andrachne, Ctenomaria, Euphorbia, Leidesia and Tragia), Haloragaceae (Laurembergia), Hamamelidaceae (Trichocladus), Loranthaceae (Tapinanthus), Moraceae (Ficus), Phytolaccaceae (Phytolacca), Salvadoraceae (Azima), Ulmaceae (Celtis), Urticaceae (Australina, Droguetia and Laportea) and Viscaceae (Viscum). The unisexual genera of larger families are Ocotea (Lauraceae), Rapanea (Myrsinaceae), Zanthopxylum (Rutaceae) and Zehneria (Cucurbitaceae). Maytenus (Celastraceae) is indicated as having bisexual to unisexual flowers.

PROPAGULE TYPES AND DISPERSAL

Propagule types differ in importance in different growth forms (Table 5). They represent the following dispersal systems: 8,0% fleshy fruits with large seeds dispersed by larger frugivores; 23,9% small seeds either from fleshy fruits or

TABLE 5 Relationship between growth form and propagule type in the southern Cape forest flora

Growth form	Propagule type						
	Fleshy fruit/seed		Dry fruit/seed		Seed/fruit with		Dust-like seeds or spores
	Large	Small	Large	Small	burs wool	pappus	
Trees							
Canopy	15	20	7	3	-	2	-
Subcanopy	7	26	4	2	-	-	-
Shrubs							
Woody	9	23	8	12	-	2	-
Soft	-	9	1	15	2	1	-
Lianes	1	9	-	-	-	5	-
Vines	1	15	-	14	-	16	-
Ferns	-	-	-	-	-	-	52
Epiphytes	-	2	-	-	-	-	23
Geophytes	4	-	-	14	-	-	10
Graminoids	-	-	-	23	10	-	-
Forbs	-	7	-	76	4	11	-
TOTAL	37	111	20	159	16	37	85

with fleshy aril from drier fruits, dispersed by frugivores; 4,3% larger dry seed from capsules, cones or nuts dispersed by mechanical means; 34,2% small dry seed dispersed by gravity (possibly assisted by wind) or ballistic mechanisms; 3,4% seed with attachment to cling to animal fur; 7,9% small seed with pappus or wool dispersed by wind; and 18,3% spores and dust-like seed dispersed by wind. Fleshy propagules, especially of small size, predominate in the tree species. Large fleshy propagules are more important in canopy than in subcanopy trees. But large dry propagules are more important than small dry propagules in both canopy and subcanopy trees. Only Tarchonanthus camphoratus and Brachylaena glabra have true wind-dispersed seeds. However, Buddleja saligna, Cunonia capensis and Nuxia floribunda have very small seeds which can drift in the wind over short distances. Small propagules predominate in the woody shrubs with 59% fleshy and 41% dry propagules overall. However of the soft shrubs only 32% have fleshy propagules and 68% have dry propagules. Almost all climbers have small propagules. Lianes have only fleshy (64%) or wind-dispersed (36%) propagules. Of the vines 64% have dry propagules of which 53% are wind-dispersed. Small dry propagules predominate in the geophytes, graminoids and forbs. The ferns and Orchidaceae have spores or dustlike seeds which are dispersed by the wind.

SPINESCENCE, DECIDUOSITY AND STORAGE ORGANS

Several species other than geophytes and ferns have conspicuous adaptations to adverse conditions. Spines or prickles on the branches and bole or stem occur in 16 species of high forest, seven species of scrub forest, and four species of disturbed forest. These are the canopy tree Scolopia zeyheri, the subcanopy trees Canthium spinosum, Dovyalis lucida, D. rotundifolia, Maytenus heterophylla, M. nemorosa and Zanthoxylum capense, the woody shrubs Azima tetracantha, Canthium ciliatum, Carissa bispinosa, Cassinopsis ilicifolia, Dovyalis rhamnoides, Putterlickia pyracantha and Rhus longispina, the soft shrubs Hibiscus diversifolius, Protasparagus macowanii and Solanum giganteum, the scramblers Capparis sepiaria var. citrifolia, Rubus pinnatus and Scutia myrtina, and the vine Protasparagus aethiopicus. Five species lose spinescence beyond the juvenile stage, i.e. the canopy trees Erythrina caffra, Scolopia mundii and

Zanthoxylum davyi (develops knobbs), and the subcanopy trees Canthium inerme and C. pauciflorum. The majority of these species occur in the dry high or scrub forest. Leaf spines occur in the subcanopy tree Cassine papillosa, in the juvenile stage only, in Aloe arborescens in scrub forest, and in three Solanum species. Two Laportea species have irritating leaf hairs. The soft shrub Sparrmannia africana of wet montane forest has dry capsules with spiny bristles.

Deciduous species are the canopy trees Calodendrum capense, Celtis africana, Ekebergia capensis (facultative), Erythrina caffra, Ficus sur, Kiggelaria africana, Rhus chirindensis, Schotia afra, S. latifolia and Vepris lanceolata, the subcanopy trees Allophylus decipiens, Hippobromus pauciflorus, Canthium inerme, C. mundianum, C. spinosum and Trimeria grandifolia, the woody shrubs Calpurnia aurea, Canthium ciliatum, Gardenia thunbergia and Rhus rehmanni, the soft shrub Heteromorpha trifoliata, the lianes Clematis brachiata, Ficus burtt-davyi, Grewia occidentalis, and Rhoicissus tomentosa, two species each of the vines Dioscorea and Myrsiphyllum, and the geophytes Chasmanthe aethiopica, Haemanthus albiflos, Melasphaerula ramosa and Scadoxus puniceus.

Water and/or food storage organs are conspicuous in certain families. Xerophytic leaves occur in the Crassulaceae, and in Aloe arborescens. Swollen root organs are typical of the geophytes. Root tubers occur in the Cucurbitaceae, Dioscoreaceae, the Cyphia species, and in Ceropegia africana and Rumex sagittatus. The Oxalis species have corms, and the species of Myrsiphyllum and Protasparagus have swollen roots. All these plants are more conspicuous in the dry scrub forest, although several occur widespread in moist high forest.

FOREST ENDEMICS

The distribution of several forbs, graminoids and geophytes listed in the Appendix as occurring in the southern Cape only, is not well known. The better known endemics are listed in Table 6. Very few endemics are entirely confined to the study area.

TABLE 6 Forest endemics of southern Cape region which are common in the study area

TREES AND SHRUBS	
Gnidia denudata	Swellendam - Humansdorp
Lachnostylis hirta	Riversdal - Port Elizabeth
Laurophyllus capensis	Somerset West - Port Elizabeth
Sparrmannia africana	Caledon - Uitenhage
Strelitzia alba	Knysna - Bloukrans River
Virgilia divaricata	Mossel Bay - Willowmore - Uitenhage
Virgilia oroboides ferruginea	Mossel Bay - George
CLIMBERS	
Myrsiphyllum scandens	Southern and south-western Cape
Myrsiphyllum volubile	Hermanus - Port Elizabeth
FERNS	
Hymenophyllum marlothii	Southern and south-western Cape
Thelypteris knysnaensis	New species: George - Keurbooms River
EPIPHYTES	
Angraecum pusillum (burchellii)	Southern Cape
GEOPHYTES	
Cyrtanthus purpureus	Mossel Bay - Uitenhage
Gladiolus sempervirens	George - Humansdorp
Liparis capensis	Southern and south-eastern Cape
SEDGES	
Schoenoxiphium altum	New species: Mossel Bay - Kromme River

DISCUSSION

The southern Cape forest flora is relatively large when compared to other forest complexes in southern Africa (Chapter 4). It has the third largest total flora, the largest herbaceous flora and the fifth largest woody flora. The size of the flora is surprising in view of its southern location on the tip of the African continent, and in view of the southward attenuation of particularly tree and shrub species along the eastern side of southern Africa (Phillips 1931; Scheepers 1978; McKenzie 1978; Tinley 1985; Cawe 1986; Chapter 4 and 6). Furthermore, the forest map shows that this forest complex is relatively isolated from the forests to the east and west (Anonymous 1987). The coastal Alexandria forest and the dry inland Suurberg forest are the nearest large forests to the east and 200km away. Foothill and montane forests of Grootvadersbos are the nearest large forests to the west and 120 km away. However, in the study area the mountains are very close to the coast. Coastal and montane forests are connected in several areas and the floral elements of both the coastal and montane areas of further east occur together in the same stands in this area. This largest forest complex in southern Africa cover a range of sites (Chapter 1) which may trap species which are dispersed along the coast or provide a refuge for species of different climatic periods (Chapter 6, 7 and 8). Furthermore, the size of the flora may reflect the intensity of plant collection. The appended species list includes species housed in different herbaria in addition to individual collections and published flora accounts of forests in the area. Most of the published species lists include only species collected during the particular studies (e.g. Scheepers 1978; Philipson 1987).

The appended species list includes many species which are widely distributed in southern Africa. White (1983) lists several of the southern Cape forest species for various parts of Africa, including high forest, scrub forest, thicket and bushland of Guineo-Congolian, Zambezian, Sudanian, Somalia-Masai, Karoo-Namib and Cape regional centres of endemism, and some regional transition zones and mosaics. However most of the listed species occur in the Afromontane regional centre of endemism (White 1978) and the Tongaland-Pondoland regional mosaic (Moll and White 1978). For example, this flora shares 68% of the 50 families, 27% of the 141 genera and 13% of the 196 species of the evergreen and semi-evergreen trees of Malawi (Chapman and White 1970). Many forest species are also important constituents of the subtropical transitional thicket in the eastern Cape. Cowling (1984) listed 67 Kaffrarian thicket species in the southeastern Cape of which 85% occur in the southern Cape forests (96% of the 24 diagnostic species). Everard (1987) listed 278 species for eastern Cape succulent and Kaffrarian thicket. Of the 97 differential species of, and common species to, xeric and succulent thicket, only 9% occur in the southern Cape forests, and of these only Sideroxylon inerme is a prominent tree. Sixty percent of the differential xeric Kaffrarian thicket species and 62% of the 90 species which occur in two or more of the suborders of thicket occur in the southern Cape forests. Many of these species cover the moist to dry gradient in the southern Cape, including Halleria lucida which I have considered to be a moist species.

The breeding and dispersal systems are typical of the closed, mixed tropical-subtropical forest (Hall and Swaine 1981; Bullock 1985). Dioecy and unisexuality is confined to trees, woody shrubs and vines, and to particular families and genera (Table 4) and show no relationship with geographic origin, geographic range or abundance of the species (Chapter 7). Pollination systems are relatively unknown for most species although insect pollination probably dominates in the woody plants (Phillips 1931). Propagule type vary significantly with growth form. Fleshy propagules are important in woody plants, whereas dry propagules predominate in herbaceous plants. Fleshy propagules are almost absent in the fynbos shrubs (Siegfried 1983).

The legumes (Fabaceae), one of the larger families, are absent from moist to dry high forest and nowhere prominent in the scrub forest. However, pure stands of the pioneer Virgilia tree species (Phillips 1926) and of Psoralea spp. develop on the forest edge after fire. Australian blackwood (Acacia melanoxylon) has established widely in forest gaps and edges since its planting in gaps early this century, but cannot tolerate the closed forest (Geldenhuys 1986a). The two Schotia species are locally common only in dry scrub forest near Plettenberg Bay, but are more prominent in eastern Cape subtropical transitional thicket (Everard 1987). Moist coastal evergreen rain forest of west Africa (e.g. Cameroun and Gabon) is rich in legumes (Caesalpinioideae) which often form pure stands, dominated by one to two species, in which abundant regeneration and a range of size-classes are well represented (White 1983). Many legume species occur in the fynbos of the Cape Floristic Region (Bond and Goldblatt 1984) and in the woodlands of Africa (White 1983), i.e. vegetation types which are frequently disturbed by fire.

Speciation as expressed in the species/family ratio (Table 2) is very low when compared to other forest floras and to floras of surrounding vegetation. Tropical rain forest of Ghana has a species/family ratio of 16,3, excluding ferns (Hall and Swaine 1981). The larger families of mostly woody plants which are shared with the southern Cape forest flora (number of Ghana species between brackets) are Rubiaceae (218), Fabaceae (163), Euphorbiaceae (97), Apocynaceae (63) and Celastraceae (49). Similarly, families which are shared between the forest and fynbos have considerably more species in the fynbos such as the Asteraceae, Fabaceae, Iridaceae, Orchidaceae, Proteaceae, Rutaceae and Schrophulariaceae (Stewart et al. 1982; Vogts 1982; Bond and Goldblatt 1984). Similarly, endemism is very low and very few species are confined to the forests of the study area. By contrast, endemism is very high in the fynbos (Bond and Goldblatt 1984).

Growth forms which are almost dependent on the closed forest environment, such as subcanopy trees, ferns and epiphytes, have a higher species-family ratio than the other typical forest growth forms. This suggests that species which are confined to the more equable microclimate of the understorey of closed forest are probably differentiated on the basis of resource partitioning. Moll (1978) indicated for Natal coastal forests that shrubs and understorey species were less dependent on the external environment than canopy species. Most of the trees and shrubs of high and scrub forest occur either in the canopy or in forest gaps and forest margin and can cope with disturbed habitats. Canopy trees should have wider tolerance limits because of the varied conditions which they experience from the forest floor to the exposed canopy. In disturbed forest differentiation is greatest in the shrubby and herbaceous growth forms.

Several statistics suggest that pressures of greater aridity and low soil fertility, and disturbance by fire have caused forest families to speciate outside the forest in shrubby and herbaceous growth forms. This is shown by the low species-family ratio in the forest compared to the high ratio in fynbos; the wide distribution of many forest species (Appendix; Chapter 4); the radiation and limited distribution of species in the fynbos of families (and genera) of those widespread forest species; the low endemism in forest compared to the high endemism in fynbos; and the preference of forest endemics for forest margins and gaps. Deacon (1983) suggested that the fynbos species radiated as a result of increasing aridity and fire frequency since the Plio-Pleistocene.

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Appendix

ANNOTATED LIST OF SPECIES OF THE SOUTHERN CAPE FORESTS (VELD TYPE 4).

The Pteridophyta follow the arrangement of Schelpe and Anthony (1986). The arrangement and genus numbers of the Gymnospermae, Monocotyledones and the Dicotyledones follow Gibbs Russell et al. (1985, 1987). The nomenclature for the different groups follow the three mentioned sources. The National Tree List numbers are provided for the trees and some shrubs (Von Breitenbach 1986). The numbers precede the respective genera or species. Information on breeding system, fruit type and dispersal mode is based on Levyns (1966), Palmer and Pitman (1972), Dyer (1975, 1976), Palgrave (1977) and personal observation.

Each species name is followed by notes on growth form, breeding system, fruit type, dispersal mode, deciduosity, spinescence, habitat, forest type, geographic range in the southern Cape, abundance and and distribution in southern Africa. Information on reproductive and other characteristics is supplied only when it deviates from the dominant character. The following definitions apply:

* Growth form represents the typical form of the plant in most of the communities and follows the definitions of Geldenhuys et al. (1988).

A tree is a woody plant with diameter at breast height (DBH) >10 mm and >3 m tall if single-stemmed or >5 m tall if multi-stemmed.

A canopy tree has a dominant or codominant position in the canopy of mature vegetation.

A subcanopy tree has an intermediate or overtopped position between the canopy and the shrub or ground layer.

A shrub is a woody plant <3 m tall if single-stemmed or <5 m tall if multi-stemmed.

A woody shrub has a woody stem and a soft shrub a herbaceous stem with woody base.

A liane is a not self-supporting woody, winding, scrambling or climbing plant with DBH >10 mm. A vine has a similar habit but with herbaceous stem <10 mm DBH.

A terrestrial fern is recorded in one of two categories: with erect rhizome, i.e. fronds originate from a central growing point (stem); or with creeping rhizome, i.e. fronds originate on various points along the rhizome.

An epiphyte is aerially supported on both trees and rocks and includes both ferns and flowering plants. Tree-borne parasites are included in this category.

A geophyte is a herbaceous non-graminoid monocotyledon with strap-like leaves and with underground storage organs such as bulbs, corms, or rhizomes.

A graminoid is a herbaceous plant with grasslike or wiry leaves and belong to the families Poaceae, Cyperaceae and Juncaceae.

A forb is a herbaceous angiosperm, excluding vines and epiphytes, which does not fit any of the former categories.

* Breeding system represents four basic modes of reproduction: asexual by spores for ferns; bisexual for most plants, i.e. with male and female parts in the same flower; unisexual with separate male and female flowers on the same plant; or dioecious with male and female flowers on separate plants.

* Fruit type is mentioned in an ecological context as observed at maturity. A pod or capsule is a mostly dry (but can be fleshy) dehiscent fruit which open at one or more sides to release the seed. Some seeds have an aril or fleshy covering. Indehiscent fruits enclose the seed and are taken from the plant with the seed during dispersal. A drupe is a fleshy, semi-fleshy or leathery fruit with a one- to many-seeded stone. A berry is a fleshy fruit with one to many seeds. A nut is a one-seeded, dry fruit with a hard pericarp. Seed size relates to the possible dispersal by small birds versus larger frugivores. A small seed has its largest diameter <5 mm and a large seed a diameter >5 mm.

* Deciduosity refers to the relative period during which plants are without leaves. Most plants are evergreen. Deciduous plants shed all their leaves simultaneously or their total above-ground biomass and stay as such for longer or shorter periods. Semi-deciduous plants produce new foliage immediately prior to or after shedding the old leaves, especially during periods of drought.

* Spinescence refers to the spines or hooks attached to the stem, branchlets, or leaves, and either in the juvenile stage only or until maturity, presumably for protection. Most plants are unarmed.

* Habitat is indicated as dry, moist or wet, and Forest type as high forest, scrub forest, forest gap or margin. Special localities are noted. In general, montane forests are wet, foothill and platform forests are moist to medium-moist (designated as moist), and dry forest, scrub forest of coastal and riverine escarpment, and dunes, are dry.

* Geographical range refers to the relevant habitat in the southern Cape. A widespread species occurs in most parts of its range. A sporadic species occurs at various discrete points of its range. An occasional species occurs at very few points of its range. A disjunct species occurs at few widely separated points of its range. In the latter two cases special localities are noted.

* Abundance relates to the geographical range, habitat and forest type. An abundant species occurs in large numbers throughout its range. A common species occurs in relatively smaller numbers but is seen throughout its range. A scattered or rare species occurs with increasingly smaller numbers which make it more difficult to locate, unless it occurs in scattered or rare clumps or groups.

* Phytogeography refers to the distribution of the species in southern Africa. It is based on published and unpublished accounts of floras and taxa (Taylor

1955, Chippindall 1959, Van der Schijff and Schoonraad 1971, Venter 1972, Campbell and Moll 1977, McKenzie et al. 1977, Van der Walt 1977, McKenzie 1978, Moll 1978, 1980a, 1980b, Scheepers 1978, Weisser and Drews 1980, Nicholson 1982, Stewart et al. 1982, Vogts 1982, Abbott 1985, Burns 1986, Cawe 1986, Schelpe and Anthony 1986, Von Breitenbach 1986, Philipson 1987, Lubke and Strong 1988, Taylor and Masson (in prep.), Geldenhuys (unpublished data), and this paper.

The species are the following:

PTERIDOPHYTA

LYCOPODIACEAE

Lycopodium L.

cernuum L. Fern with creeping rhizome, moist forest margin, common in wet spots, sporadic, western Cape to Natal coast and midlands and Transvaal.

clavatum L. Fern with creeping rhizome, moist forest, sporadic, scattered clumps, western Cape to Natal midlands and Transvaal.

gnidioides L.f. Epiphyte, also lithophytic, wet montane to dry forest, sporadic, rare, western Cape to Natal midlands and Transvaal.

SELAGINELLACEAE

Selaginella Beauv.

kraussiana (Kunze) A.Br. ex Kuhn Fern with creeping rhizome, sometimes epiphytic, moist forest, sporadic, common in clumps in forest gaps, disjunct in western Cape, southern Cape to Natal midlands and Transvaal.

MARATTIACEAE

Marattia Swartz

fraxinea J.E.Sm. ex J.F.Gmel.

var. salicifolia (Schrad.) C.Chr. Fern with erect rhizome, moist forest near streams, sporadic, rare, Mossel Bay to Natal midlands and Transvaal.

OSMUNDACEAE

Osmunda L.

regalis L. Fern with erect rhizome, open stream banks in shade, sporadic, eastern Tsitsikamma (Schelpe and Anthony 1986), western Cape to Natal midlands and Transvaal.

Todea Willd. ex Bernh.

barbara (L.) T.Moore Fern with erect rhizome, stream banks and moist sites, sporadic in plateau forests, widespread in montane forests, locally common, western Cape to Natal midlands and Transvaal.

GLEICHENIACEAE

Gleichenia J.E.Sm.

polypodioides (L.) J.E.Sm. Fern with creeping rhizome, montane and moist forest gaps and margin, widespread, common clumps, western Cape to Natal midlands and Transvaal.

SCHIZAEACEAE

Mohria Swartz

caffrorum (L.) Desv. Fern with erect rhizome, dry forest margin and coastal scrub forest, widespread, scattered clumps, western Cape to Natal and Transvaal.

CYATHEACEAE

Cyathea J.E. Sm.

2 capensis (L.f.) J.E. Sm. Fern with erect rhizome, wet montane and moist forest, widespread, common to scattered, western Cape to Natal midlands and Transvaal.

HYMENOPHYLLACEAE

Trichomanes L.

pyxidiferum L.

var. melanotrichum (Schlechtd.) Schelpe Epiphyte (low-level) and lithophyte, creeping rhizome, moist forest, widespread, common, Swellendam to Natal and Transvaal.

Hymenophyllum J.E.Sm.

capense Schrad. Epiphyte, creeping rhizome, moist to dry forest (Schelpe and Anthony 1986), western Cape to Natal midlands and Transvaal.

marlothii Brause Epiphyte and lithophyte, creeping rhizome, on decaying tree trunks in wet montane to moist forest, western Cape to Knysna.

peltatum (Poir.) Desv. Epiphyte, creeping rhizome, wet montane to moist forest, sporadic, rare, western Cape to Natal mountains.

tunbridgense (L.) J.E. Sm. Epiphyte, creeping rhizome, moist to dry forest, widespread, scattered clumps, western Cape to Natal midlands and Transvaal.

DENNSTAEDTIACEAE

Blotiella Tryon

glabra (Bory) Tryon Fern with creeping rhizome, wet montane to moist forest, widespread, scattered, Mossel Bay to Natal midlands and Transvaal.

natalensis (Hook.) Tryon Fern with erect rhizome, moist forest in damp localities, sporadic, Mossel Bay to Natal midlands.

Histiopteris (Agardh) J. Sm.

incisa (Thunb.) J. Sm. Fern with creeping rhizome, wet montane to moist forest, widespread, scattered, western Cape to Natal midlands and Transvaal.

Pteridium Gled. ex Scop.

aquilinum (L.) Kuhn

subsp. aquilinum Fern with creeping rhizome, forest margin, widespread, scattered clumps, western Cape to Natal and Transvaal.

Hypolepis Bernh.

sparsisora (Schrad.) Kuhn Fern with creeping rhizome, moist forest gaps, widespread, scattered to common, western Cape to Natal midlands and Transvaal.

VITTARIACEAE

<u>Vittaria</u> J.E. Sm.

<u>isoetifolia</u> Bory Epiphyte, rhizome erect to shortly creeping, moist to dry forest, often on stumps of <u>Ocotea bullata</u>, sporadic, scattered, western Cape to Natal and Transvaal.

ADIANTACEAE

<u>Adiantum</u> L.

<u>aethiopicum</u> L. Fern with creeping rhizome, moist forest along streambanks, sporadic, scattered clumps, western to eastern Cape.

<u>capillus-veneris</u> L. Fern with creeping rhizome, moist forest, sporadic, scattered clumps, western Cape to Natal and Transvaal.

<u>Pteris</u> L.

<u>buchananii</u> Bak. ex Sim Fern with creeping rhizome, moist forest, widespread, scattered clumps, Swellendam to Natal midlands and Transvaal.

<u>cretica</u> L. Fern with creeping rhizome, moist forest, sporadic, scattered clumps, Swellendam to Natal midlands and Transvaal.

<u>dentata</u> Forssk. Fern with erect rhizome, moist forest, widespread, scattered clumps, western Cape to Natal midlands and Transvaal.

<u>Cheilanthes</u> Swartz

<u>bergiana</u> Schlechtd. Fern with erect rhizome, moist to dry forest, widespread, common to scattered clumps, Mossel Bay to Natal and Transvaal.

<u>capensis</u> (Thunb.) Swartz Fern with erect rhizome, rhizome shortly creeping, coastal scrub forest, sporadic, scattered clumps, western Cape to Natal mountains.

<u>concolor</u> (Langsd. & Fisch) R. & A. Tryon Fern with erect rhizome, dry forest, disjunct at Mossel Bay (Schelpe and Anthony 1986), rare, eastern Cape to Natal and Transvaal.

<u>hirta</u> Swartz Fern with erect rhizome, rhizome shortly creeping, dry forest and scrub forest, widespread, scattered clumps, Mossel Bay to Natal and Transvaal.

<u>viridis</u> (Forssk.) Swartz

var. <u>viridis</u> Fern with creeping rhizome, dry forest to scrub forest and forest margin, widespread, scattered, western Cape to Natal and Transvaal.

var. <u>macrophylla</u> (Kunze) Schelpe & N.C.Anthony Fern with creeping rhizome, dry forest to scrub forest, sporadic, scattered (Schelpe and Anthony 1986), Mossel Bay to Natal and Transvaal.

POLYPODIACEAE

<u>x Pleupodium</u> Schelpe & N.C.Anthony

<u>simianum</u> Schelpe & N.C.Anthony Epiphyte, creeping rhizome, moist to dry forest, sporadic, scattered (Schelpe and Anthony 1986), Knysna to Natal midlands and Transvaal.

<u>Pleopeltis</u> H.B.K. ex Willd.

<u>macrocarpa</u> (Bory ex Willd.) Kaulf. Epiphyte and lithophyte, creeping rhizome, moist to dry forest and scrubforest, widespread, scattered, western Cape to Natal and Transvaal.

<u>schraderi</u> (Mett.) Tardieu-Blot Epiphyte, creeping rhizome, moist forest,

sporadic, scattered, Swellendam to Natal midlands and Transvaal.

Microsorium Link
ensiforme (Thunb.) Schelpe Epiphyte (high level) and lithophyte, creeping rhizome, moist to dry forest and scrub forest, sporadic, scattered, western to southern Cape and disjunct locality in Transkei.

ASPLENIACEAE

Asplenium L.
adiantum-nigrum L.
var. solidum (Kunze) J.P. Roux Fern with creeping rhizome, moist forest, sporadic, rare, Swellendam to eastern Cape coast.
aethiopicum (Burm.f.) Becherer Fern with creeping rhizome, often epiphytic or lithophytic, moist to dry forest, sporadic, rare, western Cape to Natal midlands and Transvaal.
erectum Bory ex Willd.
var. erectum Fern with erect rhizome, sometimes epiphytic, wet montane to moist forest, widespread, scattered to rare, western Cape to Natal midlands and Transvaal.
x flexuosum Schrad. Fern with erect rhizome, moist situations even in dry forest, associated with A. rutifolium and A. gemmiferum, sporadic, rare, western Cape to southern Natal and Transvaal.
gemmiferum Schrad. Fern with erect rhizome, also on humus-covered boulders or as low-level epiphyte, moist forest, sporadic, scattered clumps, western Cape to Natal midlands and Transvaal.
lobatum Pappe & Raws. Fern with erect rhizome, also low-level epiphyte, moist forest, sporadic, rare, Nature's Valley to Natal midlands and Transvaal.
lunulatum Swartz Fern with erect rhizome, wet montane to dry forest, widespread, scattered, George to Natal midlands and Transvaal.
monanthes L. Fern with erect rhizome, moist to dry forest, sporadic, rare, western Cape to Natal midlands and Transvaal.
platyneuron (L.) Oakes Fern with erect rhizome, moist to dry forest, sporadic, scattered clumps, Swellendam to Natal mountains and southern Transvaal.
protensum Schrad. Fern with erect rhizome, often lithophytic, wet montane forest, sporadic, scattered, Mossel Bay to Natal midlands and Transvaal.
rutifolium (Berg.) Kunze Fern with erect rhizome, sometimes epiphytic or lithophytic, dry forest and scrub forest, widespread, scattered to common, Swellendam to Natal and Transvaal.
simii Braithwaite & Schelpe Epiphyte, often on old decaying stumps, rhizome erect, moist to dry forest, sporadic, scattered, disjunct from George to Natal and Transvaal.
theciferum (H.B.K.) Mett.
var. concinnum (Schrad.) Schelpe Epiphyte, low to mid-level epiphyte or lithophyte, rhizome erect, moist to dry forest, sporadic, rare, Mossel Bay to Natal midlands and Transvaal.

Ceterach DC.
cordatum (Thunb.) Desv. Fern with erect rhizome, dry forest to scrub forest, including coastal forest, sporadic, rare, western Cape to Natal midlands and Transvaal drier areas.

THELYPTERIDACEAE

Thelypteris Schmid.

bergiana (Schlechtd.) Ching Fern with erect rhizome, moist forest, widespread, scattered, western Cape to Natal midlands and Transvaal.

confluens (Thunb.) Morton Fern with creeping rhizome, streambanks, moist forest, occasional (Schelpe and Anthony 1986), rare, western Cape to Natal midlands and Transvaal.

gueinziana (Mett.) Schelpe Fern with erect rhizome, moist forest, disjunct (Diepwalle forest), rare, Knysna to Natal midlands and Transvaal.

interrupta (Willd.) K. Iwats. Fern with creeping rhizome, disjunct along streambanks in dry forest (Bitou River and eastern Tsitsikamma), scattered clumps, disjunct in western and southern Cape, widespread from Transkei to Natal coast and Transvaal.

knysnaensis N.C.Anthony & Schelpe Fern with erect rhizome, new species collected from moist forest localities in Groenkop forest and Keurboomsrivier Nature Reserve.

pozoi (Lagasca) Morton Fern with erect rhizome, moist forest along streambanks, sporadic, rare, western Cape to Natal midlands and Transvaal.

LOMARIOPSIDACEAE

Elaphoglossum Schott ex J. Sm.

acrostichoides (Hook & Grev.) Schelpe Epiphyte, creeping rhizome, wet to dry forest, sporadic, scattered clumps, western Cape to Natal midlands and Transvaal.

angustatum (Schrad.) Hieron. Epiphyte, creeping rhizome, wet montane to moist forest, widespread, common, western to southern Cape and disjunct distribution in southern Natal.

ASPIDIACEAE

Dryopteris Adans.

inaequalis (Schlechtd.) Kuntze Fern with creeping rhizome, moist forest, widespread, rare, Cape Peninsula to Natal midlands and Transvaal.

Polystichum Roth

pungens (Kaulf.) Presl Fern with creeping rhizome, wet montane to dry forest, widespread, scattered to dense clumps, western Cape to Natal midlands and Transvaal.

Rumohra Raddi

adiantiformis (G.Forst.) Ching Fern with creeping rhizome, moist montane to dry forest and scrub forest, widespread, scattered to dense clumps, western Cape to southern Natal and Transvaal.

Ctenitis (C.Chr.) C.Chr. ex Tardieu-Blot

lanuginosa (Willd. ex Kaulf.) Copel. Fern with erect rhizome, moist forest, sporadic, scattered, George to Natal midlands and Transvaal.

BLECHNACEAE

Blechnum L.

australe L.

var. australe Fern with erect rhizome, moist to dry forest, widespread, scattered to rare, western Cape to Natal mountains and Transvaal.

capense Burm.f. Fern with erect rhizome, moist to wet forest, widespread, scattered to common clumps, western Cape to Natal midlands and Transvaal.
giganteum (Kaulf.) Schlechtd. Fern with erect rhizome, wet montane to dry forest, widespread, scattered to common clumps, western Cape to Natal midlands and Transvaal.
punctulatum Swartz
var. punctulatum Fern with erect rhizome, wet montane to dry forest, widespread, scattered to common clumps, western Cape to Natal and southern Transvaal.
tabulare (Thunb.) Kuhn Fern with erect rhizome, wet montane forest including margin, widespread, scattered to common clumps, western Cape to Natal midlands and Transvaal.

SPERMATOPHYTA
GYMNOSPERMAE

PODOCARPACEAE
13 Podocarpus L'Herit.
16 falcatus (Thunb.) R.Br. ex Mirb. Canopy tree, dioecious, drupe with large seed, emergent in moist to dry forest and scrub forest, widespread, scattered, Swellendam to Natal and Transvaal.
18 latifolius (Thunb.) R.Br. ex Mirb. Canopy tree, dioecious, large nut on fleshy receptacle, wet montane to dry forest and scrub forest, widespread, common, western Cape to Natal and Transvaal.

CUPRESSACEAE
38 Widdringtonia Endl.
20 nodiflora (L.) Powrie Subcanopy tree, dehiscent cone with large dry winged seed, montane forest margin, widespread, scattered, western Cape to Natal midlands and Transvaal.

MONOCOTYLEDONES

POACEAE
55 Microstegium Nees
nudum (Trin.) A.Camus Graminoid, grain with bristles, moist forest gaps, paths and roadside, widespread, scattered groups, Mossel Bay to Natal midlands and Transvaal.

104 Brachiaria Griseb
chusqueoides (Hack.) Clayton Graminoid, grain, coastal scrub forest, sporadic in Goukamma Nature Reserve, rare, eastwards to Natal coast.

108 Stenotaphrum Trin.
secundatum (Walt.) Kuntze Graminoid, grain, forest margin, river banks and moist gaps, widespread, scattered clumps, western Cape to Natal coast.

115 Oplismenus Beauv.
hirtellus (L.) Beauv. Graminoid, grain with bristles, moist to dry forest and scrub forest, widespread, common to rare, Swellendam to Natal and Transvaal.

116 Panicum L.
deustum Thunb. Graminoid, grain with bristles, dry forest, widespread, scattered but common in gaps, Swellendam to Natal and Transvaal.
subalbidum Kunth Graminoid, grain with bristles, disturbed forest margin, Witelsbos (Fourcade 1941), eastern Tsitsikamma to Natal and Transvaal.

160 Ehrharta Thunb.
calycina J.E.Sm. Graminoid, grain, moist forest, sporadic, scattered, western Cape to Natal coast.
erecta Lam. (two varieties often are intermediate)
var. erecta Graminoid, grain, wet montane to dry forest, widespread, common to scattered clumps, western Cape to Natal midlands and Transvaal.
var. natalensis Stapf Graminoid, grain, dry coastal forest, scattered, eastern Tsitsikamma (Witelsbos) to Natal coast.
rehmannii Stapf
var. rehmannii Graminoid, grain, wet montane to moist forest, widespread, scattered clumps, western Cape to Tsitsikamma.
subspicata Stapf Graminoid, grain, forest margin, sporadic, scattered, western Cape to Tsitsikamma.

243 Agrostis L.
lachnantha Nees Graminoid, grain, forest gaps and roadside, Lily Vlei forest, sporadic, rare, western Cape to Natal and Transvaal.

263 Stipa L.
dregeana Steud.
var. dregeana Graminoid, grain with bristles, dune forest, sporadic in Goukamma Nature Reserve, rare, Sedgefield to eastern Cape.
var. elongata (Nees) Stapf Graminoid, grain with bristles, dry forest gaps, widespread, scattered, western Cape to Natal and Transvaal.

283 Sporobolus R.Br.
fourcadii Stent Graminoid, grain, forest margin and roads, widespread, scattered, George to southern Natal.

417 Festuca L.
africana (Hack.) Clayton Graminoid, grain, moist mountain forest, sporadic in Kop se bos, Buffelsnek, rare.

432 Brachypodium Beauv.
flexum Nees Graminoid, grain, moist to dry forest, widespread, scattered to common, western Cape to Natal midlands and Transvaal.

CYPERACEAE
456 Carpha Banks & Soland.
glomerata Nees Graminoid, grain, wet riverine scrub, moist forest gaps and slipppaths, widespread, scattered clumps, western Cape to southern Natal.

459 Cyperus L.
tenellus L.f. Graminoid, grain, wet spots along paths in moist forest,

widespread, scattered clumps, western to eastern Cape. It has a flattened spikelet, see also Isolepis ludwigii and Juncus capensis.

465 Ficinia Schrad.

fascicularis Nees Graminoid, grain with bristles, forest margin and disturbed forest understorey, sporadic, rare clumps, George to eastern Cape.

leiocarpa Nees/sylvatica Kunth complex Graminoid, grain with bristles, forest gaps and margin and dry scrub forest, sporadic, scattered clumps, Swellendam to eastern Cape.

sp. (CJG 1064,1070) Graminoid, grain with brsitles, dry forest on slope and along river, Soutrivierbos, De Vasselot Nature Reserve, locally common.

468.2 Isolepis R.Br.

costata (Boeck.) A.Rich. Graminoid, grain, wet montane to moist forest and forest margin, widespread, scattered, Mossel Bay to eastern Cape.

ludwigii Kunth Graminoid, grain, wet sites along paths in moist forest, widespread, scattered clumps, western Cape to Natal and Transvaal. It has a rounded spikelet, see also Cyperus tenellus and Juncus capensis.

prolifer R.Br. Graminoid, grain, moist forest and forest margin, widespread, scattered, western Cape to Natal and Transvaal.

477.1 Epischoenus C.B. Cl.

adnatus Levyns Graminoid, grain with bristles, dry forest margin, widespread, scattered clumps, western Cape to Tsitsikamma.

515 Scleria Berg.

natalensis C.B. Cl. Graminoid, grain, moist forest in gaps and along slippaths, widespread, scattered dense clumps, Nature's Valley to Natal midlands and Transvaal.

521 Schoenoxiphium Nees

altum Kukkonen Graminoid, grain, unisexual, forest gaps and margin, widespread, scattered to common, new species described from southern Cape.

lanceum (Thunb.) Kuekenth. Graminoid, grain, unisexual, wet montane and moist forest, widespread, scattered to common, western Cape to Natal midlands and Transvaal.

lehmannii (Nees) Steud. Graminoid, grain, unisexual, wet montane to dry forest and scrub forest, widespread, scattered to common, western Cape to southern Natal and Transvaal.

525 Carex L.

aethiopica Schkuhr Graminoid, grain, unisexual, moist to dry forest, widespread, scattered, western Cape to Natal midlands and Transvaal.

ARACEAE

748 Zantedeschia Spreng.

aethiopica (L.) Spreng. Geophyte, unisexual, berry with large seed, moist sites or on tree trunks, widespread, rare, western Cape to Natal and Transvaal.

COMMELINACEAE

896 Commelina L.

africana L. Herb, capsule, small seed, dry coastal forest, sporadic, rare, western Cape to Natal and Transvaal.

JUNCACEAE

936 Juncus L.

capensis Thunb. Graminoid, grain, wet sites along paths in moist forest, widespread, scattered clumps, western Cape to southern Natal. It has a larger, open inflorescence and broader leaves, see also Cyperus tenellus and Isolepis ludwigii.

lomatophyllus Spreng. Graminoid, grain, marshy sites in moist forest and along streams, widespread, scattered groups, western Cape to Natal and Transvaal.

LILIACEAE

985 Bulbine Willd.

latifolia (L.f.) Roem. & Schult. Geophyte, capsule, small seed, dry scrub forest, widespread, rare groups, Swellendam to southern Natal.

985.1 Trachyandra Kunth

ciliata (L.f.) Kunth Geophyte, capsule, small seed, coastal dune forest, occasional (in Goukamma Nature Reserve), rare, western to eastern Cape.

990 Chlorophytum Ker-Gawler

comosum (Thunb.) Jacq. Geophyte, capsule, small seed, dry forest and scrub forest, widespread, scattered groups, western Cape to Natal and Transvaal.

1026 Aloe L.

arborescens Mill. Soft shrub, capsule, small seed, spinescent leaves, dry scrub forest, widespread, rare, western Cape to Natal midlands and Transvaal.

1027 Gasteria Duval

acinacifolia (Jaq.) Haw Geophyte, capsule, small seed, coastal scrub forest, occasional groups, Knysna to southern Natal.

1046 Agapanthus L'Herit

praecox Willd.

subsp. minimus (Lindl.) Leighton Geophyte, capsule, small seed, dry forest and scrub forest, along river valleys and on coast, occasional clumps, southern Cape to southern Natal.

1047 Tulbaghia L.

violacea Harv. Geophyte, capsule, small seed, coastal scrub forest, sporadic, scattered groups, Knysna to Port Elizabeth.

1089 Ornithogalum L.

dubium Houtt. Geophyte, capsule, small seed, dry scrub forest margin, sporadic, rare groups, western Cape to southern Natal.

longibracteatum Jacq. Geophyte, capsule, small seed, dry forest and scrub forest, along river valleys and on coast, widespread, scattered groups, Swellendam to East London.

1113.1 Protasparagus Oberm.

aethiopicus (L.) Oberm. Vine, berry, small seed, spiny stem, dry forest and scrub forest, widespread, scattered, western to eastern Cape.

macowanii (Bak.) Oberm. Soft shrub, berry, small seed, spiny stem, dry scrub forest, widespread, scattered, Swellendam to Natal coast and Transvaal.

setaceus (Kunth) Oberm. Vine, berry, small seed, moist to dry forest and scrub forest, widespread, scattered, Swellendam to Natal and Transvaal.

1113.2 Myrsiphyllum Willd.

asparagoides (L.) Willd. Vine, berry, small seed, deciduous to semi-deciduous, dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.

scandens (Thunb.) Oberm. Vine, berry, small seed, wet montane to dry forest, widespread, scattered, western Cape to eastern Tsitsikamma.

volubile (Thunb.) Oberm. Vine, berry, small seed, deciduous, known only from coastal scrub forest at Nature's Valley, Wilderness and Klein Brak River, Hermanus to Port Elizabeth along coast.

AMARYLLIDACEAE

1167 Haemanthus L.

albiflos Jacq. Geophyte, berry, large seed, deciduous, moist montane forest to dry scrub forest, widespread, rare, Mossel Bay to Natal coast.

1167.1 Scadoxus Raf.

puniceus (L.) Friis & Nordal Geophyte, berry, large seed, deciduous, moist to dry forest, sporadic, rare, George to Natal and Transvaal.

1191 Cyrtanthus L.f.

purpureus (Ait.) Traub Geophyte, berry, large seed, moist forest margin, sporadic, scattered, Mossel Bay to Uitenhage.

HYPOXIDACEAE

1230 Hypoxis L.

sp. Geophyte, capsule, small seed, moist forest, sporadic, rare.

DIOSCOREACEAE

1252 Dioscorea L.

mundtii Bak. Vine, dioecious, capsule, small winged seed, tuberous rootstock, deciduous, moist to dry forest and scrub forest, widespread, scattered, Mossel Bay to eastern Cape.

sylvatica (Kunth) Eckl. Vine, dioecious, capsule, small winged seed, tuberous rootstock, deciduous, sporadic, rare, Keurbooms river to Natal and Transvaal.

IRIDACEAE

1265.1 Dietes Salisb. ex Klatt

iridioides (L.) Sweet ex Klatt Geophyte, capsule, small seed, moist to dry forest and scrub forest, widespread, common to scattered, Swellendam to Natal and Transvaal.

1295 Aristea Ait.
ensifolia Muir Geophyte, capsule, small seed, wet montane forest and moist sites and gaps in moist to dry forest and scrub forest, widespread, scattered, sometimes clumps, Swellendam to eastern Cape.

1302 Ixia L.
polystachya L. Geophyte, capsule, small seed, deciduous, dry forest margin, fynbos component, sporadic, rare, western to southern Cape.

1305 Melasphaerula Ker-Gawl.
ramosa (L.) N.E.Br. Geophyte, capsule, small seed, deciduous, coastal forest and scrub forest, sporadic, scattered, western Cape to Tsitsikamma.

1306.3 Chasmanthe N.E.Br.
aethiopica (L.) N.E.Br. Geophyte, capsule, small seed, deciduous, forest and scrub forest margin on sandy soils, sporadic, common in clumps, western to eastern Cape.

1311 Gladiolus L.
sempervirens G.J.Lewis Geophyte, capsule, small seed, wet montane forest margin, occasional, rare, George to Humansdorp.

1312.2 Anapalina N.E. Br.
caffra G. Lewis Geophyte, capsule, small seed, forest margin after fire, fynbos component, widespread, rare, Swellendam to Port Elizabeth.

STRELITZIACEAE
1319 Strelitzia Ait.
32 alba (L.f.) Skeels Subcanopy tree, capsule, large seed, moist forest and forest margin, locally common, scattered clumps (Geldenhuys 1986), Knysna to Bloukrans River.

ORCHIDACEAE
1408 Holothrix L.C.Rich. ex Hook.
parviflora Lindl. Geophyte, capsule, dustlike seed, dry coastal scrub forest, sporadic, scattered, Swellendam to southern Natal.
villosa Lindl.
var. villosa Geophyte, capsule, dustlike seed, moist to dry forest margin, fynbos component, western to southern Cape.

1422 Habenaria Willd.
arenaria Lindl. Geophyte, capsule, dustlike seed, dry forest to scrub forest on dunes, sporadic, scattered, Swellendam to Natal midlands and Transvaal.

1422.2 Bonatea Willd.
speciosa (L.f.) Willd.
var. speciosa Geophyte, capsule, dustlike seed, dry forest to scrub forest, sporadic, scattered, western Cape to Natal and Transvaal.

1430 Satyrium Swartz
ligulatum Lindl. Geophyte, capsule, dustlike seed, dry forest to scrub

forest margin, sporadic, rare, western Cape to southern Natal.

1432 Schizodium Lindl.
inflexum Lindl. Geophyte, capsule, dustlike seed, forest margin, fynbos component, western to southern Cape.

1433 Brownleea Harv. ex Lindl.
recurvata Sond. Geophyte, capsule, dustlike seed, forest margin, fynbos component, southern Cape to southern Natal.

1436 Monadenia Lindl.
bracteata (Swartz) Dur. & Schinz Geophyte, capsule, dustlike seed, forest margin, sporadic, rare, western to southern Cape.

1437 Disperis Swartz
lindleyana Reichb.f. Geophyte, capsule, dustlike seed, moist to dry forest, widespread, scattered, Mossel Bay to Natal midlands and Transvaal.
thorncroftii Schltr. Geophyte, capsule, dustlike seed, moist forest, occasional, rare, Knysna (Diepwalle forest) to Natal and Transvaal.

1556 Liparis L.C.Rich.
capensis Lindl. Geophyte, capsule, dustlike seed, in sandy soil in forest, sporadic, rare, southern and southeastern Cape endemic.
remota J. Stewart & Schelpe Geophyte, capsule, dustlike seed, dry forest to scrub forest, sporadic, scattered groups, George to Natal coast and Swaziland.

1565 Polystachya Hook.
ottoniana Reichb.f. Epiphyte, capsule, dustlike seed, wet montane to dry forest mostly on Ocotea bullata and Podocarpus falcatus, sporadic, scattered to rare, Swellendam to Natal and Transvaal.

1631 Calanthe R.Br.
sylvatica (Thouars) Lindl. Geophyte, capsule, dustlike seed, moist to dry forest including margin, sporadic, rare, George to Natal and Transvaal.

1828 Angraecum Bory
conchiferum Lindl. Epiphyte, capsule, dustlike seed, dry forest and scrub forest, sporadic, scattered, George to Natal midlands and Transvaal.
pusillum Lindl. (A. burchellii Reichb.f. in Rolfe 1913) Epiphyte, capsule, dustlike seed, moist to dry forest, widespread, common, southern Cape.
pusillum Lindl. (A. pusillum Lindl. in Rolfe 1913, CJG 586, 1214) Epiphyte, capsule, dustlike seed, moist to dry forest, sporadic, scattered groups, Swellendam to Natal midlands and Transvaal.
sacciferum Lindl. Epiphyte, capsule, dustlike seed, moist to dry forest and scrub forest, widespread, scattered, Swellendam to Natal midlands and Transvaal.

1828.1 Tridactyle Schltr.
bicaudata (Lindl.) Schltr. Epiphyte, capsule, dustlike seed, moist to dry forest and scrub forest, widespread, common, Mossel Bay to Natal coast and Transvaal.

1835 Cyrtorchis Schltr.
arcuata (Lindl.) Schltr. Epiphyte, capsule, dustlike seed, moist to dry forest, widespread, common, Mossel Bay to Natal and Transvaal.

1837 Mystacidium Lindl.
capense (L.f.) Schltr. Epiphyte, capsule, dustlike seed, moist to dry forest, widespread, common, Mossel Bay to Natal and Transvaal.

DICOTYLEDONES

PIPERACEAE
1862 Piper L.
capense L.f. Soft shrub, drupe, small seed, wet montane to moist forest, sporadic, scattered groups, Swellendam to Natal midlands and Transvaal.

1866 Peperomia Ruiz & Pav.
retusa (L.f.) A. Dietr. Epiphyte, also lithophytic and terrestrial, minute nuts on fleshy receptacle, moist to dry forest, sporadic, scattered clumps, western Cape to Natal midlands and Transvaal.
tetraphylla (G. Forst.) Hook. & Arn. Epiphyte, minute nuts on fleshy receptacle, wet to dry forest, widespread, common, Swellendam to Natal midlands and Transvaal.

MYRICACEAE
1874 Myrica L.
cordifolia L. Woody shrub, dioecious, drupe, small seed, coastal scrub forest margin, fynbos component, widespread, scattered, western to eastern Cape.
humilis Cham. & Schlechtd. Woody shrub, dioecious, drupe, small seed, montane forest margin, fynbos component, widespread, scattered, western to eastern Cape.
quercifolia L. Woody shrub, dioecious, drupe, small seed, coastal scrub forest margin, marshy areas, sporadic, rare, western Cape to southern Natal.
38 serrata Lam. Woody shrub, dioecious, drupe, small seed, forest margin, widespread, scattered, western Cape to Natal and Transvaal.

ULMACEAE
1898 Celtis L.
39 africana Burm.f. Canopy tree, unisexual, berry, small seed, deciduous, dry forest to scrub forest, sporadic, scattered but common in dune forest near Sedgefield, western Cape to Natal and Transvaal.

MORACEAE
1961 Ficus L.
49 burtt-davyi Hutch. Woody shrub, often epiphytic on emergent trees or lithophytic, unisexual, fleshy fig with small nuts, moist to dry forest and scrub forest, sporadic, scattered to rare, Mossel Bay (Gouritz River) to Natal coast.
50 sur Forssk. Canopy tree, unisexual, fleshy fig with small nuts, deciduous, moist to dry forest often along shale bands, sporadic, scattered to rare, George to Natal and Transvaal.

URTICACEAE
1980 Laportea Gaudich
grossa (Wedd.) Chew Herb, unisexual, small nut, stinging hairs on leaves cause irritation, moist to dry forest, sporadic, scattered groups, George to southern Natal and Transvaal.
peduncularis (Wedd.) Chew
subsp. peduncularis Herb, unisexual, small nut, stinging hairs on leaves cause irritation, moist to dry forest, sporadic, scattered groups, Mossel Bay to Natal and Transvaal.

2013 Droguetia Gaudich.
burchellii N.E. Br. Herb, unisexual, small nut, moist sites in dry forest, widespread, rare groups, Swellendam to eastern Cape.

2014 Australina Gaudich.
capensis Wedd. Herb, unisexual, small nut, coastal forest, scattered, western Cape to Tsitsikamma.

PROTEACEAE
2034 Faurea Harv.
74 macnaughtonii Phill. Canopy tree, large nut with hairs, moist to dry parts of Lily Vlei forest, disjunct, locally common (Phillips 1927), Knysna to Natal and Transvaal.

2035 Protea L.
93 mundii Klotzsch Woody shrub, collective fruit with large achenes, moist to dry forest margin, fynbos component, widespread, scattered, southwestern Cape and George to Port Elizabeth.

2037 Leucadendron R.Br
78.1 conicum (Lam.) I.Williams Woody shrub, dioecious, collective fruit with samara, montane forest margin, fynbos component, widespread, scattered groups, Riversdal to Port Elizabeth.
81 eucalyptifolium Buek ex Meisn. Woody shrub, dioecious, collective fruit with samara, forest margin, fynbos component, widespread, scattered groups, Montagu to Grahamstown.

LORANTHACEAE
2074 Tapinanthus Blume
sp. (CJG 371) Parasitic woody shrub on branches, unisexual, small berry, moist forest on Maytenus peduncularis, Groenkop forest near George.

VISCACEAE
2093 Viscum L.
obscurum Thunb. Parasitic woody shrub on branches, unisexual, small berry, common in Virgilia stands and forest margin, widespread, scattered, Swellendam to Natal midlands and Transvaal.
rotundifolium L.f. Parasitic woody shrub on branches, unisexual, small berry, dry scrub forest, sporadic, rare, western Cape to Natal and Transvaal.

SANTALACEAE
2104 Colpoon Berg.
99 compressum Berg. Woody shrub, parasitic on roots, drupe, large seed, dry forest and scrub forest margin, widespread, scattered, western Cape to Natal and Transvaal.

POLYGONACEAE
2195 Rumex L.
sagittatus Thunb. Vine, small winged nut, tuberous rootstock, dry forest and scrub forest margin, widespread, scattered, western Cape to Natal midlands and Transvaal.

2201 Polygonum L.
salicifolium Brouss ex Willd. Herb, small winged nut, moist sites in forest, widespread, scattered clumps, western Cape to Natal coast.

AMARANTHACEAE
2299 Amaranthus L.
thunbergii Moq. Herb, small membraneous utricle with bristles, coastal scrub forest, occasional, rare, western Cape to Natal and Transvaal.

2309.2 Nelsia Schinz.
quadrangula (Engl.) Schinz Herb, small membranous utricle with bristles, dry forest, single record from farm Rozenhof, eastern Tsitsikamma to eastern Cape.

2314 Pupalia Juss.
atropurpurea Moq. Herb, small membranous utricle with bristles, dry scrub forest, sporadic, scattered, southern Cape to Natal coast.

PHYTOLACCACEAE
2380 Phytolacca L.
americana L. Soft shrub, unisexual, berry, small seed, forest margin and gaps, widespread, rare groups, western Cape to southern Natal.
octandra L. Soft shrub, unisexual, berry, small seed, forest margin and gaps, sporadic, rare groups, western Cape to Natal midlands and Transvaal.

AIZOACEAE
2389 Pharnaceum L.
thunbergii Adamson Herb, capsule, small seeds, coastal dune forest, sporadic, scattered, southern Cape to Natal coast.

2403 Tetragonia L.
glauca Fenzl Vine, small winged nut, coastal dune forest, sporadic, scattered, western to southern Cape.

MESEMBRYANTHEMACEAE
2405.9 Aptenia N.E. Br.
cordifolia (L.f.) Schwant.
var. cordifolia Herb, fleshy capsule, small seeds, dry scrub forest along Keurbooms river, sporadic, scattered groups, Plettenberg Bay to Natal and Transvaal.

CARYOPHYLLACEAE
2452 Drymaria Willd. ex Roem. & Schult.
cordata (L.) Willd.
subsp. diandra (Blume) J. Duke Herb, capsule, small seeds, moist forest, sporadic, scattered groups, George to southern Natal.

ILLECEBRACEAE
2490 Silene L.
bellidioides Sond. Herb, capsule, small seeds, coastal scrub forest, sporadic, rare, western Cape to Natal and Transvaal.
crassifolia L. Herb, capsule, small seeds, dune forest margin, fynbos component, sporadic, scattered, western to southern Cape.
primuliflora Eckl. & Zeyh. Herb, capsule, small seeds, dune forest margin, fynbos component, sporadic, scattered, southern Cape to southern Natal.
undulata Ait. Herb, capsule, small seeds, coastal scrub forest margin, sporadic, scattered, western Cape to Natal.

RANUNCULACEAE
2541.1 Knowltonia Salisb.
cordata H. Rasm. Herb, small berry, dry coastal scrub forest margin, sporadic, scattered to rare, southern to eastern Cape.
filia (L.f.) Dur. & Schinz
subsp. scaposa H. Rasm. Herb, small berry, dry forest, widespread, rare, southern Cape.
vesicatoria (L.f.) Sims
subsp. humilis H. Rasm. Herb, small berry, coastal scrub forest, Goukamma Nature Reserve.
subsp. grossa H. Rasm. Herb, small berry, moist to dry forest, widespread, scattered, western Cape to southern Natal.

2542 Clematis L.
brachiata Thunb. Liane, small achene, wet montane to dry forest, widespread, scattered to common, western Cape to Natal and Transvaal.

2546 Ranunculus L.
multifidus Forssk. Herb, small achene with bristles, moist to dry forest in moist places, widespread, scattered, western Cape to Natal and Transvaal.

MENISPERMACEAE
2574 Cissampelos L.
capensis L.f. Vine, dioecious, small drupe, coastal dry forest to scrub forest, widespread, common, western Cape to Sedgefield.
torulosa E.Mey. ex Harv. Vine, dioecious, small fleshy drupe, moist to dry forest, widespread, scattered, Mossel Bay to Natal and Transvaal.

LAURACEAE
2788 Ocotea Aubl.
118 bullata (Burch.) Baill. Canopy tree, unisexual, semi-fleshy drupe, large seed, common in wet montane forest, scattered in moist to dry forest, widespread, western Cape to Natal midlands and Transvaal.

2825 Cassytha L.
ciliolata Nees Parasitic vine on branches, small fruit in fleshy receptacle, forest margin often on Virgilia, sporadic, western Cape to Natal midlands and Transvaal.

BRASSICACEAE
2883 Lepidium L.
ecklonii Schrad. Herb, capsule, small seed, coastal forest margin, Ratelsbos (Fourcade 1941), western to eastern Cape.

2966 Cardamine L.
africana L. Herb, capsule, small seed, dry forest and scrub forest, widespread, scattered, often small groups, western Cape to Natal midlands and Transvaal.

CAPPARACEAE
3101 Capparis L.
sepiaria L.
130 var. citrifolia (Lam.) Toelken Scrambling liane, berry, large seed, spines at leave base on stem, moist to dry forest and scrub forest, widespread, scattered, Swellendam to Natal coast.

3112 Maerua Forssk.
134 racemulosa (DC.) Gilg & Ben. Woody shrub, berry, large seed, dry forest and scrub forest, widespread, rare, George to Natal coast.

CRASSULACEAE
3164 Cotyledon L.
orbiculata L. Soft shrub, capsule, small seed, dry scrub forest margin, widespread, scattered, western Cape to southern Natal.

3168 Crassula L.
cordata Thunb. Herb, capsule, small seed, dry scrub forest, sporadic, scattered, George to Natal.
ericoides Harv. Herb, capsule, small seed, coastal scrub forest margin, fynbos component, sporadic, scattered groups, western Cape to Natal.
lactea Soland. Herb, capsule, small seed, dry scrub forest along Keurbooms river, scattered groups, Riversdal to eastern Cape.
orbicularis L. Herb, capsule, small seed, dry scrub forest, widespread, scattered groups, western Cape to Natal.
pellucida L.
subsp. alsinoides (Hook.f.) Toelken Herb, capsule, small seed, common in moist sites in moist forest, sporadic, western Cape to southern Natal.
subsp. marginalis (Dryand. in Ait.) Toelken Herb, capsule, small seed, dry scrub forest, sporadic, scattered, southern to eastern Cape.
perforata Thunb. Herb, capsule, small seed, dry scrub forest, sporadic, scattered, western Cape to southern Natal.
rubricaulis Eckl. & Zeyh. Herb, capsule, small seed, dry scrub forest, widespread, scattered in rocky sites, Swellendam to eastern Cape.
sarmentosa Harv. Herb, capsule, small seed, moist sites along forest margin, scattered groups, George to southern Natal.
spathulata Thunb. Herb, capsule, small seed, understorey in moist forest

on shale, sporadic, scattered groups, Mossel Bay to eastern Cape.
subulata L.
var. subulata Herb, capsule, small seed, dry coastal dune scrub forest, sporadic, scattered, western to eastern Cape.

PITTOSPORACEAE
3252 Pittosporum Banks ex Soland.
139 viridiflorum Sims Canopy tree, capsule, small sticky orange seed, dry forest to scrub forest, widespread, scattered, Swellendam to Natal and Transvaal.

CUNONIACEAE
3269 Platylophus D.Don
141 trifoliatus (L.f.) D.Don Canopy tree, small bladdered capsule, wet montane to moist forest, widespread, common, western Cape to eastern Tsitsikamma.

3275 Cunonia L.
140 capensis L. Canopy tree, capsule, small seed, widespread, abundant in wet montane forest, rare in moist sites in moist forest, western Cape to southern Natal.

BRUNIACEAE
3294 Berzelia Brongn.
intermedia (Dietr.) Schlechtd. Woody shrub, collective fruit with small nuts, moist forest margin, fynbos component, widespread, scattered, western to eastern Cape.

HAMAMELIDACEAE
3311 Trichocladus Pers.
142 crinitus (Thunb.) Pers. Woody shrub, unisexual, capsule, large seed, abundant in medium-moist to dry forest, scattered in moist forest and dry scrub forest, widespread, Swellendam to Natal coast.
143 ellipticus Eckl. & Zeyh. ex Walp. Woody shrub, unisexual, capsule, large seed, sporadic small, dense patches in Gouna and Goudveld forests, scattered, Knysna to Natal midlands and Transvaal.

ROSACEAE
3353 Rubus L.
pinnatus Willd. Scrambler, drupecetum, small seed, spinescent, moist forest gaps and margin, widespread, scattered, western Cape to Natal midlands and Transvaal.

3375 Alchemilla L.
capensis Thunb. Herb, achenecetum with receptacle, small seed, moist to dry forest margin, widespread, scattered clumps, western to eastern Cape.

3396 Prunus L.
147 africana (Hook.f.) Kalkm. Canopy tree, drupe, large seed, scattered in Bloukrans river gorge (Geldenhuys 1981), western Tsitsikamma to Natal midlands and Transvaal.

FABACEAE
3506 Schotia Jacq.
afra (L.) Thunb.
201 var. afra Canopy tree, pod, large arillated seed, coastal scrub forest, disjunct in Keurbooms River, Klein Brak River and thicket near Gouritz River, scattered, Riversdale coast to eastern Cape including Little Karoo and Valley Bushveld.
204 latifolia Jacq. Canopy tree, pod, large arillated seed, dry scrub forest in Plettenberg Bay area, scattered, southern Cape to southern Natal and northern Transvaal.

3607 Calpurnia E. Mey.
aurea (Ait.) Benth.
220 subsp. sylvatica (Burch.) Brummitt Woody shrub, pod, small seed, dry forest, Bitou River valley, scattered, southern to eastern Cape.

3608 Virgilia Poiret (Van Wyk 1986)
221.1 divaricata Adamson Canopy tree, pod, large seed, common in pure stands in forest margin, widespread, endemic George to Grahamstown.
oroboides (Berg.) Salter
221 subsp. ferruginea B.-E. Van Wyk Canopy tree, pod, large seed, common in pure stands in forest margin, endemic Mossel Bay to George.

3669 Crotalaria L.
224.1 capensis Jacq. Woody shrub, pod, large seed, dry forest and coastal forest margin, sporadic, scattered, western Cape to Natal and Transvaal.

3673 Argyrolobium Eckl. & Zeyh.
tomentosum (Andr.) Druce Woody shrub, pod, small seed, dry forest and scrub forest, sporadic, scattered, Knysna to Natal midlands and Transvaal.

3703 Psoralea L.
225.8 pinnata L. Woody shrub, pod, large seed, forest margin in moist sites, widespread, scattered, western Cape to Natal and Transvaal.

3703.4 Ortholobium C.H.Stirton
fruticans (L.) Druce Woody shrub, pod, large seed, dry forest margin, sporadic, scattered, western to eastern Cape.

3807 Desmodium Desv.
repandum (Vahl) DC. Woody shrub, pod, small seed, moist to dry forest and scrub forest, sporadic, rare, George to Natal and Transvaal.

3861 Dumasia DC.
villosa DC.
var. villosa Vine, pod, small seed, moist forest, sporadic, rare, Knysna to Natal and Transvaal.

3870 Erythrina L.
242 caffra Thunb. Canopy tree, pod, large red seed, dry coastal forest and moist forest on coastal platform, occasional (Driefontein, Bluelíliesbush and possibly Nature's Valley), rare, eastern Tsitsikamma to Natal coast.

3897 Rhynchosia Lour.
caribaea (Jacq.) DC. Vine, pod, small seed, coastal scrub forest, sporadic, rare, George to Natal coast and Transvaal.

3909.1 Dipogon Liebm.
lignosus (L.) Verdc. Vine, pod, small seed, dry forest margin and gaps, widespread, scattered clumps, western to eastern Cape.

GERANIACEAE
3928 Pelargonium L'Herit.
cordifolium (Cav.) Curtis Soft shrub, mericarp, small bristled achene, moist forest margin, widespread, scattered, Bredasdorp to King Williams Town.
papilionaceum (L.) L'Herit. Soft shrub, mericarp, small bristled achene, moist forest margin, sporadic, rare, western to eastern Cape.
zonale (L.) L'Herit. Soft shrub, mericarp, small achene, dry forest and scrub forest margin (moist sites), widespread, scattered groups, western Cape to southern Natal.

OXALIDACEAE
3936 Oxalis L.
incarnata L. Herb with bulb, small capsule, moist forest gaps, sporadic, scattered, western to eastern Cape.
purpurea L. Herb with bulb, small capsule, moist to dry forest, widespread, scattered, western to eastern Cape.
stellata Eckl. & Zeyh.
var. gracilior Salter Herb with bulb, small capsule, dry coastal scrub forest along paths in De Vasselot Nature Reserve, western to eastern Cape.

ZYGOPHYLLACEAE
3965 Zygophyllum L.
morgsana L. Soft shrub, often a scrambler, large winged capsule, coastal scrub forest, widespread, locally common, western Cape to Alexandria.

RUTACEAE
3991 Zanthoxylum L.
253 capense (Thunb.) Harv. Subcanopy tree, unisexual, capsule, small seed,spines on stem and branches, dry scrub forest, sporadic, scattered, Riversdale coast to Natal coast and Transvaal.
254 davyi (Verdoorn) Waterm. Canopy tree, unisexual, capsule, small seed, corky knobs on stem, moist to dry forest, widespread, rare, Knysna to Transvaal, rarely Natal coast.

4035 Calodendrum Thunb.
256 capense (L.f.) Thunb. Canopy tree, capsule, large seed, deciduous, dry forest, widespread, rare, Swellendam to Natal coast and Transvaal.

4037 Agathosma Willd.
ovata (Thunb.) Pillans Woody shrub, capsule, small seed, forest margin, fynbos component, widespread, scattered, western Cape to southern Natal.

4046 Empleurum Ait.
unicapsulare (L.f.) Skeels Woody shrub, capsule, small seed, forest margin in moist sites, fynbos component, widespread, scattered, western to eastern Cape.

4076 Vepris Comm. ex A.Juss.
261 lanceolata (Lam.) G.Don Canopy tree, dioecious, fleshy drupe or capsule, small seed, semi-deciduous, dry forest, widespread, rare, Swellendam to Natal coast and Transvaal.

4091 Clausena Burm.f.
265 anisata (Willd.) Hook.f. ex Benth. Subcanopy tree, fleshy drupe, large seed, dry scrub forest, widespread, rare, Riversdale coast to Natal coast and Transvaal.

MELIACEAE
4193 Ekebergia Sparrm.
298 capensis Sparrm. Canopy tree, dioecious, berry, large seed, semideciduous, moist to dry forest, widespread, rare, western Cape to Natal coast and Transvaal.

POLYGALACEAE
4273 Polygala L.
fruticosa Berg. Woody shrub, membraneous capsule, small seed, moist to dry forest margin and gaps, sporadic, scattered, western Cape to Natal coast.
myrtifolia L. Woody shrub, membraneous capsule, small seed, moist to dry forest margin and gaps, widespread, scattered, western Cape to southern Natal.

EUPHORBIACEAE
4286 Andrachne L.
305 ovalis (Sond.) Muell. Arg. Woody shrub, unisexual, capsule, small seed, moist to dry forest and scrub forest in gaps, paths and margin, widespread, scattered to locally common, George to Natal midlands and Transvaal.

4291 Lachnostylis Turcz.
307 hirta (L.f.) Muell. Arg. Subcanopy tree, dioecious, capsule, large seed, dry forest and scrub forest, widespread, scattered groups, Swellendam to southern Natal.

4370 Adenocline Turcz.
acuta (Thunb.) Baill. Vine, dioecious, capsule, small seed, dry forest and scrub forest, widespread, rare, western Cape to Natal midlands and Transvaal.

4372 Leidesia Muell.-Arg.
procumbens (L.) Prain Herb, unisexual, capsule, small seed, moist sites in dry forest, sporadic, scattered groups, western Cape to Natal midlands and Transvaal.
4407 Acalypha L.
capensis (L.f.) Prain & Hutch. Herb, unisexual, capsule, small seed, dry

forest to scrub forest margin, widespread, scattered clumps, western to eastern Cape.
ecklonii Baill. Herb, unisexual, capsule, small seed, moist to dry forest, collected from elephant faeces in forest, southern Cape to Natal coast.

4416 Tragia L.
sp. (C Jacobs 13) Vine, unisexual, capsule, small seed, dry forest margin, Groenkop forest, rare.

4416.1 Ctenomeria Harv.
capensis (Thunb.) Harv. ex Sond. Vine, unisexual, capsule, small seed, moist to dry forest, sporadic, rare, Mossel Bay to Natal and Transvaal.

4448 Clutia L.
affinis Sond. Woody shrub, dioecious, capsule, small seed with elaiosome, forest margin, gaps and understorey, widespread, scattered, western Cape to Natal midlands and Transvaal.
alaternoides L. Soft shrub, dioecious, capsule, small seed with elaiosome, forest margin, sporadic, scattered, western Cape to Natal.
laxa Eckl. ex Sonder Soft shrub, dioecious, capsule, small seed with elaiosome, montane forest margins, sporadic, rare, Riversdal to Natal midlands and Transvaal.
pulchella L. Woody shrub, dioecious, capsule, small seed with elaiosome, wet montane to dry forest and scrub forest understorey, gaps and margin, widespread, scattered to common, western Cape to Natal midlands and Transvaal.

4478 Excoecaria L.
simii (Kuntze) Pax Woody shrub, dioecious, capsule, large seed, dry forest and scrub forest, widespread, scattered to locally common, George to Natal coast.

4498 Euphorbia L.
kraussiana Bernh.
var. erubescens N.E.Br. Soft shrub, unisexual, capsule, small seed, dry forest to scrub forest, sporadic, rare, Mossel Bay to Natal and Transvaal.

ANACARDIACEAE
4586 Loxostylis Spreng. f. ex Reichb.
365 alata A. Sprengel ex Reichb. Canopy tree, dioecious, small drupe, dry scrub forest, rare, eastern Tsitsikamma (Kromme river) to southern Natal.

4587 Laurophyllus Thunb.
366 capensis Thunb. Woody shrub, dioecious, large samara, moist forest margin, sometimes in forest gaps, widespread, scattered, Grabouw to Uitenhage.

4594 Rhus L.
380 chirindensis Bak.f. Canopy tree, dioecious, small semi-fleshy drupe, deciduous, dry forest and scrub forest, widespread, rare groups, Swellendam (Grootvadersbosch) to Natal coast and Transvaal.
380.1 crenata Thunb. Woody shrub, dioecious, small semi-fleshy drupe, coastal

forest margin and scrub forest, widespread, common, western to eastern Cape.

383.2 glauca Thunb. Woody shrub, dioecious, small semi-fleshy drupe, coastal scrub forest, sporadic, scattered, western to eastern Cape.

388 longispina Eckl. & Zeyh. Woody shrub, scandent, dioecious, small semi-fleshy drupe, dry scrub forest, sporadic, rare, Mossel Bay to eastern Cape.

388.1 lucida L. Subcanopy tree, dioecious, small semi-fleshy drupe, dry forest and scrub forest, including gaps and margin, widespread, scattered, western Cape to Natal midlands and Transvaal.

refracta Eckl. & Zeyh. Woody shrub, dioecious, small semi-fleshy drupe, dry scrub forest, Bietou river valley, rare, Plettenberg Bay to eastern Cape.

393.1 rehmanniana Engl. Woody shrub, dioecious, small semi-fleshy drupe, dry forest and scrub forest margin, Bietou river valley, rare, Swellendam to Natal coast and Transvaal.

395 undulata Jacq. Woody shrub, dioecious, small semi-fleshy drupe, dry forest and scrub forest margin near coast, sporadic, scattered, mostly drier parts of southern Africa.

AQUIFOLIACEAE

4614 Ilex L.

397 mitis (L.) Radlk. Canopy tree, unisexual, berry, small seed, rare in wet montane forest, scattered in moist forest, often along streams, widespread, western Cape to Natal and Transvaal.

CELASTRACEAE

4626 Maytenus Molina

acuminata (L.f.) Loes.

398 var. acuminata Subcanopy tree, unisexual to bisexual, capsule, small arillated seed, dry forest and scrub forest, often margin, widespread, scattered, western Cape to Natal and Transvaal.

399 heterophylla (Eckl. & Zeyh.) N.K.B. Robson Subcanopy tree, unisexual to bisexual, capsule, small arillated seed, spinescent, moist to dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.

399.3 nemorosa (Eckl. & Zeyh.) Marais Subcanopy tree, unisexual to bisexual, capsule, small arillated seed, spinescent, moist to dry forest, widespread, scattered to common, Mossel Bay to Natal coast.

401 peduncularis (Sond.) Loes. Canopy tree, unisexual to bisexual, capsule, large arillated seed, moist to dry forest and scrub forest, widespread, scattered to rare, George to Natal and Transvaal.

401.1 procumbens (L.f.) Loes. Woody shrub, unisexual to bisexual, capsule, small arillated seed, dry scrub forest on dunes, sporadic, scattered, Riversdal to Natal coast.

403 undata (Thunb.) Blakelock Subcanopy tree, unisexual to bisexual, capsule, small arillated seed, rare - one dubious record for Nature's Valley, eastwards to Natal and Transvaal.

4628 Putterlickia Endl.

403.1 pyracantha (L.) Szyszyl. Woody shrub, capsule, small arillated seed, spinescent, dry scrub forest, widespread, scattered to rare, Cape Peninsula to Natal and Transvaal.

4630 Pterocelastrus Meisn.
408 rostratus Walp. Subcanopy tree, fleshy capsule, small arillated seed, wet montane forest, widespread west of George, scattered to common, western Cape to George, eastern Cape to Natal mountains.
409 tricuspidatus (Lam.) Sond. Canopy tree, fleshy capsule, small arillated seed, moist to dry forest and scrub forest, widespread, rare to common, western Cape to Natal coast.

4641 Cassine L.
410 aethiopica Thunb. Canopy tree, drupe, small seed, dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.
413 eucleiformis (Eckl. & Zeyh.) Kuntze Subcanopy tree, drupe, small seed, moist to dry forest and scrub forest, widespread, scattered, western Cape to Natal midlands and Transvaal.
maritimum L.Bol. Woody shrub, drupe, small seed, coastal scrub forest margin, sporadic, scattered, Cape Peninsula to eastern Cape coast.
414 peragua L. Canopy tree, drupe, large seed, dry forest and scrub forest, widespread, scattered to common, western Cape to drier Natal coast and midlands.
415 papillosa (Hochst.) Kuntze Subcanopy tree, semi-fleshy drupe, moist to dry forest and scrub forest, widespread, scattered to rare, Swellendam to Natal and Transvaal.
415.1 parvifolia Sond. Woody shrub, drupe, small seed, forest margin, widespread, rare, disjunct between western Cape and southern Cape (to eastern Tsitsikamma).
411.1 tetragona (L.f) Loes. Scrambling liane, drupe, small seed, dry forest to scrub forest, widespread, scattered to common, western Cape to Natal and Transvaal.

4645 Hartogiella Codd
418 schinoides (Spreng.) Codd Subcanopy tree, drupe, small seed, forest margin, sporadic, scattered but more common in Tsitsikamma, western and southern Cape, and rare in eastern Cape.

ICACINACEAE
4671 Cassinopsis Sond.
420 ilicifolia (Hochst.) Kuntze Woody shrub, drupe, large seed, spinescent, moist to dry forest, widespread, rare, western Cape (Stanford) to Natal mountains and Transvaal.

4686 Apodytes E.Mey. ex Arn.
dimidiata E.Mey. ex Arn.
422 subsp. dimidiata Canopy tree, drupe, small seed, moist to dry forest, widespread, scattered to common, western Cape to Natal and Transvaal.

4709 Pyrenacantha Wight
scandens Planch. ex Harv. Vine, dioecious to unisexual, drupe, large seed, moist to dry forest, widespread, scattered to common, Swellendam to Natal coast.
SAPINDACEAE
4734 Allophylus L.
423 decipiens (Sond.) Radlk. Subcanopy tree, carpel, small seed, deciduous,

dry scrub forest, widespread, scattered, Mossel Bay (Herbertsdale) to Natal and Transvaal.

4831 Dodonaea Mill.
437.1 angustifolia L.f. Woody shrub, dioecious, large membraneous capsule, dry forest and scrub forest margin, sporadic, scattered, drier areas from western Cape to Transvaal.

4836 Hippobromus Eckl. & Zeyh.
438 pauciflorus (L.f.) Radlk. Subcanopy tree, drupe, small seed, common in dry scrub forest in Nature's Valley, rare in eastern parts of area (Geldenhuys 1986b), Tsitsikamma to Natal coast and Transvaal.

BALSAMINACEAE
4856 Impatiens L.
hochstetteri Warb.
subsp. hochstetteri Herb, fleshy capsule, small seed, moist sites in moist forest, sporadic, locally common, Grabouw to Natal midlands and Transvaal.

RHAMNACEAE
4874 Scutia Comm. ex Brongn.
451 myrtina (Burm.f.) Kurz Scrambling liane, drupe, small seed, spinescent, dry forest to scrub forest, widespread, scattered to common, western Cape to Natal and Transvaal.

4875 Rhamnus L.
452 prinoides L'Herit. Subcanopy tree, berry, small seed, forest and scrub forest gaps and margin, widespread, scattered, Swellendam to Natal mountains and Transvaal.

4886 Phylica L.
axillaris Lam. Woody shrub, capsule, small seed, forest margin, fynbos component, widespread, scattered, western to eastern Cape.
pinea Thunb. Woody shrub, capsule, small seed, forest margin, fynbos component, sporadic, scattered, western to southern Cape.
purpurea Sond. Woody shrub, capsule, small seed, forest margin, fynbos component, sporadic, scattered, western to southern Cape.

VITACEAE
4917 Rhoicissus Planch.
456.2 digitata (L.f.) Gilg & Brandt Liane, berry, small seed, dry forest and scrub forest, widespread, scattered to common, western Cape (Betty's bay) to Natal coast.
456.5 tomentosa (Lam.) Wild & Drum. Liane, berry, small seed, moist to dry forest and scrub forest, often covering canopy trees, widespread, scattered to common, western Cape to Natal and Transvaal.
456.6 tridentata (L.f.) Wild & Drum. Liane, berry, small seed, dry forest, sporadic, rare, Swellendam to Natal and Transvaal.
4918.1 Cyphostemma Alston
sp. cf C. hypoleucum (Harv.) Desc. ex Wild & Drum. Vine, berry, small seed, dune forest, occasional, rare, eastern Tsitsikamma (Driefontein) to

southern Natal.

TILIACEAE
4957 Sparrmannia L.f.
457 africana L.f. Woody shrub, prickly capsule, small seed, wet mountain forest including margin, widespread, scattered to locally common, Swellendam to Uitenhage.

4966 Grewia L.
463 occidentalis L. Scrambling liane, drupe, small seed, dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.

MALVACEAE
4983 Abutilon Mill.
sonneratianum (Cav.) Sweet Herb, carpel, small seed, dry scrub forest gaps and margin, sporadic, rare, Mossel Bay to Natal and Transvaal.

4998 Sida L.
dregei Burtt Davy Herb, carpel, small seed, dry scrub forest margin at Wilderness, rare, George to Natal midlands and Transvaal.
ternata L.f. Herb, carpel, small seed, dry forest margin, sporadic, rare, Mossel Bay to Natal midlands and Transvaal.

5007 Pavonia Cav.
columella Cav. Herb, carpel, small seed, dry forest margin, sporadic, rare, George to Natal midlands and Transvaal.

5013 Hibiscus L.
diversifolius Jacq.
subsp. diversifolius Soft shrub, spinescent stem, capsule, small seed, forest margin, sporadic, rare, Knysna, Bitou river valley and Nature's Valley to Natal coast.
ludwigii Eckl. & Zeyh. Herb, capsule, small seed, coastal forest margin in De Vasselot Nature Reserve, sporadic, rare, southern Cape to Natal.
pedunculatus L.f. Soft shrub, capsule, small seed, dry forest and scrub forest, widespread, scattered to rare, George to Natal midlands and Transvaal.

OCHNACEAE
5112 Ochna L.
arborea Burch. ex DC.
479 var. arborea Subcanopy tree, drupe, large seed, moist to dry forest and scrub forest, widespread, scattered, George to Natal and Transvaal.
479.1 serrulata (Hochst.) Walp. Woody shrub, drupe, large seed, dry forest, locally common to scattered, Knysna to Natal and Transvaal.

FLACOURTIACEAE
5296 Kiggelaria L.
494 africana L. Canopy tree, dioecious, capsule, small arillated seed, semi-deciduous, moist to dry forest, widespread, rare, western Cape to Natal midlands and Transvaal.

5304 Scolopia Schreb.
496 mundii (Eckl. & Zeyh.) Warb. Canopy tree, berry, small seed, juvenile plants spinescent, dry forest and scrub forest, widespread, scattered, Cape Peninsula to Natal midlands and Transvaal.
498 zeyheri (Nees) Harv. Canopy tree, berry, small seed, spinescent branchlets on bole, dry forest and scrub forest, widespread, rare, Mossel Bay (Herbertsdale) to Natal and Transvaal.

5315 Trimeria Harv.
503 grandifolia (Hochst.) Warb. Subcanopy tree, dioecious, capsule, small arillated seed, deciduous, moist to dry forest, widespread, scattered, George to Natal and Transvaal.

5328 Dovyalis E.Mey. ex Arn.
508 lucida Sim Subcanopy tree, dioecious, berry, small seed, spinescent, occasional, rare, eastern Tsitsikamma (Koomansbos) to Natal and Transvaal.
509 rhamnoides (Burch. ex DC.) Harv. Woody shrub, dioecious, berry, small seed, spinescent, dry forest and scrub forest, widespread, scattered to common, George to Natal coast, disjunct in Transvaal.
510 rotundifolia (Thunb.) Thunb. & Harv. Subcanopy tree, dioecious, berry, small seed, spinescent, dry scrub forest, occasional, rare, eastern Tsitsikamma (Driefontein) to eastern Cape.

ACHARIACEAE
5374 Ceratiosicyos Nees
laevis (Thunb.) A.Meeuse Vine, unisexual, capsule, small seed, moist places in dry forest and scrub forest, widespread, scattered to rare, Mossel Bay to Natal and Transvaal.

PENAEACEAE
5425 Penaea L.
cneorum Meerb.
subsp. gigantea R. Dahlg. Woody shrub, capsule, small seed, forest margin, fynbos component, widespread, rare, western to eastern Cape.

OLINIACEAE
5428 Olinia Thunb.
513 ventosa (L.) Cufod. Canopy tree, drupe, large seed, moist to dry forest on drier sites, widespread, scattered, often small groups, western Cape to southern Natal.

THYMELAEACEAE
5435 Gnidia L.
denudata Lindl. Woody shrub, dry fruit, small seed, moist to dry forest gaps, widespread, scattered groups, Swellendam to Humansdorp.

5436 Struthiola L.
ciliata (L.) Lam. Woody shrub, dry fruit, small seed, forest margin, fynbos component, sporadic, scattered, western to eastern Cape.
ecklonianа Meisn. Woody shrub, dry fruit, small seed, forest margin, fynbos component, sporadic, scattered, western to southern Cape.
hirsuta Wikstr. Woody shrub, dry fruit, small seed, forest margin, fynbos

component, sporadic, scattered, Riversdal to Humansdorp.

5461 Passerina L.
520 falcifolia C.H.Wr. Woody shrub, fleshy pericarp, small seed, moist to dry forest margin, widespread, scattered to locally common, Mossel Bay to Port Elizabeth.

MYRTACEAE
5583 Syzygium Gaertn.
555 cordatum Hochst. Canopy tree, berry, large seed, two large trees in scrub forest at Nature's Valley, eastwards to Natal coast and Transvaal.

ONAGRACEAE
5795 Epilobium L.
hirsutum L. Herb, capsule, small seed with hairs, moist forest paths, Diepwalle forest, locally common, western Cape to Transvaal.

HALORAGACEAE
5833 Laurembergia Baill. or Berg.
repens Berg.
subsp. brachypoda (Hiern) Oberm. Herb, unisexual, small fleshy nut, moist sites in forest, widespread, scattered groups, western Cape to Natal and Transvaal.

ARALIACEAE
5852 Schefflera J.R. & G.Frost
566 umbellifera (Sond.) Baill. Canopy tree, berry, small seed, locally common in Elands river valley in eastern Tsitsikamma from the mountains to the coast, disjunct until Natal coast and Transvaal.

5872 Cussonia Thunb.
spicata Thunb.
564 var. spicata Subcanopy tree, berry, small seed, dry scrub forest, disjunct in small forest patches (along Kromme river in eastern Tsitsikamma, Gouritz River in west, northern slopes of Outeniqua mountains), scattered, western Cape to Natal and Transvaal.
565 thyrsiflora Thunb. Scrambling liane, berry, small seed, dry scrub forest, widespread, scattered, western Cape to southern Natal.

APIACEAE
5894 Centella L.
eriantha (Rich.) Drude
var. eriantha Herb, mericarp, small seed, damp places in moist to dry forest and forest margin, widespread, scattered to common, western Cape to Natal.

5918 Sanicula L.
elata Buch.-Ham. Herb, mericarp, small seed, moist to dry forest, widespread, scattered (see also Ranunculus multifidus), western Cape to Natal midlands and Transvaal.

5992 Heteromorpha Cham. & Schlechtd.
568 trifoliata (Wendl.) Eckl. & Zeyh. Woody shrub, mericarp, small seed, dry scrub forest and margin, sporadic, rare, western Cape to Natal and Transvaal.

5996 Rhyticarpus Sond.
difformis Benth. & Hook. Soft shrub, mericarp, small seed, dry scrub forest, sporadic, rare, western to eastern Cape.

6116 Peucedanum L.
capense (Thunb.) Sond. Soft shrub, mericarp, small seed, dry scrub forest margin, sporadic, scattered, Swellendam to Natal and Transvaal.

CORNACEAE
6156 Curtisia Ait.
570 dentata (Burm.f.) C.A.Sm. Canopy tree, fleshy drupe, small seed, moist to dry forest, widespread, scattered, western Cape to Natal midlands and Transvaal.

ERICACEAE
6237 Erica L.
canaliculata Andr. Woody shrub, capsule, minute seed, forest margin, fynbos component, widespread, locally common, southern Cape.
copiosa Wendl. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, scattered, western Cape to southern Natal.
curviflora L. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, scattered, western to eastern Cape.
densifolia Willd. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, scattered, southern Cape.
gibbosa Klotzsch ex Benth. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, rare, southern Cape.
seriphiifolia Salisb. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, scattered, southern Cape.
sparsa Lodd. Woody shrub, capsule, minute seed, forest margin, fynbos component, sporadic, scattered, Swellendam to Port Elizabeth.

6244 Simocheilus Klotzsch
multiflorus Klotzsch Woody shrub, capsule, minute seed, dry forest margin, fynbos component, sporadic, scattered, southern Cape.

MYRSINACEAE
6313 Myrsine L.
africana L. Woody shrub, dioecious, small berry, moist to dry forest margin, widespread, scattered, western Cape to Natal midlands and Transvaal.

6314 Rapanea Aubl.
578 melanophloeos (L.) Mez Canopy tree, unisexual, berry, small seed, moist to dry forest and scrub forest, often in margin, widespread, scattered to common, western Cape to Natal and Transvaal.

PLUMBAGINACEAE

6343 Plumbago L.

auriculata Lam. Woody shrub, capsule, small seed, scrub forest to dry forest gaps and understorey, occasional (Bietou River Valley and western tributaries of Keurbooms river), rare, Plettenberg Bay to Natal midlands and Transvaal.

6351 Limonium Adans. or Mill.

scabrum (Thunb.) Kuntze

var. scabrum Herb, capsule, small seed, margin of dry scrub forest near coast, sporadic, scattered to common, western Cape to eastern Cape coast.

SAPOTACEAE

6368 Sideroxylon L.

579 inerme L. Canopy tree, berry, large seed, dry forest and scrub forest, common near coast or above water line of lakes, widespread, western Cape to Natal coast and Transvaal.

EBENACEAE

6404 Euclea Murray

crispa (Thunb.) Guerke

594 subsp. crispa Subcanopy tree, dioecious, small berry, dry scrub forest, sporadic, rare, Bredasdorp to Natal midlands and Transvaal.

polyandra (L.f.) E.Mey. ex Hiern Subcanopy tree, dioecious, large nut, dry scrub forest margin, sporadic, scattered, western Cape to Natal and Transvaal.

599 racemosa Murray Subcanopy tree, dioecious, berry, small seed, dry scrub forest, sporadic, scattered, western to eastern Cape.

schimperi (A.DC.) Dandy

600 var. schimperi Subcanopy tree, dioecious, berry, large seed, dry forest and scrub forest, widespread, scattered to rare, western Cape to Natal coast, disjunct in Transvaal.

undulata Thunb.

601 var. undulata Subcanopy tree, dioecious, berry, small seed, dry scrub forest, sporadic, rare, western Cape to Natal and Transvaal drier areas.

6406 Diospyros L.

603 dichrophylla (Gand.) De Winter Subcanopy tree, dioecious, berry, large seed, dry forest and scrub forest including margin, widespread, scattered to common, Bredasdorp to Natal coast.

603.1 glabra (L.) De Winter Woody shrub, dioecious, berry, large seed, moist to dry forest margin, widespread, scattered, western Cape to eastern Tsitsikamma.

pallens (Thunb.) F.White Woody shrub, dioecious, berry, large seed, coastal scrub forest, sporadic, scattered, George to southern Natal.

611 whyteana (Hiern) F.White Subcanopy tree, dioecious, berry, large seed, moist to dry forest and scrub forest, widespread, scattered to common, western Cape to Natal midlands (occasionally Maputaland coast) and Transvaal.

OLEACEAE
6428 Chionanthus L.
foveolata (E. Mey.) Stearn
615 subsp. foveolata Subcanopy tree, drupe, large seed, medium-moist to dry forest and scrub forest, widespread, rare to scattered, western Cape to Natal and Transvaal.
615.1 subsp. tomentellus (Verdoorn) Stearn Subcanopy tree, drupe, large seed, coastal scrub forest, sporadic, rare, Cape Peninsula to southern Natal.
616 peglerae (C.H. Wr.) Stearn Canopy tree, drupe, large seed, mediummoist to dry forest, occasional (Koomansbos and Witelsbos), rare, eastern Tsitsikamma to Natal, disjunct in Transvaal.

6434 Olea L.
europaea L.
617 subsp. africana (Mill.) P.S.Green Canopy tree, drupe, small seed, dry scrub forest, widespread, scattered to rare, western Cape to Natal and Transvaal drier areas.
capensis L.
618 subsp. capensis Subcanopy tree, drupe, small seed, wet montane, moist to dry forest and scrub forest, widespread, scattered to common, western Cape to southern Natal, scattered further north.
618.2 subsp. macrocarpa (C.H.Wr.) Verdoorn Canopy tree, drupe, large seed, common in moist to dry forest, scattered to rare in scrub forest, widespread, western Cape to Natal and Transvaal.
619 exasperata Jacq. Subcanopy tree, drupe, small seed, coastal scrub forest, sporadic, scattered, western to eastern Cape.

6440 Jasminum L.
angulare Vahl Vine, berry, small seed, dry scrub forest, sporadic in Bitou river valley and Keurboomsrivier Nature Reserve, rare, Plettenberg Bay to Natal.

SALVADORACEAE
6444 Azima Lam.
622.1 tetracantha Lam. Woody shrub, unisexual, small berry, spinescent, dry scrub forest margin, widespread, scattered, Cape Infanta to Natal and Transvaal.

LOGANIACEAE
6460 Strychnos L.
624 decussata (Pappe) Gilg Canopy tree, berry, large seed, medium-moist to dry forest, disjunct (single plants in Biervlei and Brackenhill forests, extensive population in Nature's Valley, Geldenhuys 1986b), southern Cape to Natal coast and Transvaal lowveld.

6469 Nuxia Lam.
634 floribunda Benth. Canopy tree, capsule, minute seed, moist to dry forest, widespread, scattered, Swellendam to Natal midlands and Transvaal.

6473 Buddleja L.
636 saligna Willd. Canopy tree, capsule, minute seed, dry scrub forest including dry forest margin, widespread, scattered to common, western Cape

to Natal and Transvaal.
637 salviifolia (L.) Lam. Woody shrub, capsule, minute seed, dry forest to scrub forest margin, sporadic, scattered, western Cape to Natal midlands and Transvaal.

GENTIANACEAE
6503 Chironia L.
baccifera L. Herb, fleshy capsule, small seed, coastal forest margin, fynbos component, sporadic, scattered, western Cape to Natal coast.
decumbens Levyns Herb, fleshy capsule, small seed, coastal forest margin, fynbos component, sporadic, scattered, western to southern Cape.
melampyrifolia Lam. Herb, fleshy capsule, small seed, forest margin, fynbos component, widespread, rare, western to eastern Cape.

APOCYNACEAE
6558 Acokanthera G.Don
638 oblongifolia (Hochst.) Codd Woody shrub, berry, large seed, dry scrub forest on dunes, occasional, rare, Mossel Bay and Knysna to Natal coast.
639 oppositifolia (Lam.) Codd Woody shrub, berry, large seed, dry forest to scrub forest, widespread, scattered to rare, western Cape to Natal coast and Transvaal.

6559 Carissa L.
bispinosa (L.) Desf. ex Brenan
640.1 var. acuminata (E.Mey.) Codd Woody shrub, berry, small seed, spinescent, moist to dry forest and scrub forest, widespread, scattered to common, disjunct between western Cape, Natal coast and mountains and Transvaal.

6581 Gonioma E.Mey.
641 kamassi E.Mey. Subcanopy tree, mericarp, large winged seeds, wet montane to dry forest and scrub forest, widespread, scattered to common, Mossel Bay to Natal coast and southern Transvaal.

ASCLEPIADACEAE
6758 Astephanus R.Br.
marginatus Decne. Vine, follicle, small seed with hairs, coastal scrub forest, sporadic, rare, George to eastern Cape.
triflorus (L.f.) Schultes Vine, follicle, small seed with hairs, scrub forest, sporadic in De Vasselot Nature Reserve, scattered, western to southern Cape.

6791 Asclepias L.
fruticosa L. Herb, follicle, small seed with hairs, forest margin and gaps, sporadic, rare groups, western Cape to Transvaal.

6834 Cynanchum L.
ellipticum (Harv.) R.A.Dyer Vine, follicle, small seed with hairs, dry forest margin and scrub forest, widespread, scattered, southern Cape to Natal coast and Transvaal.
natalitium Schltr. Vine, follicle, small seed with hairs, coastal scrub forest margin, sporadic, rare, Sedgefield to Natal coast.
obtusifolium L.f.

var. _obtusifolium_ Vine, follicle, small seed with hairs, dry forest margin and scrub forest, widespread, scattered, western Cape to Natal coast.
var. _pilosum_ Schltr. Vine, follicle, small seed with hairs, coastal forest margin, sporadic, scattered, Sedgefield to eastern Cape.
tetrapterum (Turcz.) R.A.Dyer Vine, almost leafless green stem, follicle, small seed with hairs, dry scrub forest, rare, Nature's Valley to Natal and Transvaal.

6842 _Oncinema_ Arn.
lineare (L.f.) Bullock Vine, follicle, small seed with hairs, wet montane to dry forest, widespread, rare, western to eastern Cape.

6849 _Sarcostemma_ R.Br.
viminale (L.) R.Br. Vine, almost leafless green stem, follicle, small seed with hairs, dry scrub forest, sporadic, scattered, Riversdale to Natal and Transvaal.

6860 _Secamone_ R.Br.
alpinii Schultes Liane, follicle, small seed with hairs, wet montane to dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.

6874 _Ceropegia_ L.
africana R. Br. Herb, capsule, small seed, tuberous, scrambling on forest floor and lower stems of trees, dry forest to scrub forest, sporadic, scattered, Mossel Bay to Natal.

6899 _Tylophora_ R.Br.
cordata (Thunb.) Druce Vine, follicle, small seed with hairs, dry forest and scrub forest, widespread, scattered to rare, Mossel Bay to southern Natal.

CONVOLVULACEAE
6968 _Cuscuta_ L.
africana Willd. Parasitic vine on branches, fleshy capsule, small seed, common in _Virgilia_ stands on forest margin, widespread, Swellendam to Port Elizabeth.

6971 _Dichondra_ Forst.
repens J.R. & G. Forst. Herb, membraneous capsule, small seed, damp sites in coastal forest, sporadic in De Vasselot Nature Reserve, scattered, western Cape to Transvaal.

6972 _Falkia_ L.f.
repens L. Herb, membraneous utricle, small seed, damp sites in coastal forest, sporadic in De Vasselot Nature Reserve, scattered, western Cape to Natal.

6993 _Convolvulus_ L.
capensis Burm. f.
var. _bowieanus_ (Rundle) A. Meeuse Vine, capsule, small seed, coastal

scrub forest, sporadic, rare, western to eastern Cape.
farinosus L. Vine, capsule, small seed, montane forest margin, sporadic, rare, western Cape to Transvaal.

BORAGINACEAE
7064 Cynoglossum L.
lanceolatum Forssk. Herb, aggregation of nutlets, dry scrub forest margin, sporadic, scattered, southern Cape to Transvaal.

VERBENACEAE
7191 Clerodendron L.
glabrum E. Mey
667 var. glabrum Subcanopy tree, capsule, small seed, dry coastal dune forest, occasional, scattered, eastern Tsitsikamma (Driefontein) to Natal and Transvaal.

LAMIACEAE
7264 Leonotis R.Br.
leonurus (L.) R.Br. Soft shrub, aggregation of nutlets, forest margin, sporadic, rare, western Cape to Natal and Transvaal.

7281 Stachys L.
aethiopica L. Herb, aggregation of nutlets, dry forest and scrub forest margin and gaps, widespread, scattered, western Cape to Natal and Transvaal.
graciliflora Presl Herb, aggregation of nutlets, moist forest and coastal scrub forest margins, occasional, rare, George to southern Natal.
scabrida Skan Herb, aggregation of nutlets, coastal scrub forest margin, Knysna to southern Natal.
thunbergii Benth. Herb, aggregation of nutlets, moist to dry forest gaps and margin, widespread, scattered groups, western Cape to Knysna.

7350 Plectranthus L'Herit
ciliatus E. Meyer ex Benth. Herb, aggregation of nutlets, forest margins, sporadic, rare, Knysna to southern Natal and eastern Transvaal.
fruticosus L'Herit Soft shrub, aggregation of nutlets, moist forest, sporadic, scattered to common, western Cape to Natal and Transvaal.
laxiflorus Benth. Herb, aggregation of nutlets, forest margin, occasional, rare groups, eastern Tsitsikamma (Rozenhof) to Transvaal.
madagascariensis (Pers.) Benth.
var. madagascariensis Herb, aggregation of nutlets, dry forest, occasional along Keurbooms river, rare groups, Plettenberg Bay to Transvaal.
verticillatus (L.f.) Druce Herb, aggregation of nutlets, moist places in dry scrub forest, sporadic, scattered clumps, Mossel Bay to Natal and Transvaal.

SOLANACEAE
7407 Solanum L.
aculeastrum Dunal Soft shrub, berry, small seed, spiny leaves, forest margin, sporadic, scattered, western Cape to Transvaal.
aculeatissimum Jacq. Herb, berry, small seed, spiny leaves, forest gaps,

sporadic, scattered, southern Cape to Transvaal.
<u>geniculatum</u> E. Mey. Liane, berry, small seed, coastal scrub forest, sporadic, scattered, southern Cape to Transvaal.

669.4 <u>giganteum</u> Jacq. Soft shrub, berry, small seed, spiny stem, moist forest and gaps, sporadic, scattered groups, western Cape to Transvaal.
<u>hermannii</u> Dun. Soft shrub, berry, small seed, spinescent leaves, berry, moist to dry forest and scrub forest gaps, widespread, rare, western Cape to Transvaal.

SCROPHULARIACEAE
7476 <u>Nemesia</u> Vent.
<u>melissifolia</u> Beth. Herb, capsule, small seed, moist forest margin, occasional, rare, Knysna to southern Natal.

7477 <u>Diclis</u> Benth.
<u>reptans</u> Benth. Herb, capsule, small seed, moist forest and scrub forest, sporadic, rare, George to Natal and Transvaal.

7493 <u>Halleria</u> L.
670 <u>lucida</u> L. Subcanopy tree, berry, small seed, wet montane to moist forest, widespread, scattered, western Cape to Natal and Transvaal.

7494 <u>Teedia</u> Rudolphi
<u>lucida</u> Rudolphi Soft shrub, berry, small seed, dry forest margin, sporadic, scattered groups, western Cape to Natal.

7519 <u>Sutera</u> Roth
<u>aethiopica</u> (L.) Kuntze Soft shrub, capsule, small seed, coastal scrub forest margin, widespread, scattered, western Cape to Nature's Valley.
<u>cordata</u> (Thunb.) Kuntze
var. <u>cordata</u> Herb, capsule, small seed, moist sites in dry forest and scrub forest, sporadic, scattered, George to eastern Cape.
sp. cf var. <u>hirsutior</u> Hiern Herb, capsule, small seed, coastal scrub forest, Goukamma Nature Reserve, rare, southern Cape.

7627 <u>Harveya</u> Hook.
<u>capensis</u> Hook. Herb parasitic on roots, white flower, capsule, small seed, wet forest margins, sporadic, scattered, western to eastern Cape.
<u>stenosiphon</u> Hiern Herb parasitic on roots, red flower, capsule, small seed, wet forest margin, sporadic, scattered, Swellendam to Humansdorp.

GESNERIACEAE
7823 <u>Streptocarpus</u> Lindl.
<u>rexii</u> (Hook.) Lindl. Herb, sometimes epiphytic, capsule, small seed, damp microsites in dry scrub forest, sporadic, scattered, George to southern Natal.

ACANTHACEAE
7914 <u>Thunbergia</u> Retz.
<u>dregeana</u> Nees Vine, capsule, small seed, moist to dry forest, sporadic, scattered. Beervlei forest (near George) to Natal coast.

8031 Dicliptera Juss.
zeylanica Nees Herb, capsule, small seed, moist to dry forest, sporadic, scattered groups, Mossel Bay to Transvaal.

8032 Hypoestes Soland. ex R.Br.
aristata R. Br.
var. aristata Herb, capsule, small seed, coastal scrub forest, sporadic, scattered groups, Bredasdorp to Natal and Transvaal.
forskaolei (Vahl) R.Br. Herb, capsule, small seed, moist to dry forest, sporadic, scattered groups, George to Natal and Transvaal.

8049 Siphonoglossa Oerst.
leptantha (Nees) Immelman
subsp. late-ovata (C.B.Cl.) Immelman Herb, capsule, small seed, coastal dry forest and scrub forest, rare, Knysna (Harkerville) to southern Natal.
subsp. leptantha Herb, capsule, small seed, coastal scrub forest, sporadic, scattered groups, George to southern Natal.

8079 Isoglossa Oerst.
ciliata (Nees) Lindau Herb, capsule, small seed, moist to dry forest, sporadic, scattered groups, George to southern Natal.
eckloniana (Nees) Lindau Herb, capsule, small seed, dry forest and scrub forest, sporadic, scattered, Nature's Valley to Natal and Transvaal.
grantii C.B. Cl. Herb, capsule, small seed, dry coastal forests, sporadic, scattered, George to Natal coast.
hypoestiflora Lindau Herb, capsule, small seed, coastal forest, sporadic, rare, Storms river to southern Natal.
prolixa (Nees) Lindau Herb, capsule, small seed, riverine forest, sporadic, rare, from Keurbooms river eastwards.
sylvatica Burchell ex C.B. Clarke Herb, capsule, small seed, forest, southern Cape (Bond and Goldblatt 1984).

8094 Justicia L.
anselliana (Nees) T. Anders. Herb, capsule, small seed, coastal forest and scrub forest, sporadic, rare, from Knysna eastwards.
sp. cf J protracta (Nees) T. Anders. Herb, capsule, small seed, coastal scrub forest, occasional, rare, eastern Tsitsikamma (Witelsbos) to Natal and Transvaal.

RUBIACEAE
8281 Burchellia R.Br.
688 bubalina (L.f.) Sims Subcanopy tree, berry, small seed, moist to dry forest, widespread, scattered, Swellendam to Natal and Transvaal.

8285 Gardenia Ellis
692 thunbergii L.f. Woody shrub, woody berry, small seed, moist forest to coastal scrub forest, occasional, rare, eastern Tsitsikamma (Kromrivier State Forest) to Natal coast.

8285.1 Rothmannia Thunb.
693 capensis Thunb. Subcanopy tree, berry, small seed, moist to dry forest, widespread, scattered to rare, Swellendam to Natal midlands and Transvaal.

695 globosa (Hochst) Keay Subcanopy tree, berry, small seed, moist forest, disjunct small group of trees in Diepwalle forest, Knysna to Natal coast and Transvaal.

8352 Canthium Lam.
705.1 ciliatum (Klotzsch) Kuntze Woody shrub, drupe, small seed, spinescent, dry forest and scrub forest, occasional, rare, Tsitsikamma (Lottering forest) to Natal and Transvaal.
708 inerme (L.f.) Kuntze Subcanopy tree, drupe, large seed, spinescent in juvenile stage, dry forest and scrub forest, widespread, scattered, western Cape to Natal and Transvaal.
710 mundianum Cham. & Schlechtd. Subcanopy tree, drupe, small seed, deciduous, moist to dry forest and scrub forest, widespread, scattered, often groups, western Cape to Natal midlands and Transvaal.
708.1 pauciflorum (Klotzsch) Kuntze Subcanopy tree, drupe, small seed, spinescent in juvenile stage, rare, single records from George (Witfontein) and Knysna, eastwards to Natal and Transvaal.
707 spinosum (Klotzsch) Kuntze Subcanopy tree, drupe, small seed, spinescent, dry forest, occasional, scattered, eastern Tsitsikamma (farm Rozenhof) to Natal coast.

8352.3 Psydrax Gaertn.
obovata (Eckl. & Zeyh.)Bridson
711 subsp. obovata Canopy tree, drupe, small seed, moist to dry forest, widespread, scattered, Swellendam to Natal and Transvaal.

8399 Psychotria L.
723 capensis (Eckl.) Vatke Woody shrub, berry, small seed, confined to a small area of Lily Vlei Nature Reserve, locally common, Knysna to Natal and Transvaal.

8435 Galopina Thunb.
circaeoides Thunb. Herb, mericarp, small seed, moist to dry forest, widespread, scattered to common, Swellendam to Natal and Transvaal.

8489 Rubia L.
petiolaris DC. Herb, mericarp, small seed, coastal dune forest, occasional, scattered, Swellendam (De Hoop) to Transvaal.

CUCURBITACEAE
8564 Zehneria Endl.
scabra (L.f.) Sond.
subsp. scabra Vine, unisexual, berry, small seed, tuberous rootstock, moist to dry forest and scrub forest, widespread, scattered to rare, western Cape to Transvaal.

8568 Kedrostis Medik.
foetidissima (Jacq.) Cogn.
subsp. obtusiloba (Sond.) A. Meeuse Vine, dioecious, berry, small seed, tuberous rootstock, dry forest margin and coastal scrub forest, sporadic, scattered, Nature's Valley to Natal coast.
nana (Lam.) Cogn.

var. nana Vine, dioecious, berry, small seed, tuberous rootstock, coastal forest to scrub forest, widespread, scattered, western Cape to southern Natal.

8610 Lagenaria Ser.
sphaerica (Sond.) Naud. Vine, dioecious, berry, small seed, coastal dune forest near Knysna, scattered, southern Cape to southern Natal.

LOBELIACEAE
8681 Cyphia Berg.
digitata (Thunb.) Willd. Vine, capsule, small seed, tuberous rootstock, dry forest margin, sporadic, rare, western Cape to Sedgefield.
heterophylla Presl Vine, capsule, small seed, tuberous rootstock, dry scrub forest gap, above Wilderness, scattered, southern Cape.

8694 Lobelia L.
anceps L.f. Herb, capsule, small seed, moist forest gaps and roadside, sporadic, scattered clumps, western to eastern Cape.
coronopifolia L. Herb, capsule, small seed, dry scrub forest margin, fynbos component, sporadic, rare, western Cape to Natal.
cuneifolia Link & Otto Herb, capsule, small seed, moist forest to dry scrub forest in damp sites, sporadic, scattered clumps, southern Cape.
neglecta Roem. & Schult. Herb, capsule, small seed, forest margin, fynbos component, widespread, scattered, southern to eastern Cape.
patula L.f.
var. patula Herb, capsule, small seed, moist to dry forest, sporadic, scattered, George to southern Natal.
pubescens Ait. Herb, capsule, small seed, forest margin, fynbos component, sporadic, scattered, western to southern Cape.

ASTERACEAE
8751 Vernonia Schreb.
anisochaetoides Sond. Liane, composite fruit with pappus, dry forest and scrub forest including margin, sporadic, scattered, Nature's Valley to Natal coast.
mespilifolia Less. Liane, composite fruit with pappus, dry forest and scrub forest including margin, widespread, scattered, George to Transvaal.

8818 Mikania Willd.
natalensis DC. Liane, composite fruit with pappus, dry scrub forest, sporadic, rare, Knysna to Natal and Transvaal.

8919 Felicia Cass.
aculeata Grau Herb, head with pappus, forest gaps and margin, sporadic, scattered, western to southern Cape.
westae (Fourc.) Grau Herb, head with pappus, moist forest margin, sporadic, scattered, southern Cape.

8936 Brachylaena R.Br.
726 glabra (L.f.) Druce Canopy tree, dioecious, composite fruit with pappus, moist forest, sporadic from Lottering forest eastwards, scattered, disjunct between Hermanus, southern Cape and southern Natal.

729 neriifolia (L.) R.Br. Woody shrub, dioecious, composite fruit with pappus, along streams through forest, common, western Cape to Humansdorp (Loerie forest).

8937 Tarchonanthus L.
733 camphoratus L. Canopy tree, dioecious, composite fruit with woolly seed, dry forest and scrub forest, widespread, scattered, Cape Peninsula to Natal and Transvaal.

9006 Helichrysum Mill.
cymosum (L.) D. Don
subsp. cymosum Herb, composite fruit with pappus, forest margin, widespread, scattered, western Cape to Natal coast and Transvaal.
petiolare Hilliard & Burtt Herb, composite fruit with pappus, moist to dry forest gaps and margin, widespread, scattered clumps, southern to eastern Cape.

9098 Osmitopsis Cass.
osmitoides (Less.) Bremer Soft shrub, composite fruit with pappus, wet sites in forest margin, widespread, scattered clumps, Caledon to southern Cape.

9357 Hippia L.
frutescens L. Herb, head with pappus, forest gaps and margin, widespread, scattered clumps, western to southern Cape.

9365 Peyrousea DC.
umbellata (L.f.) Fourc. Herb, composite fruit with pappus, forest margin, fynbos component, sporadic, scattered clumps, Riviersonderend to southern Cape.

9406 Cineraria L.
lobata L'Herit. Vine, composite fruit with pappus, scrub forest margin, Herolds Bay, rare, southern Cape to southern Natal.

9411 Senecio L.
amabilis DC. Herb, head with pappus, forest margin, sporadic, scattered, western to southern Cape.
angulatus L.f. Vine, head with pappus, dry forest and coastal scrub forest margin, widespread, scattered, southern and eastern Cape.
crenatus Thunb. Herb, head with pappus, moist to dry forest margin, sporadic, rare, Swellendam to eastern Cape.
deltoideus Less. Vine, head with pappus, forest gaps and margin, widespread, scattered, Swellendam (De Hoop) to Natal and Transvaal.
ilicifolius L. Herb, head with pappus, forest margin, sporadic, scattered, Riversdal to eastern Cape.
mikanioides Otto ex Harv. Vine, head with pappus, coastal forest, widespread, scattered, Swellendam to Natal and Transvaal.
quinquelobus (Thunb.) DC. Vine, head with pappus, moist forest to dry scrub forest, widespread, scattered, Swellendam to Transvaal.

9417 Euryops Cass.
virgineus (L.f.) DC. Soft shrub, head with pappus, forest margin, fynbos component, widespread, scattered, western to eastern Cape.
9427.2 Chrysanthemoides Tourn. ex Medik.
736.1 monilifera (L.) T. Norl. Soft shrub, composite fruit with pappus and berries, forest gaps and margin, widespread, scattered to common, western Cape to Transvaal.

9528 Gerbera L.
cordata (Thunb.) Less. Herb, head with pappus, medium-moist to dry forest, widespread, scattered to common, southern to eastern Cape.

Chapter 4

RICHNESS, COMPOSITION AND RELATIONSHIPS OF THE FLORAS OF SELECTED FORESTS IN SOUTHERN AFRICA

CONTENTS

ABSTRACT

Species lists of 14 widely separated forests representing particular geographic regions in southern Africa were used to study the size and composition of the individual floras, the similarities between them, and possible determinants of the observed patterns. The forests contain 1438 species which belong to 155 families and 661 genera. The growth form spectra show specific patterns amongst the individual forests such as an abundance of ferns in the montane forests, and of woody plants and vines in the coastal forests. The richness of a forest flora therefore increase with increasing altitudinal range. Linear species-area relationships are significant for both woody and herbaceous species, but explain respectively only 30% and 38% of the variation in the size of the floras. In a multiple regression model the number of dispersal corridors, the proximity to other forests and mean altitude explained 81% of the variation in number of woody plants. The number of landscape types and the number of dispersal corridors explained 75% of the variation in number of herbaceous plants. Several other factors contribute to the disproportionately large floras of relatively small forests such as the Umtamvuna, Sabie and Richards Bay forests. Analysis of unique and shared taxa indicated a high proportion of unique taxa (30% woody and 42% herbaceous species). The shared taxa show definite trends of the southward attenuation of species and the presence of the Afromontane and Indian Ocean Coastal Regions. In conclusion it is suggested that the southern Cape forests have been isolated from forests along the escarpment and mountains to the east since at least the Pliocene due to the Sundays river valley which stretch from th coast to the escarpment in the arid interior.

INTRODUCTION

Many forest species have a wide distribution in southern Africa (Palgrave 1972; Von Breitenbach 1986) and characterize two main floristic regions (White 1978, 1983; Moll and White 1978). Forests of the Afromontane Region occur along the Drakensberg escarpment, the Natal and eastern Cape midlands and the southern and southwestern Cape mountains and coastal plateaux. Tongaland-Pondoland forests of the Indian Ocean Coastal Region occur along the coastal dunes and lowlands. The distribution of many other species overlap the two regions. Transitional forests in the drier lowlands and river valleys between the two regions such as Kaffrarian Subtropical Transitional Thicket in the eastern Cape (Cowling 1984; Everard 1987) and similar types in Natal (Edwards 1967) contain species of either regions. The strong southern attenuation of species have been attributed to the sub-tropical - temperate transition (Scheepers 1978; Tinley 1985; Cawe 1986) and the increasing fragmentation of forests due to climatic deterioration (Chapter 6). The few widely separated, large forests are interspersed with many smaller forests (Anonymous 1987).

The aims of this study were to determine

* the floristic richness of widely separated, well-studied forests which represent the different geographic regions in southern Africa, and the floristic relationships between them. There is a need for this because recent studies of the southern African flora have excluded the forest flora because of the small size of the forest biome and the difficulties posed by the techniques used to study the floras (Gibbs Russell 1985, 1987). Furthermore, the studies of White (1978, 1983) and Moll and White (1978) focused on trees only.

* the most likely of several possible sources for the variation in the size, composition and interrelationships of the floras. According to biogeographic principles, the following factors are considered (Brown and Gibson 1983):
    + The size and spatial separation of the individual forests.
    + The role of dispersal corridors and barriers.

+ The climatic gradient from tropical northeast to temperate southwest and from the mountains to the coast.

+ Habitat diversity within a forest, including climatic and edaphic gradients and disturbance regimes.

+ Speciation centres, the development of wider tolerance ranges through different ecotypes of a species, and the increase in smaller and more herbaceous growth forms with a more confined distribution due to increased stress.

STUDY AREA AND METHODS

Fourteen forests or forest complexes (several smaller forests in close proximity) were selected because relatively detailed floristic information was available for them and because they represented different geographic areas of the forest biome in southern Africa (Figure 1). The forests varied greatly in total area, altitudinal range, geographic location and isolation, geology, landscape types, surrounding vegetation types, total annual rainfall and mean annual maximum and minimum temperature (Table 1 and 2). Values for area of the Transvaal and Natal forests were obtained from Cooper (1985), and for the forests in Transkei, Ciskei and the Cape Province from the relevant floristic sources.

Various published and unpublished species lists (Taylor 1955; Killick 1963; Moll 1969, 1978, 1980; Van der Schijff and Schoonraad 1971; Venter 1972; Campbell and Moll 1977; McKenzie et al. 1977; McKenzie 1978; Scheepers 1978; Weisser 1980; Weisser and Drews 1980; Nicholson 1982; Abbott 1985; Deall 1985; Burns 1986; Cawe 1986; Philipson 1987; Lubke and Strong 1988; Geldenhuys unpublished data; Chapter 3) were used to compile a list of species for each forest (Appendix). Each species was classified as canopy tree, subcanopy tree, woody shrub, soft shrub, liane (woody climber), vine (herbaceous climber), fern (terrestrial) with erect or creeping rhizome, epiphyte, geophyte, graminoid or forb using the system of Geldenhuys et al. (1988). Only presence or absence of a species was indicated for each forest.

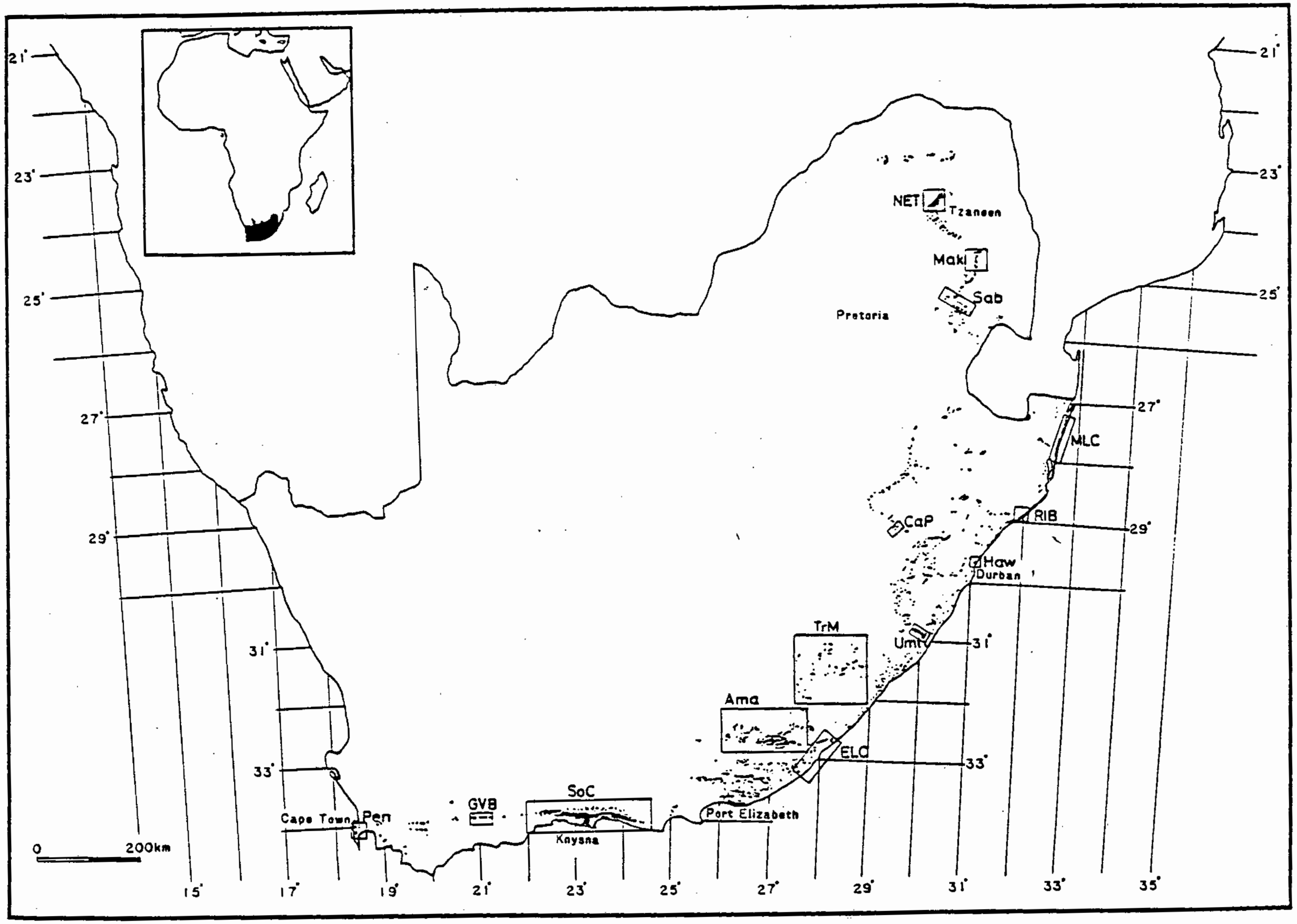


Figure 1 Distribution of the forests in southern Africa (adapted from Anonymous 1987). International political boundaries are not indicated in order not to clutter the forest pattern. The location of the study areas is indicated.

TABLE 1 Environmental data for forests included in this study. The abbreviations for the forest names are used in the figures and other tables

Forest Size ha		Grid reference Altitude m (mean)	Geology	Landscape types	Other vegetation
Cape Peninsula	Pen	34,0°S 18,5°E	Quartzite	Mountain slope	Fynbos
150		150 - 730 (260)	Granite	Valley	
Grootvadersbosch	GVB	34,0°S 20,8°E	Quartzite	Mountain slope	Fynbos
250		200 - 1100 (300)	Shale	Valley	Renosterveld
				Gorge	Thicket
Southern Cape	SoC	34,0°S 24,5°E	Quartzite	Mountain slope	Fynbos
60500		34,0°S 22,0°E	Shale	Coastal platform	Thicket
		5 - 1220 (240)	Schist	Coast scarp	
			Conglomerate	Gorge and valley	
			Dune sand	Dune	
Amatole	Ama	32,7°S 27,2°E	Shale	Mountain slope	Alpine
mountains		700 - 1250 (1000)	Sandstone	Mountain plateau	Grassland
8000			Mudstone	Escarpment	Thornveld
			Dolerite	Valley	Thicket
East London	ELC	32,6°S 28,4°E	Dune sand	Dune	Thicket
coast		33,6°S 27,0°E	Shale	Valley	Thornveld
1000		5 - 180 (50)	Mudstone	Estuary	Grassland
			Dolerite		Marshes
Transkei	TrM	31,5°S 28,5°E	Shale	Mountain slope	Alpine
mountains		600 - 1400 (1000)	Mudstone	Mountain plateau	Grassland
15000			Sandstone	Escarpment	Thornveld
			Dolerite	Valley	Thicket
Umtamvuna gorge	Umt	31,0°S 30,2°E	Quartzite	Gorge	Grassland
1100		50 - 500 (200)	Shale	Coastal platform	Thornveld
Hawaan	Haw	29,7°S 31,1°E	Dune sand	Dune	Grassland
100		15 - 60 (30)			Woodland
Richards Bay	RiB	28,8°S 32,0°E	Dune sand	Dune	Grassland
540		10 - 70 (30)	Alluvium (mud)	Estuary	Marshes
				River	Woodland
Maputaland	MLC	28,4°S 32,4°E	Dune sand	Dune	Marshes
coast		26,8°S, 32,8°E	Limestone	Estuary	Grassland
11400		10 - 100 (30)		River valley	Woodland
Cathedral Peak	CaP	29,0°S 29,3°E	Sandstone	Mountain slope	Grassland
350		1280 - 1830 (1500)	Shale	Gorge	Alpine
			Dolerite	Escarpment	Woodland
Sabie transect	Sab	25,2°S 30,6°E	Quartzite	Mountain slope	Woodland
1100		500 - 1600 (1200)	Granite	Mountain plateau	Grassland
			Shale	Valley	Thicket
			Dolomite	Escarpment	
Mariepskop	MaK	24,5°S 30,9°E	Quartzite	Mountain slope	Woodland
2950		760 - 1900 (1200)	Shale	Mountain plateau	Grassland
			Granite	Valley	Thicket
			Conglomerate	Escarpment	
Northeastern	NET	23,7°S 30,0°E	Granite	Mountain slope	Woodland
Transvaal		750 - 1400 (1200)	Xenolith	Mountain plateau	Grassland
escarpment				Escarpment	Thicket
6600				Valley	

The woody and herbaceous plants were separated for the different analyses because the two categories show contrasting patterns along the climatic gradients from mountain to coast (Geldenhuys and MacDevette 1989).

TABLE 2 Rainfall and temperature data for forests included in this study. Data were obtained from the respective study reports or from published and unpublished sources for nearby stations

Forest	Total Annual Rainfall mm	Percentage summer rain (October to March)	Mean Daily Temperature °C	
			Maximum - warmest month	Minimum - coldest month
Pen	1000-1400	22,5	25 - January	9 - July
GVB	1070	56,8	29 - January	4 - July
SoC	500-1200	54,9	26 - January	5 - July
Ama	750-1500	70,5	23 - January	6 - June
ELC	745-1025	63,8	26 - February	6 - July
TrM	800-1340	78,6	25 - January	6 - June
Umt	1220	71,4	26 - January	12 - July
Haw	1000	66,2	28 - February	10 - June
RiB	1110	62,4	28 - January	14 - June
MLC	1000	73,2	28 - January	14 - June
CaP	1230-1580	83,4	23 - December	5 - June
Sab	1000-1850	83,1	25 - December	3 - July
MaK	1360	83,7	23 - January	4 - July
NET	1000-2090	84,8	24 - December	4 - June

The effect of forest area on species richness was investigated by means of the species-area relationship $S = cA^z$,

where S is the number of species,

A is area and

c and z are constants.

These were fitted by means of a linear log.log regression. The relationship between the logarithm of the number of woody or herbaceous plants in a forest and several environmental variables was determined by means of the stepwise forward selection procedure of multiple regression analysis (STSC 1986; Kleinbaum and Kupper 1978). The following independent variables were included:

* log forest area (ha)
* log mean altitude (m)
* log altitudinal range (m)
* distance from the tropical source as measured along the forest zone from arbitrary points, i.e. the Zimbabwe border for the mountain forests, and the Mozambique border for coastal forests

* the proximity to other large forests (1 for close to several large forests; 2 for close to several small forests but distant from large forests; 3 for very isolated from most forests),
* the number of geological types (quartzite, sandstone, mudstone, limestone, dolerite, dolemite, shale, schist, conglomerate, granite and dune sand)
* the number of landscape types (mountain slope, mountain plateau, escarpment, valley, gorge, estuary and dune)
* the number of plant dispersal corridors present (mountain range, escarpment, river, and coastal dune system)
* the number of different structural vegetation types surrounding the forest (fynbos, renosterveld, grassland, thornveld, woodland and thicket).

Information for the last four variables were obtained from descriptions of the study areas of the relevant floristic sources.

The index of similarity of Czekanowski (as used by Rogers and Moll 1975), expressed as percentage, was used to compare the similarity of each of the forests with each other forest. The formula used is 200w/(a+b) where a and b are the numbers of species present in each forest, and w is the number of species common to both forests.

RESULTS

SIZE AND COMPOSITION OF THE FOREST FLORA

Number of taxa

Table 3 lists the number of families, genera and species, as well as the species-family and species-genus ratios for the vascular plants in each forest and for the total forest flora. The list (Appendix) represents the bulk of the species occurring in the southern African forests.

Twenty-six families each contain 1% (14) or more of the taxa of the total forest flora. The families, with number of species between brackets, are: Acanthaceae (45), Adiantaceae (21), Anacardiaceae (29), Apocynaceae (19), Asclepiadaceae

TABLE 3 Number of families, genera and species, and species/family and species/genus ratios for the different forests and the total forest flora

Forest*	Number of			Ratio	
	Families	Genera	Species	Species/family	Species/genus
Pen	52	79	103	2,0	1,3
GVB	68	119	151	2,2	1,3
SoC	108	284	465	4,3	1,6
Ama	104	257	390	3,8	1,5
ELC	72	170	242	3,4	1,4
TrM	78	160	255	3,3	1,6
Umt	117	316	501	4,3	1,6
Haw	56	119	151	2,7	1,3
RiB	104	324	449	4,3	1,4
MLC	79	213	338	4,3	1,6
CaP	76	140	176	2,3	1,3
Sab	102	254	366	3,6	1,4
MaK	101	254	373	3,7	1,5
NET	97	244	324	3,3	1,3
TOTAL	155	661	1438	9,3	2,2

* See Table 1 for forest names

(31), Aspleniaceae (24), Asteraceae (81), Capparaceae (14), Celastraceae (40), Convolvulaceae (15), Crassulaceae (20), Cyperaceae (35), Ebenaceae (19), Euphorbiaceae (67), Fabaceae (79), Flacourtiaceae (21), Lamiaceae (33), Liliaceae (42), Malvaceae (15), Moraceae (14), Oleaceae (17), Orchidaceae (53), Poaceae (57), Rubiaceae (66), Scrophulariaceae (19) and Vitaceae (14). These families account for 17% of the families, 55% of the genera and 62% of all forest species. Fifty-four percent of the families have four or fewer species. Sixty-five families are represented by a single genus and 37 by a single species.

Only 15 genera contain 10 or more species. Of these, only *Streptocarpus* (12) (Gesneriaceae) does not belong to one of the largest families. The other genera are *Asplenium* (23), *Crassula* (18), *Cyperus* (11), *Diospyros* (12), *Ficus* (12), *Helichrysum* (10), *Isoglossa* (10), *Maytenus* (14), *Pavetta* (13), *Plectranthus* (18), *Protasparagus* (10), *Rhus* (21), *Senecio* (19) and *Vernonia* (10). Sixty-one percent of the genera are represented by a single species.

Growth forms

The growth form spectra varied significantly between the different forests (Table 4; Chi-square value = 593,7, df = 143, P<0,001). Values with a particularly high Chi-square value for the particular cell are indicated in the table. None of the forests contain canopy trees, soft shrubs or geophytes in disproportionate numbers. The forests which contain species of a particular growth form in excess of the expected number are Maputaland (subcanopy trees and graminoids), Umtamvuna (woody shrubs), Hawaan (lianes), Transkei mountains and Cape Peninsula (erect ferns), Mariepskop (epiphytes) and the southern Cape (forbs). Growth forms in numbers less than the expected number occur in the southern Cape (subcanopy trees and lianes), Transkei mountains (vines, graminoids and forbs), Umtamvuna (graminoids), Richards Bay (erect ferns), Maputaland (all ferns and forbs) and northeastern Transvaal (woody shrubs).

TABLE 4 Number of species by growth forms for the different forests. The signs following some numbers indicate that the number is much higher (+) or lower (-) than the expected number under assumption of independence

Growth form	Forest*														
	Pen	GVB	SoC	Ama	ELC	TrM	Umt	Haw	RiB	MLC	CaP	Sab	Mar	NET	Total
Canopy trees	17	26	46	41	35	46	58	18	56	48	20	38	42	40	109
Subcanopy trees	15	20	40-	48	52	58	97	36	67	77+	17	59	60	41	191
Woody shrubs	9	18	58	63	48	56	135+	34	78	79	26	59	55	33-	276
Soft shrubs	4	7	27	20	9	1	13	3	12	4	8	13	16	14	58
Lianes	3	7	12-	16	12	13	35	22+	41	27	5	25	23	27	77
Vines	6	12	45	29	26	6-	28	10	46	32	15	28	32	40	122
Erect ferns	18+	11	35	23	6	29+	15	0	3-	1-	14	25	25	25	58
Creeping ferns	8	10	17	22	2	15	7	0	6	1-	12	15	21	15	38
Epiphytes	6	9	26	17	4	9	17	3	10	4	9	13	28+	24	58
Geophytes	3	5	28	21	4	11	18	2	21	6	9	10	11	11	75
Graminoids	6	9	33	23	13	3-	9-	9	38	34+	14	25	16	12	93
Forbs	8	17	98+	67	31	8-	69	14	70	25-	27	56	44	42	283
Total															
Woody+	48	78	183	188	156	174	338	113	254	235	76	194	196	155	711
Herbaceous	55	73	282	202	86	81	163	38	194	103	100	172	177	169	727
All plants	103	151	465	390	242	255	501	151	448	338	176	366	373	324	1438
Percentage woody	47	52	39	48	64	68	67	75	57	70	43	53	53	48	49

* See Table 1 for meaning of abbreviations
+ Woody species include trees, shrubs and lianes

Woody plants form approximately 50% of the total flora over all forests but this percentage varies greatly between the individual forests (Table 4). In general, the coastal forests have a woody ratio in excess of 60%, whereas the montane forests have ratios which vary between 39% and 53%. However, the Transkei mountain forests have a ratio of 68% and the Richards Bay coastal forests a ratio of 57%.

The geographical range of a species is significantly related to its growth form (Chi-square value based on absolute frequencies = 246,7, df = 99, P<0,001). Cell values which have made a large contribution to the significant Chi-square value are indicated in Table 5. Trees, lianes and ferns occur relatively widely: 37% of canopy trees, 26% of subcanopy trees, 27% of lianes, 31% of erect ferns and 24% of creeping ferns occur in more than five of the forests. Fifteen per cent

TABLE 5 The frequency of occurrence of species of different growth forms in 14 widely separated forests of southern Africa

Number of forests	Growth form* 1	2	3	4	5	6	7	8	9	10	11	12	All growth forms	
	Frequency for species:						Relative							Absolute
1	14-	30	43	40	31	39	21	16	26	48	39	54+	38	542
2	18	18	19	24	17	21	16	11	24	24	26	23	20	294
3	15	15	13	14	16	10	14	24	26	17	13	9	14	195
4	9	8	6	9	8	8	10	21+	3	5	6	5	7	103
5	6	5	7	3	3	8	7	5	5	1	5	4	5	75
6	8	7	4	3	14+	4	17+	11	3	0	5	2	5	78
7	6	6	3	2	3	4	7	5	5	1	1	1	3	50
8	5	6+	2	2	3	2	3	0	3	0	1	1	2	34
9	4	2	1	2	3	2	3	0	2	0	1	0	1	20
10	5	2	0	2	1	2	2	8	2	1	1	1	2	22
11	5 +	1	0	0	0	1	0	0	0	1	1	0	1	13
12	2	1	0	0	3	0	0	0	0	0	0	0	0	6
13	2	1	1	0	0	0	0	0	0	0	0	0	0	6
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total species	109	191	276	58	77	122	58	38	58	75	93	283	1438	

* 1: canopy trees; 2: subcanopy trees; 3: woody shrubs; 4: soft shrubs; 5: lianes; 6: vines; 7: erect ferns; 8: creeping ferns; 9: epiphytes; 10: geophytes; 11: graminoids; 12: forbs

or less of the other growth forms occur in more than five forests. No species occur in all the forests but the species which occur in more than 10 forests (75%) are Apodytes dimidiata, Calodendrum capense, Canthium inerme, Celtis africana, Clausena anisata, Cussonia spicata, Dietes iridioides, Ekebergia capensis, Galopina circaeoides, Grewia occidentalis, Halleria lucida, Ilex mitis, Maytenus heterophylla, Maytenus undata, Olea capensis subsp. macrocarpa, Oplismenus hirtellus, Pittosporum viridiflorum, Protasparagus setaceus, Psychotria capensis, Psydrax obovata, Rapanea melanophloeos, Rhoicissus tridentata, Scutia myrtina, Secamone alpinii and Zanthoxylum capense.

REGRESSION ANALYSES

The area and species richness of the different forests vary greatly (Table 1 and 3). The number of species of both woody and herbaceous plants show a significant log species - log area relationship (Table 6). However, this relationship explains only 30% and 38% respectively of the variation in the size of the floras. In both models a number of forests lie outside the 95% confidence intervals. The Umtamvuna, Richards Bay and Sabie forests have many more plants of both categories, the Peninsula, Grootvadersbosch and Cathedral Peak forests have much fewer woody species, and the Transkei mountain, East London coast, Hawaan and Maputaland coast forests have much fewer herbaceous species than the number predicted by the model.

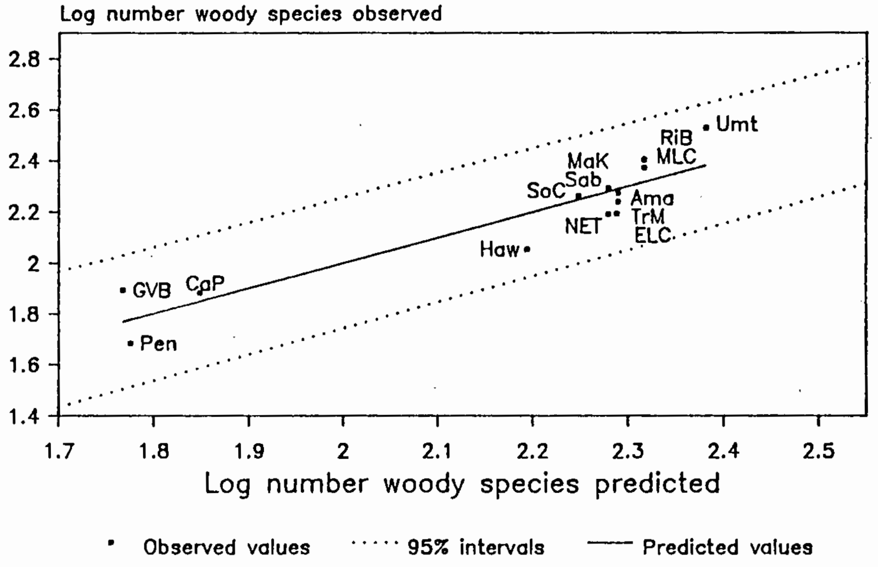
TABLE 6 Constants and significance of the linear log-log models of the species-area relationships for the forests

Plant group	Woody	Herbaceous
Intercept	1,71514	1,47996
Slope	0,14573	0,18278
Error MS	0,03702	0,04084
F-ratio (12 df)	5,24493	7,47886
Probability level	0,04092	0,01811
Correlation coefficient	0,55149	0,61964

In the multiple regression analysis for woody plants, proximity to other forests, the number of dispersal corridors and mean altitude explained 81,6% of the variation in the observed values (Table 7). The use of fewer or more variables in the model caused a reduction in the coefficient of determination (R^2). The number of landscape types and dispersal corridors explained 75,1% of the observed variation in the number of herbaceous plants (Table 7). Data for the Transkei mountain forests were excluded from this analysis because Cawe (1986) undersampled herbaceous plants other than ferns. All the observed values, except the herbaceous plants for the Transkei mountain forests, fall within the 95% confidence intervals around the values predicted by the regression models (Figure 2).

TABLE 7 Analysis of variance for the significant regression variables in the order in which they were fitted, and estimates of the regression coefficients

Source	df	Mean square	P-value	Coefficient	SE	P-value
i Woody plants						
Constant				2,289104	0,1862	0,0000
Mean altitude	1	0,0185411	0,1979	-0,131281	0,0575	0,0456
Corridors	1	0,5281966	0,0000	0,172275	0,0728	0,0394
Proximity	1	0,0450090	0,0572	-0,123031	0,0573	0,0572
Error	10	0,0097458				
Model	3	0,1972489	0,0001			
R^2 (adjusted for df) = 0,81617			SE of estimate = 0,0987209			
ii Herbaceous plants (excluding data for Transkei mountains)						
Constant				1,361557	0,1242	0,0000
Landscapes	1	0,4923280	0,0002	0,112245	0,0352	0,0097
Corridors	1	0,1154728	0,0226	0,155882	0,0579	0,0226
Error	10	0,0159350				
Model	2	0,3039004	0.0004			
R^2 (adjusted for df) = 0,75074			SE of estimate = 0,126234			



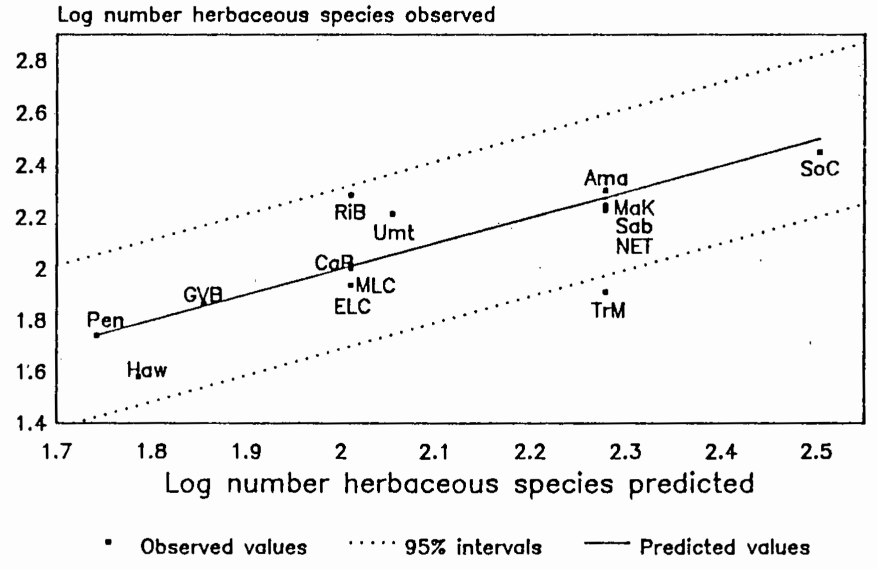


Figure 2 Observed and predicted values, and 95% confidence intervals in relation to predicted values for the number of woody and harbaceous plants in a forest. The coefficients for the multiple regression equations are presented in Table 7.

SHARED AND UNIQUE TAXA AND PERCENTAGE SIMILARITY

Shared taxa

The shared taxa show at least three distinct patterns (Table 8). Firstly, forests share many more of their species with forests to their north and east

TABLE 8 The percentage shared taxa for the 14 forests. The upper triangle gives the values for the woody plants and the lower triangle the values for the herbaceous plants. In each cell of two values in the triangles, the upper value indicates the percentage of the species of the forest of that row which is shared with the forest of that column. The bottom value of the cell shows the reverse relationship

Forest

Percentage of species shared between forests

Woody species (upper triangle); Herbaceous species (lower triangle)

	Pen	GVB	SoC	Ama	ELC	TrM	Umt	Haw	RiB	MLC	CaP	Sab	MaK	NET
Pen		75	85	69	31	56	54	15	27	33	46	38	52	38
		46	22	18	10	16	8	6	5	9	29	9	13	12
GVB	45		95	74	46	67	62	15	35	37	44	38	54	46
	60		40	31	23	30	14	11	11	12	45	15	21	23
SoC	17	24		63	45	49	56	15	33	29	26	32	43	37
	87	92		61	53	51	30	25	24	23	63	30	40	43
Ama	15	26	67		46	63	65	18	41	35	31	39	48	43
	56	73	48		56	68	36	30	30	28	78	38	46	52
ELC	19	28	58	59		49	66	30	51	54	14	25	35	28
	29	33	18	25		44	30	42	30	36	29	20	28	28
TrM	20	25	53	64	25		71	24	47	40	30	43	48	45
	29	27	15	26	23		37	37	32	30	68	39	43	50
Umt	8	13	43	39	17	15		22	42	34	12	30	36	29
	24	30	25	32	31	31		65	56	49	55	53	61	64
Haw	0	3	18	29	24	8	26		78	72	7	28	28	23
	0	1	2	5	10	4	6		35	34	11	16	16	17
RiB	3	8	25	26	15	7	25	12		56	10	33	33	29
	11	22	17	25	35	16	29	61		60	34	44	43	47
MPC	4	6	19	20	15	2	17	17	75		10	26	26	22
	7	8	7	10	17	2	10	47	40		30	31	32	33
CaP	13	30	47	58	17	36	27	0	26	9		54	59	51
	24	41	17	29	20	44	17	0	13	9		21	23	25
Sab	8	15	34	38	13	23	26	5	29	14	24		58	49
	25	36	21	32	26	49	27	21	26	23	42		57	62
MaK	16	24	50	49	16	21	30	5	24	12	27	42		60
	51	58	32	43	34	47	33	21	22	20	47	43		76
NET	10	20	47	50	16	22	29	5	26	9	29	43	58	
	31	45	28	42	31	47	30	21	23	16	49	42	55	

Herbaceous species

than what they share with forests to their south and west. This indicate an erosion of species from the two tropical source areas, i.e. the Transvaal and Maputaland forests, to the southwestern Cape forests. Secondly, forests share many more species with their nearest neighbours than with forests further away. Note that the forests to the south share more species with the Mariepskop forest than with either the Sabie or the northeastern Transvaal forests. Thirdly, the Afromontane forests, i.e. including forests from the southern to western Cape, share relatively fewer species with the forests of the coastal areas. The Umtamvuna and Transkei mountain forests, however, share relatively many species with both the coastal and montane areas.

Unique taxa

A large proportion of the species are unique to individual forests: 33% of the woody and 42% of the herbaceous species (Table 9). Canopy trees and ferns have the lowest proportions of unique species, whereas these proportions are $\geq$40% for the shrubs, geophytes and forbs (Table 5). Umtamvuna (20%), southern Cape (16%), Richards Bay (13%), Maputaland Coast (13%) and the Sabie transect (12%) together contributed 74% of the unique species, and were the most important contributors to the unique species of each growth form. The Mariepskop and northeastern Transvaal escarpment forests contain relatively many unique soft shrubs and epiphytes.

Percentage similarity

The mean percentage similarity between any two forests is 34,4% for woody plants and 23,7% for herbaceous plants (Table 10). The individual forests differ widely in the number of forests and the particular forests with which they share a similarity higher than the mean for the particular plant group.

TABLE 9 The number of unique species over growth forms, and the unique species as a percentage of all plants, for each forest

Forest	Growth form*												% of flora	
	1	2	3	4	5	6	7/8	9	10	11	12	Total	Woody	Herbs
Pen	-	3	2	-	-	-	1	-	1	1	1	9	10	7
GVB	-	-	-	-	-	-	-	-	-	-	4	4	-	5
SoC	2	2	11	5	-	8	2	4	10	10	35	89	11	24
Ama	-	-	2	-	1	-	1	1	2	1	1	9	2	3
ELC	-	2	3	2	-	4	-	-	-	2	10	23	4	19
TrM	-	2	2	-	-	-	1	-	-	-	1	6	2	4
Umt	-	19	43	2	4	3	3	2	6	-	25	107	21	24
Haw	1	1	-	-	1	1	-	-	-	1	6	11	3	21
RiB	6	4	8	2	8	10	3	-	7	2	19	69	11	21
MLC	5	11	27	-	4	4	1	-	3	8	6	69	20	21
CaP	-	-	1	2	-	-	1	-	2	2	9	17	4	14
Sab	1	8	11	3	4	7	4	1	1	7	21	68	17	29
MaK	-	6	5	4	1	4	1	3	3	-	10	37	8	12
NET	-	-	3	3	1	6	-	4	1	1	5	24	5	10
Total	15	58	118	23	24	47	18	15	36	35	153	542	33	42

* 1: canopy trees; 2: subcanopy trees; 3: woody shrubs; 4: soft shrubs; 5: lianes; 6: vines; 7: erect ferns; 8: creeping ferns; 9: epiphytes; 10: geophytes; 11: graminoids; 12: forbs

TABLE 10 Percentage Czekanowski similarity of the woody and herbaceous components of the floras of the 14 forests. The upper triangle gives the values for the woody plants (trees, shrubs and lianes) and the lower triangle the values for the herbaceous plants

	Forest													
	Pen	GVB	SoC	Ama	ELC	TrM	Umt	Haw	RiB	MLC	CaP	Sab	MaK	NET
Pen	-	57	35	28	15	24	13	9	9	11	35	15	20	18
GVB	52	-	57	44	31	41	23	13	16	19	44	22	31	31
SoC	28	38	-	62	48	50	39	19	28	25	37	31	41	40
Ama	24	39	56	-	51	65	46	23	35	31	45	38	47	47
ELC	23	30	27	35	-	47	42	35	39	43	19	22	31	28
TrM	24	26	24	37	24	-	48	29	38	34	42	41	45	47
Umt	12	19	31	35	22	20	-	33	48	40	20	38	45	40
Haw	0	2	4	9	15	5	10	-	48	47	8	21	21	19
RiB	5	12	20	26	21	9	27	20	-	58	16	38	38	36
MLC	5	7	10	14	16	2	13	26	52	-	15	28	29	26
CaP	17	35	25	38	18	40	21	0	18	9	-	30	33	34
Sab	12	21	26	35	17	32	26	8	27	17	31	-	57	55
MaK	24	34	39	46	22	29	31	7	23	15	34	42	-	67
NET	15	27	35	45	21	30	30	8	24	12	36	42	57	-

DISCUSSION

Before the results are discussed, it is necessary to note that some components of the flora, in particular some herbaceous growth forms, may have been undersampled. This is understandable in studies of forests because most focus is on the trees and conspicuous components of the understorey. Firstly, this is shown in the Transkei mountain forest data where Cawe (1986) was concerned with the timber resource potential but also sampled the conspicuous fern understorey as a possible indicator of site productivity. This undersampling of herbaceous species in Transkei was considered in the regression analyses for herbaceous species, and explain the deviations of the Transkei herbaceous data from the observed general trends (see Table 4, 8, 10). Secondly, several species, especially herbaceous plants, are absent from forests which lie between forests where those particular species have been collected. This may reflect inadequate collection of inconspicuous and rare plants. The recently published species list for the Amatole forests (Phillipson 1987) lacked several species which by that time had been collected from the eastern parts of the forests (C J Geldenhuys, unpublished data). It may also reflect the inclusion of species which are usually associated with other biomes but which are contained in particular development stages of some forests. It may also merely reflect the true distribution pattern of some species. More detailed studies may clarify this and the Appendix is included to assist in this clarification.

FLORA SIZE AND RELATIONSHIPS

The evergreen forests in southern Africa cover only 0,08% of the area and contain only 7,1% of the indigenous vascular species, and thus have a relatively rich 0,58 species/km^2, making it the second richest biome per unit area in southern Africa. The overall ratio for southern Africa with over 20 227 indigenous vascular taxa is 0,0079 plant species/km^2 (Gibbs Russell 1985). Fynbos has 1,36 species/km^2 with a total of 7 316 species and grassland has 0,25 species/km^2 with 3 788 species Gibbs Russell (1987).

Sixteen of the largest families of the forest flora are included amongst the 38 largest flowering plant families listed by Gibbs Russell (1985). The other large forest families are Adiantaceae, Apocynaceae, Aspleniaceae, Capparaceae, Celastraceae, Ebenaceae, Flacourtiaceae, Moraceae, Oleaceae and Vitaceae. Of these latter families only Capparaceae is indicated by Gibbs Russell (1987) as a characteristic family of another biome, i.e. the desert biome. However, most families listed by Gibbs Russell (1987) as characteristic of the other biomes are also contained in the forest list. Notable absences are the two large families listed by Gibbs Russell (1985): Restionaceae and Chenopodiaceae, which respectively partly distinguish fynbos and desert (Gibbs Russell 1987).

Gibbs Russell (1985) suggested that families with a species/genus ratio more than twice the overall ratio of 9,6 for southern African seed plants have diversified extensively within southern Africa. The species/genus ratio for the total forest flora is only 2,2 with the ratio for the individual forests ranging between 1,3 and 1,6 (Table 3). Forty-nine of the families have a species/genus ratio greater than 2,2 (Appendix 1). The families with a species/genus ratio of more than 4,4, i.e. twice the overall mean, are Aspleniaceae (12,0), Crassulaceae (6,7), Dioscoreaceae (6,0), Ebenaceae (9,5), Gesneriaceae (12,0), Lycopodiaceae (6,0), Moraceae (4,7), Ochnaceae (7,0), Polygalaceae (9,0), Solanaceae (5,0) and Thelypteridaceae (4,5). The high ratio of these families can be attributed to a single genus with many species. They are mostly forest understorey or subcanopy plants.

SIZE OF INDIVIDUAL FOREST FLORAS

Species-area relationships

Forest area determines the richness of a flora but only in simple linear regression and explains 30% to 38% of the observed variation in species richness. It explains the rich southern Cape forest flora despite its extreme southern location at the western end of the larger forests of southern Africa (see

Anonymous 1987). However, forest area does not explain the rich floras of the small Umtamvuna, Richards Bay and Sabie forests. In the multiple regression analyses forest area was an insignificant variable whereas variables which explain dispersal patterns and habitat diversity (proximity to other forests, the number of dispersal corridors and landscape types, and mean altitude) explained 75% to 82% of the variation in species richness.

<u>Number of dispersal corridors</u>

The number of dispersal corridors meeting in a particular forest is one of the strongest variables determining the number of woody plants in a forest (<u>Table</u> 7). A dispersal corridor provides environments which are similar to the two source areas on either end of it, or it is a broad band of similar habitat (Brown and Gibson 1983). Mountain chains (Transkei and Amatole mountains), escarpments (Natal and Transvaal Drakensberg), river valleys (Tugela river, Edwards 1967) and coastal dune systems (Zululand and eastern Cape) link forests into larger complexes and link forest complexes on either side of dry, open valleys and lowlands (see Anonymous 1987). The most prominent dry zone stretch from the Transvaal lowveld to the eastern Cape between the southwest-northeast mountain chains and escarpment, and the Indian Ocean coast (Zucchini and Adamson 1984).

Each type of corridor provides a different set of environmental conditions and provides for a specific direction of dispersal for the plants.

* The Tugela river basin is a good example of a corridor which allows coastal and montane species to mix along the rivers and escarpments, at a distance from both sources, for example in the Qudeni, Nkandhla and Ngoye forests on the eastern margin of the Tugela river basin (Edwards 1967; Anonymous 1987). This explains in part the high similarity between the small Sabie and Richards Bay forests and the higher similarity of the Transvaal escarpment forests to the Richards Bay forest than to the other two Natal north coast forests (<u>Table</u> 10). But those species cannot establish in the area between the rivers because the climatic conditions (summer drought and frosts) and the frequent fires do not facilitate the establishment of forest.

* The corridor provided by the Drakensberg escarpment explains the high similarity amongst the Transvaal forests, and between them and those occurring in the Transkei and Amatole mountains (Table 10). The Transvaal escarpment provides sites with very uniform climate over a latitudinal gradient, and which protect the forest against the frequent grassland fires such as the Wonderwoud near Tzaneen. This escarpment is also part of the mountain chains as far south as the Amatole forests.

* Mountain ranges and dune systems provide greater habitat diversity through climatic (altitudinal range and different slopes and exposures), edaphic and disturbance gradients (Van der Schijff and Schoonraad 1971; Scheepers 1978; Deall 1985; Burns 1986; Chapter 2). The diversity of habitats allow species to move around within the system during conditions of environmental change (Scheepers 1978). Mountain ranges also allow forests to persist within areas of totally different, extreme climatic and disturbance regimes such as the Karoo and Fynbos (Anonymous 1987; Van Wyk 1988; Chapter 5).

Both the number of corridors present in a forest and the proximity of the forest to other forests have a significant positive effect on the number of woody species in that forest (Table 7). If a particular forest is linked to different forest types by different types of corridors, one can expect a larger number of species in such a forest. I attribute the rich woody flora of the small Umtamvuna gorge forest partly to a combination of corridors which allow an interchange of species between forests along the coast, mountain ranges and the Drakensberg escarpment, and its central position between the coastal and mountain forests of the eastern Cape, Transkei and Natal. This is evidenced by the high similarity between the Umtamvuna and the other mentioned forests. The gorge is relatively deep but open which allows protection against fires and which allows coastal environments to extend inland and mountain environments to extend towards the coast.

Proximity between forests

The greater sharing of taxa between forests of the larger complexes which occur in relative close proximity is attributed to their sharing of similar environments. Examples are the high similiraties between the Transvaal escarpment forests, between the Natal coastal forests and between the Amatole, Transkei and Umtamvuna forests (Table 10). The probability of successful establishment after chance events of long-distance dispersal (Brown and Gibson 1983) is increased if the forests in close proximity share similar environments. By contrast, the Natal coastal forests share much fewer species with the distant Drakensberg escarpment forests of great climatic and edaphic dissimilarity.

The smaller similarity between more isolated forests is attributed to the effective abiotic and biotic barriers to dispersal of propagules between them, and the lack of effective dispersal corridors. Firstly, the climate in the valleys and lowlands between adjacent forest complexes (Muir 1929; Edwards 1967; Cowling 1984; Everard 1987), the more extreme fire regimes of adjacent woodlands, grasslands and fynbos (Granger 1984; Edwards 1984), and the exposed mountain peaks and ridges (Killick 1963; Chapter 5) are barriers to the successful dispersal of forest biota. Van Daalen (1981) noted the inability of forest species to establish in fynbos. Secondly, The Peninsula, Grootvadersbosch, southern Cape, Hawaan and Cathedral Peak forests occur isolated from most other forests and are linked with them by few and ineffective corridors.

* The Peninsula, Grootvadersbosch and Cathedral Peak forests have high similarities only with their nearest neighbours, and share mostly the widespread species.
* The Peninsula forests presently is very isolated from the main western Cape mountain ranges. However, their species richness is higher than the forests of those mountains (for example McKenzie 1978). They share several species with forests along the coast to the east (Masson and McKenzie 1989) which makes a coastal corridor very likely.
* Grootvadersbosch occurs very isolated from other forests, even the southern Cape forests. The links between Grootvadersbosch and the coast are poor and cross relatively dry country (Muir 1929).
* Cathedral Peak forests is isolated from the rest of the Drakensberg escarpment forests. They have very poor links with the Natal midlands and coastal forests. They are surrounded by extensive grasslands which burn frequently (Edwards 1984; Tainton and Mentis 1984; Everard 1986).

* Hawaan forest shares several species with smaller forests in the vicinity such as Steinbank and Krantzkloof (coastal scarp), and Karkloof (Natal midlands) although it is most similar to the Hlogwene dune forest (Rogers and Moll 1975; Moll 1978).

* The southern Cape forest is large, cover several landscape types and is linked with the forests to the east mainly through the discontinuous mountain ranges and along the coast. The rivers provide only local links with the inland mountains which have very small, isolated forests (Chapter 1, 5).

<u>Altitude</u>

Mean altitude improved the coefficient of determination of the number of woody plants although was not in itself a significant variable (<u>Table</u> 7). Its negative coefficient emphasizes the higher richness of coastal forests compared to the montain forests. This was also shown by Geldenhuys and MacDevette (1989) for both the southern Cape and Natal. I attribute its insignificance in itself to the wide altitudinal range of many forests along the eastern eascarpment and mountains.

<u>Number of landscape types</u>

The number of landscape types in a forest is the most significant variable which determine the number of herbaceous species (<u>Table</u> 7). Different landscape types provide different combinations of slopes, aspects, soil depths, soil nutrient and moisture status, and different disturbance regimes (Scheepers 1978; Deall 1985; Chapter 1 and 2). Each landscape type carry a subset of unique species with narrower habitat tolerances. Geldenhuys and MacDevette (1989) have shown that different herbaceous growth forms show different habitat preferences along gradients from the coast to the mountain, both in Natal and the southern Cape. This is particularly evident in the southern Cape, Amatole, and Transvaal escarpment forests which include the largest number of landscape types (<u>Table</u> 1) and which have many species in most of the herbaceous growth forms (<u>Table</u> 4).

HABITAT REQUIREMENTS AND DISTRIBUTION OF SPECIES

The physiological tolerances to climatic conditions of species are reflected in the growth form spectra of different forests (Table 4) and the distribution ranges of species of different growth forms. This would also contribute to the observed variation in the richness of the floras of different forests. The southern African forest environment is characterized by relatively steep climatic gradients (Killick 1963; Venter 1972; Scheepers 1978; Campbell and Moll 1977; McKenzie 1978; Deall 1985; Burns 1986). The mountains are cool to cold and the coastal areas warm to hot. The northeastern parts are subtropical-tropical with summer rain and the southwestern parts almost cool temperate with winter rain. The mountains and coast receive high rainfall with relatively dry areas in between.

The growth form spectra indicates that the cooler mountain forests have a larger proportion of herbaceous plants and the warm, humid coastal forests have a larger proportion of woody plants (Table 4; Geldenhuys and MacDevette 1989). The coastal forests are particularly rich in trees, woody shrubs, lianes and vines. The mountain forests are particularly rich in ferns, which are deficient in the coastal forests, and are deficient in climbers except at the lower-lying (drier and/or warmer) parts. Fern and bryophyte epiphytes are generally associated with mountain forests and mistbelts (Pocs 1982) and epiphytic orchids with tropical lowlands (Harrison 1972). The mountain forests generally contain many epiphytes (e.g. Scheepers 1978). Notable exceptions are the Peninsula, Grootvadersbosch, Transkei (where they were not collected) and Cathedral Peak forests. In the southern Cape the epiphytes are abundant and rich in species, not in the mountain forests, but in the large, less frequently disturbed forests (by fire) of the coastal platform and river valleys (Geldenhuys and MacDevette 1989). More frequent disturbance by fire could explain, in part, the lack of epiphytes in the smaller mountain forests. The protection from fire could explain the many species in the larger montane forests of the Transvaal escarpment and in the well-protected but small Umtamvuna forests.

Many species drop out along the tropical-temperate gradient (Table 8). This southward attenuation of species has been mentioned in several studies (Phillips 1931; McKenzie 1978; Moll and White 1978; Scheepers 1978; Tinley 1985; Cawe 1986; MacDevette 1987; Chapter 6). The high number of unique trees and shrubs of the Maputaland dune forests have been related to the deterioration of the tropical climate to the south (Table 9; Moll and White 1978; Tinley 1985). I have related the sharp decline in numbers of species from the southern Cape to the west to the increasing aridity, fire frequency and forest fragmentation since the Pliocene (Chapter 6).

The implications of the steep gradients are that the widespread species have wide habitat tolerances, and that the restricted species have narrower tolerances. Tree species have much wider ranges than shrubs, and ferns have much wider ranges than the other herbaceous growth forms (Table 5). But only 7% of all the species occur in eight or more of the forests, and no species occur in all the forests.

INTERACTION WITH ADJACENT VEGETATION TYPES

The climatic and disturbance regimes and structure of the surrounding vegetation types will determine the interaction of the forest with those vegetation types. This interaction can increase the number of species in the forest in several ways.

* The forest margin is in close contact with the disturbance regimes of adjacent vegetation types. Small forests have a large ratio of forest margin to forest area. As such they may contain proportionately more species which are usually associated with the adjacent vegetation types but which are contained in the forest communities during the successional stages. The Richards Bay and Sabie forest communities contained particularly shrub, graminoid and forb species which were common in communities other than the forests. The forests occurred in complex mosaics with other vegetation communities (Venter 1972; Deall 1985) and partly explain the high species richness of these two forests in relation to their small size (Figure 2). The inclusion of many ecotone species in the

forest floras of Sabie, Richards Bay and the southern Cape could also explain the high number of unique species of several different growth forms of these forests (Table 8). By contrast, Hawaan forest is well-protected and mature but surrounded by cultivated land (Moll 1969; Cooper 1985). It lacks the ecotone vegetation which could partly explain its low number of herbaceous plants. Everard (1986) also pointed to the negative effect on species richness of a forest if the forest ecotone is frequently destroyed by fire.

* Vegetation types with structure and disturbance regimes somewhat similar to forest, such as the eastern Cape subtropical transitional thicket in the eastern Cape (Cowling 1984; Everard 1987), similar types in Natal (Edwards 1967) and moist savanna (Huntley 1984) of the Transvaal (Van der Schijff and Schoonraad 1971; Scheepers 1978; Deall 1985) and Natal (Edwards 1967) share various proportions of forest taxa. As such they provide corridors for the dispersal of forest species across the barriers (Edwards 1967; Moll and White 1978; Cowling 1984; Everard 1987). Current landuse practices, such as intensive agriculture in the eastern Cape and Natal, remove this corridor and may intensify the isolation of the forests. However, plantation forestry and the associated reduction of fire and amelioration of the microclimate provide corridors for plant species migration (Geldenhuys et al. 1986; Knight et al. 1987).

ENVIRONMENTAL CHANGE

The present patterns of composition and interrelationships of the different forests suggest that much of their high similarities may have been established before the major fragmentation of the forests. For example, the southern Cape forests are relatively similar to the Amatole, Transkei and Transvaal forests. Yet they are linked with the forests to the east by broken mountain ranges which are separated by relatively dry wide open valleys and extensive lowlands. One particularly prominant gap in forest distribution is formed by the Sundays river valley east of Port Elizabeth (Figure 1). It stretches in a northwesterly direction towards remnants of the escarpment of the African Surface in the vicinity of Graaff Reinet in the arid interior. East of this valley a massive uplift occurred during late Pliocene (ca 2,5 million years ago) along the Ciskei-Swaziland axis, whereas west of the valley the uplift was of lesser magnitude. This resulted in significant rejuvenation along the major inland drainage lines which are evident in the high accumulation rates of sediment at the mouths of major rivers along the southeastern coast (Partridge and Maud 1987).

I suggest that the forests in the southern Cape became isolated from the forests along the escarpment to the east of the Sundays river valley by the late Pliocene. According to maps of Partridge and Maud (1987), the Sundays river covered extensive distances already during the Miocene but indications are that aridity increased rapidly towards the the Pliocene-Pleistocene (Deacon 1983). The relatively dry Suurberg forests immediately to the east of the Sundays river valley are the closest forests to the southern Cape (Geldenhuys 1985). The only connections of the southern Cape forests with those to the east would have been along the coast and by means of the subtropical transitional thicket.

The increasing aridity since the Pliocene (Deacon 1983) have increasingly fragmented the forests. Forests were probably most limited during the last cold, dry Glacial Maximum of 18 000 years ago (Deacon et al. 1983; Scholtz 1986). Although Acocks (1953) and White (1983) attributed the relic nature of the forests within the grassland and fynbos biomes to the destructive activities of man during the relatively recent 100 to 300 years. However, Feely (1980, 1986) indicated that most of the present southern African grassland existed throughout the Holocene and was not induced by recent forest clearing. Forests still persist today in areas where Iron Age farmers in Transkei settled in high density for at least the last 1 400 years. I have indicated that fires associated with hot, desiccating winds have confined forests to shadow areas of fire-bearing winds (Chapter 2) whereas others (Story 1952; McKenzie 1978; Scheepers 1978; Deacon et al. 1983) have also commented on the role of fire.

During this long period of forest fragmentation, forests and forest biota survived in areas which we now consider as dispersal corridors. I suggest that the forest species responded in different ways to the increasing pressures of drought and fire. Some species survived in the specific landscape types because of better availability of moisture and protection against fires. Outside of these sites many species were eliminated due to pressures from droughts and fires. Species with wider climatic tolerances persisted with a wide distribution range and with the adoption of a range of sizes and shapes. The pressures of drought and fire caused many other species to evolve into smaller growth forms. This view is supported by two findings of this study. Firstly, forests in closer proximity share more species than forests further apart. Dispersal may play a role, but I suggest that this role is if lesser significance. Secondly, most of the large families, and many of the other important families and genera are shared between the forest and the other vegetation types. Their species-family ratios are small in the forests compared to the large ratios outside the forest. They have few but widespread species in the forest, and many but relatively localized species in the surrounding vegetation types. Species with the taller, longer-living growth forms occur in the forests whereas the smaller and often herbaceous growth forms occur in the vegetation types which are exposed to more extreme environmental conditions.

CONCLUSION

I suggest that the fragmentation of the forests and the increase in vegetation types which are tolerant of frequent fires or droughts had a profound effect on the speciation of the southern African flora. Most of the large plant families, and many of the other important families, are shared between the forest and the other vegetation types. This sharing suggests that the forest might have been the original gene source for the speciation of many of the families and genera. A few examples are the Anacardiaceae, especially Rhus, Asteraceae, Liliaceae, Orchidaceae, Proteaceae and Rosaceae. This effect of increasing aridity and disturbance pressure on the radiation of species outside the forests should be considered in studies of the phylogenies of many of the groups.

I have indicated that several factors contributed to the variation in sizes of the floras of individual forests. Forests where several positive factors operate have rich floras compared to the poorer floras of forests with fewer positive factors (Table 1). However, the significant variables do not explain the large number of both woody and herbaceous plants of the Umtamvuna forest, except perhaps the number of corridors. The Umtamvuna forest forms part of the southern Natal/Pondoland quartzite sandstone complex which is known to have a remarkably high number of endemic woody species (Van Wyk 1981). This whole complex requires a detailed study to determine the composition and distribution of different plant communties, and the distribution of the rare and endemic species. This would allow more objective explanation of its high number of species in the relatively confined area.

The fragmentation had been aggravated by current landuse practices, such as clearing for agriculture, forestry and subsistence utilization, and veld burning practices for grazing and improved water runoff in catchments (Phillips 1963; Feely 1980, 1986; Cooper 1985) and the development of coastal resorts and townships. I suggest that more localized studies should be conducted to determine the effect of these landuse practices on the survival of species in different regions.

The suggestion of the isolation of the southern Cape forests from those to the east already by the Pliocene implies long isolation and stability of the forest species. Several well-defined provenances may exist in many of the taxa. Collection of seed of those species for planting in other parts of their range may have serious implications for the conservation of the ecological species within those taxonomic species.

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Appendix

LIST OF SPECIES RECORDED FOR 14 FORESTS OR FOREST COMPLEXES IN SOUTHERN AFRICA.

The families, genera and species are listed alphabetically. The family name is followed by the number of genera, the number of species and the species/genus ratio for the family. The nomenclature of the species follows Gibbs Russell et al. (1985, 1987).

The growth form (GF) symbols have the following meaning (after Geldenhuys et al. 1988): 1: Canopy tree; 2: Subcanopy tree; 3: Woody shrub; 4: Soft shrub; 5: Liane; 6: Vine; 7: Fern with erect rhizome; 8: Fern with creeping rhizome; 9: Epiphyte; 10: Geophyte; 11: Graminoid; 12: Forb.

Absolute frequency (Fre) of occurrence is indicated in the third column.

The forests included in this list are (with abbreviation as used in the heading of columns four to seventeen indicated between brackets): Cape Peninsula (Pen), Grootvadersbosch and Boosmansbos (GVB), southern Cape forest complex (SoC), Amatole forest complex (Ama), East London coast forest complex (ELC), Transkei mountain forest complex (TrM), Umtamvuna Nature Reserve (Umt), Hawaan forest (Haw), Richards Bay forest (RiB), Maputaland coast forest complex (MLC), Cathedral Peak forest (CaP), Sabie transect forest complex (Sab), Mariepskop forest complex (MaK) and Northeastern Transvaal escarpment forest complex (NET).

FAMILY Genus species	GF	Fre	FOREST -------------- PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
ACANTHACEAE 15, 45, 3,0			
Asystasia gangetica (L.)T. Anders.	12	3	00000010110000
Asystasia varia N.E. Br.	12	1	00000010000000
Barleria gueinzii Sond.	12	3	00000010000110
Barleria meyeriana Nees	12	1	00000010000000
Barleria obtusa Nees	12	3	00000010110000
Barleria repens Nees	12	1	00000000010000
Barleria rotundifolia Oberm.	12	1	00000000000010
Dicliptera clinopodia Nees	12	3	00000000000111
Dicliptera heterostegia Presl ex Nees	12	1	00000001000000
Dicliptera mossambicensis Klotzsch.	12	1	00000001000000
Dicliptera zeylanica Nees	12	2	00100000000010
Duvernoia adhatodoides E. Mey. ex Nees	12	2	00000010000010
Hypoestes aristata (Vahl)Soland.ex Roem.& Schult.	12	7	00101010100111
Hypoestes forskaolii (Vahl)R. Br.	12	7	00111010100011
Hypoestes triflora (Forssk.)Roem. & Schult.	12	5	00010000001111
Isoglossa ciliata (Nees)Lindau	12	2	00100010000000
Isoglossa cooperi C.B. Cl.	12	4	00011010000001
Isoglossa delicatula C.B. Cl.	12	2	00000010000001
Isoglossa eckloniana (Nees)Lindau	12	4	00110000001100
Isoglossa grantii C.B. Cl.	12	2	00100000100000
Isoglossa hypoestiflora Lindau	12	2	00100010000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Isoglossa prolixa (Nees)Lindau	12	1	00100000000000
Isoglossa stipitata C.B. Cl.	12	1	00000010000000
Isoglossa sylvatica C.B. Cl.	12	1	00100000000000
Isoglossa woodii C.B. Cl.	4	3	00001000110000
Justicia anselliana (Nees)T.Anders.	12	1	00100000000000
Justicia bowiei C.B. Cl.	12	1	00001000000000
Justicia campylostemon (Nees)T. Anders.	12	5	00011011000001
Justicia capensis Thunb.	12	1	00000000010000
Justicia petiolaris (Nees)T. Anders.	12	2	00010000000010
Justicia protracta (Nees)T. Anders.	12	4	00100000110010
Makaya bella Harv.	3	3	00000010000011
Peristrophe cernua Nees	12	1	00000010000000
Phaulopsis imbricata (Forssk.)Sweet	4	4	00000001100101
Rhinacanthus gracilis Klotzsch	12	2	00000010100000
Ruttya ovata Harv.	12	2	00000011000000
Sclerochiton harveyanus Nees	3	7	00010110010111
Sclerochiton odoratissimus Hilliard	3	1	00010000000000
Siphonoglossa leptantha (Nees)Immelman			
subsp. late-ovata (C.B. Cl.)Immelman	12	1	00100000000000
subsp. leptantha	12	2	00100010000000
Thunbergia alata Sims	6	4	00000000110011
Thunbergia dregeana Nees	6	6	00111011010000
Thunbergia natalensis Hook.	4	3	00000010000011
Thunbergia neglecta Sond.	6	1	00000000000100
Thunbergia purpurata Harv. ex C.B. Cl.	6	1	00000010000000
ACHARIACEAE 2, 2, 1,0			
Acharia tragodes Thunb.	6	1	00001000000000
Ceratiosicyos laevis (Thunb.)A. Meeuse	6	5	00110010100001
ADIANTACEAE 5, 21, 4,2			
Acrostichum aureum L.	8	1	00000000100000
Adiantum aethiopicum L.	8	4	10100100000010
Adiantum capillus-veneris L.	8	4	00110000000110
Adiantum poiretii Wikstr.	8	4	00010000001011
Cheilanthes bergiana Schlechtd.	7	6	00111110000001
Cheilanthes capensis (Thunb.)Swartz	7	2	00110000000000
Cheilanthes concolor (Langsd.& Fisch.)R.& A. Tryon	7	6	00111110000100
Cheilanthes eckloniana (Kunze)Mett.	8	3	00010100001000
Cheilanthes hirta Swartz	7	7	00110100001111
Cheilanthes quadripinnata (Forssk.)Kuhn	8	4	00010100001010
Cheilanthes viridus (Forssk.)Swartz			
var. glauca (Sim)Schelpe & N.C. Anthony	8	1	00000000000100
var. macrophylla (Kunze)Schelpe	8	4	00110010000010
var. viridis	8	10	01111110100111
Pellaea calomelanos (Swartz)Link	7	2	00000000001100
Pellaea pectiniformis Bak.	7	1	00000000000100

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Pellaea pteroides (L.)Prantl	7	1	10000000000000
Pteris buchananii Bak. ex Sim	8	4	01110000000010
Pteris catoptera Kunze	8	5	00000100001111
Pteris cretica L.	8	7	01110100001101
Pteris dentata Forssk.	7	7	11111100000010
Pteris vittata L.	8	3	00000000100011
AIZOACEAE 3, 3, 1,0			
Limeum viscosum (Gay)Fenzl	12	2	00000000110000
Pharnaceum thunbergii Adamson	12	1	00100000000000
Tetragonia glauca Fenzl	12	1	00100000000000
AMARANTHACEAE 8, 8, 1,0			
Achyranthes aquatica R. Br.	12	1	00000000100000
Achyropsis avicularis (E. Mey. ex Moq.)Hook. f.	12	1	00000000100000
Amaranthus thunbergii Moq.	12	1	00100000000000
Celosia trigyna L.	12	2	00000001100000
Cyathula cylindrica Moq.	12	3	00000010000101
Nelsia quadrangula (Engl.)Schinz	12	1	00100000000000
Psilotrichum africanum Oliv.	12	2	00000001100000
Pupalia atropurpurea Moq.	12	6	00111000110100
AMARYLLIDACEAE 4, 10, 2,5			
Clivia caulescens R.A. Dyer	10	3	00000000000111
Clivia gardenii Hook.	10	1	00000010000000
Clivia miniata Regel	10	1	00000010000000
Cyrtanthus purpureus (Ait.)Traub	10	1	00100000000000
Cyrtanthus sp	10	2	00010100000000
Haemanthus albiflos Jacq.	10	4	00110010100000
Haemanthus sp	10	1	00000000010000
Scadoxus membranaceus (Bak.)Friis & Nordal	10	1	00000010000000
Scadoxus multiflorus (Martyn)Raf.	10	2	00000100000100
Scadoxus puniceus (L.)Friis & Nordal	10	7	00110011100011
ANACARDIACEAE 8, 29, 3,6			
Harpephyllum caffrum Bern. ex Krauss	1	6	00011110100001
Lannea discolor (Sond.)Engl.	2	1	00000000000100
Laurophyllus capensis Thunb.	3	2	01100000000000
Loxostylis alata Spreng.f ex Reichb.	1	2	00100010000000
Ozoroa obovata (Oliv.)R.A. Fernandes	3	1	00000000010000
Ozoroa paniculosa (Sond.)R.&A. Fernandes	3	1	00000000010000
Protorhus longifolia (Bernh.)Engl.	1	9	00011111100111
Rhus chirindensis Bak.f.	1	10	01111110100111
Rhus crenata Thunb.	3	2	00101000000000
Rhus dentata Thunb.	3	6	00010110101100
Rhus excisa Thunb.	3	1	00000010000000
Rhus fastigiata Eckl. & Zeyh.	3	2	00010010000000
Rhus glauca Thunb.	3	2	00101000000000
Rhus gueinzii Sond.	3	1	00000100000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Rhus krebsiana Presl ex Engl.	3	2	00010100000000
Rhus longispina Eckl. & Zeyh.	3	2	00101000000000
Rhus lucida L.	2	7	11100110001010
Rhus natalensis Bernh. ex Krauss	3	4	00001111110000
Rhus nebulosa Schonl.	3	5	00000111110000
Rhus pentheri Zahlbr.	3	3	00000100100100
Rhus pyroides Burch.	3	6	00011100000111
Rhus refracta Eckl. & Zeyh.	3	2	00101000000000
Rhus rehmanniana Engl.	3	8	01110110100011
Rhus sp nov	3	2	00000010000010
Rhus tomentosa L.	3	2	11000000011000
Rhus transvaalensis Engl.	3	1	00000000000100
Rhus tumulicola S. Moore	3	1	00000000000100
Rhus undulata Jacq.	3	1	00100000000000
Sclerocarya birrea (A. Rich.)Hochst.	1	3	00000000110100
ANNONACEAE 4, 4, 1,0			
Annona senegalensis Pers.	2	3	00000000110100
Artabotrys monteiroae Oliv.	5	2	00000001100000
Monanthotaxis caffra (Sond.)Verdc.	5	6	00010011110100
Uvaria caffra E. Mey. ex Sond.	5	4	00000011110000
APIACEAE 7, 10, 1,4			
Berula erecta (Hudson)Cov.	12	1	00001000000000
Centella asiatica (L.) Urb.	12	2	00010000100000
Centella eriantha (Rich.)Drude	12	3	01110000000000
Conium chaerophylloides (Thunb.)Eckl. & Zeyh.	12	1	00000000001000
Heteromorpha pubescens Burtt Davy	3	2	00000000000110
Heteromorpha trifoliata (Wendl.)Eckl. & Zeyh.	3	9	01111110001011
Peucedanum capense (Thunb.)Sond.	4	3	00110000001000
Peucedanum venosum Burtt Davy	4	1	00000000000001
Rhyticarpus difformis (L.)Benth. & Hook.	4	1	00100000000000
Sanicula elata Buch.-Ham.	12	7	01110000001111
APOCYNACEAE 10, 19, 1,9			
Acokanthera oblongifolia (Hochst.)Codd	3	5	00101011010000
Acokanthera oppositifolia (Lam.)Codd	3	9	00111111110001
Acokanthera rotundata (Codd)Kupicha	3	1	00000000010000
Carissa bispinosa (L.)Desf. ex Brenan			
var. acuminata (E. Mey.)Codd	3	10	00111011110111
var. bispinosa	3	6	01010110011000
Carissa edulis Vahl	3	2	00000000000011
Carissa macrocarpa (Eckl.)A. DC.	3	2	00001000110000
Carissa wyliei N.E. Br.	3	2	00000010100000
Ephippiocarpa orientalis (S. Moore)Markg.	3	1	00000000010000
Gonioma kamassi E. Mey.	2	2	00100010000000
Landolphia capensis Oliv.	5	1	00000000000010
Landolphia kirkii T.-Dyer	5	2	00000001100000
Landolphia petersiana (Klotsch)T.-Dyer	5	1	00000000100000

FAMILY	GF	Fre	PGSAETUHRMCSMN
Genus species			eVomLrmaiLaaaE
			nBCaCMtwBCPbKT
Oncinotis inandensis Wood & Evans	5	1	00000010000000
Rauvolfia caffra Sond.	1	4	00000000100111
Strophanthus speciosus (Ward & Harv.)Reber	5	4	00010010000011
Tabernaemontana elegans Stapf	2	1	00000000010000
Tabernaemontana ventricosa Hochst. ex A. DC.	1	1	00000000100000
Voacanga thouarsii Roem. & Schult.	2	2	00000010100000
AQUIFOLIACEAE 1, 1, 1,0			
Ilex mitis (L.)Radlk.	1	12	11110110111111
ARACEAE 4, 6, 1,5			
Gonatopus boivinii (Decne.)Engl.	10	2	00000000110000
Stylochiton natalense Schott	10	3	00000000110100
Stylochiton sp	10	1	00000000000010
Zamioculcas zamiifolia (Lodd.)Engl.	10	1	00000000100000
Zantedeschia aethiopica (L.)Spreng.	10	5	11110000100000
Zantedeschia albomaculata (Hook.)Baill.	10	3	00010000000011
ARALIACEAE 3, 9, 3,0			
Cussonia arenicola Strey	2	2	00001000010000
Cussonia natalensis Sond.	2	1	00000000000010
Cussonia nicholsonii Strey	2	1	00000010000000
Cussonia sphaerocephala Strey	1	4	00000110110000
Cussonia spicata Thunb.	1	11	01111110011111
Cussonia thyrsiflora Thunb.	5	4	11101000000000
Cussonia zuluensis Strey	2	2	00000000110000
Schefflera umbellifera (Sond.)Baill.	1	6	00100010100111
Seemannaralia gerrardii (Seemann)Vig.	2	1	00000000000010
ARECACEAE 1, 1, 1,0			
Phoenix reclinata Jacq.	2	6	00001010110110
ASCLEPIADACEAE 15, 31, 2,1			
Asclepias fruticosa L.	12	2	00110000000000
Astephanus marginatus Decne.	6	1	00100000000000
Astephanus triflorus (L.f.)Schultes	6	1	00100000000000
Ceropegia africana R. Br.	12	1	00100000000000
Ceropegia nilotica Kotschy	12	1	00000000100000
Ceropegia racemosa N.E. Br	6	1	00000000000100
Ceropegia woodii Schltr.	12	2	00000000000101
Cynanchum ellipticum (Harv.)R.A. Dyer	6	6	00111001110000
Cynanchum natalitium Schltr.	6	3	00101000100000
Cynanchum obtusifolium L.f.			
var. obtusifolium	6	5	10101000110000
var. pilosum Schltr.	6	1	00100000000000
Cynanchum tetrapterum (Turcz.)R.A. Dyer	6	3	00100000010001
Dregea floribunda E. Mey.	6	1	00001000000000
Oncinema lineare (L.f.)Bullock	6	2	01100000000000
Pentarrhinum sp	6	2	00000000110000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Pergularia daemia (Forssk.)Chiov.	6	1	00000000100000
Riocreuxia picta Schltr.	6	2	00000000000011
Riocreuxia torulosa Decne.	6	5	00000010101011
Sarcostemma viminale (L.)R. Br.	6	7	00110010110011
Schizoglossum bidens E. Mey.	6	1	00000010000000
Secamone alpinii Schultes	5	12	11111110011111
Secamone filiformis (L.f.)J.H. Ross	5	3	00011000010000
Secamone frutescens Decne.	5	3	00000010100010
Secamone gerrardii Harv. ex Benth.	5	6	00000101100111
Secamone parvifolia (Oliv.)Bullock	5	1	00000000000100
Stapelia hystrix N.E. Br.	12	1	00000010000000
Telosma africana (N.E. Br.)N.E. Br.	6	2	00000010000001
Tylophora anomala N.E. Br.	6	3	00000000100101
Tylophora cordata (Thunb.)Druce	6	3	00111000000000
Tylophora flanaganii Schltr.	6	4	00010000001101
Tylophora umbellata Schltr.	6	1	00000010000000
ASPIDIACEAE 8, 12, 1,5			
Arachniodes foliosa (C. Chr.)Schelpe	8	3	00010010000001
Ctenitis lanuginosa (Willd. ex Kaulf.)Copel.	7	3	00100100000001
Cyrtomium caryotideum (Wall. ex Hook.& Grev.)Presl	8	3	00010100000100
Dryopteris athamantica (Kunze)Kuntze	8	3	00000100001100
Dryopteris inaequalis (Schlechtd.)Kuntze	8	10	11111100001111
Hypodematium crenatum (Forssk.)Kuhn	8	1	00000100000000
Polystichum luctuosum (Kunze)T. Moore	7	4	00010100001100
Polystichum pungens (Kaulf.)Presl	8	6	11110100000001
Polystichum transkeiense W.B.G. Jacobsen	8	2	00010010000000
Polystichum transvaalense N.C. Anthony	7	2	00000000001001
Rumohra adiantiformis (G. Forst.)Ching	8	6	11110000000110
Tectaria gemmifera (Fee)Alston	7	2	00000000000101
ASPLENIACEAE 2, 24, 12,0			
Asplenium adiantum-nigrum L.	7	2	10100000000000
Asplenium aethiopicum (Burm.f.)Becherer	7	8	11111100000011
Asplenium anisophyllum Kunze	9	3	00000000000111
Asplenium boltonii Hook. ex Schelpe	7	2	10000100000000
Asplenium dregeanum Kunze	7	1	00000000010000
Asplenium erectum Bory ex Willd.	7	5	10100100000011
Asplenium friesiorum C. Chr.	7	1	00000000000010
Asplenium gemmiferum Schrad.	7	3	00100000000011
Asplenium inaequilaterale Willd.	7	3	00000000000111
Asplenium lobatum Pappe & Raws.	7	4	00100100000101
Asplenium lunulatum Swartz	7	7	10111110000100
Asplenium monanthes L.	7	4	10100100001000
Asplenium platyneuron (L.)Oakes	7	2	10100000000000
Asplenium protensum Schrad.	7	4	10110100000000
Asplenium prionites Kunze	7	3	00000110100000
Asplenium rutifolium (Berg.)Kunze	7	10	11110110001111
Asplenium sandersonii Hook.	9	2	00000000000011

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Pergularia daemia (Forssk.)Chiov.	6	1	00000000100000
Riocreuxia picta Schltr.	6	2	00000000000011
Riocreuxia torulosa Decne.	6	5	00000010101011
Sarcostemma viminale (L.)R. Br.	6	7	00110010110011
Schizoglossum bidens E. Mey.	6	1	00000010000000
Secamone alpinii Schultes	5	12	11111110011111
Secamone filiformis (L.f.)J.H. Ross	5	3	00011000010000
Secamone frutescens Decne.	5	3	00000010100010
Secamone gerrardii Harv. ex Benth.	5	6	00000101100111
Secamone parvifolia (Oliv.)Bullock	5	1	00000000000100
Stapelia hystrix N.E. Br.	12	1	00000010000000
Telosma africana (N.E. Br.)N.E. Br.	6	2	00000010000001
Tylophora anomala N.E. Br.	6	3	00000000100101
Tylophora cordata (Thunb.)Druce	6	3	00111000000000
Tylophora flanaganii Schltr.	6	4	00010000001101
Tylophora umbellata Schltr.	6	1	00000010000000
ASPIDIACEAE 8, 12, 1,5			
Arachniodes foliosa (C. Chr.)Schelpe	8	3	00010010000001
Ctenitis lanuginosa (Willd. ex Kaulf.)Copel.	7	3	00100100000001
Cyrtomium caryotideum (Wall. ex Hook.& Grev.)Presl	8	3	00010100000100
Dryopteris athamantica (Kunze)Kuntze	8	3	00000100001100
Dryopteris inaequalis (Schlechtd.)Kuntze	8	10	11111100001111
Hypodematium crenatum (Forssk.)Kuhn	8	1	00000100000000
Polystichum luctuosum (Kunze)T. Moore	7	4	00010100001100
Polystichum pungens (Kaulf.)Presl	8	6	11110100000001
Polystichum transkeiense W.B.G. Jacobsen	8	2	00010010000000
Polystichum transvaalense N.C. Anthony	7	2	00000000001001
Rumohra adiantiformis (G. Forst.)Ching	8	6	11110000000110
Tectaria gemmifera (Fee)Alston	7	2	00000000000101
ASPLENIACEAE 2, 24, 12,0			
Asplenium adiantum-nigrum L.	7	2	10100000000000
Asplenium aethiopicum (Burm.f.)Becherer	7	8	11111100000011
Asplenium anisophyllum Kunze	9	3	00000000000111
Asplenium boltonii Hook. ex Schelpe	7	2	10000100000000
Asplenium dregeanum Kunze	7	1	00000000010000
Asplenium erectum Bory ex Willd.	7	5	10100100000011
Asplenium friesiorum C. Chr.	7	1	00000000000010
Asplenium gemmiferum Schrad.	7	3	00100000000011
Asplenium inaequilaterale Willd.	7	3	00000000000111
Asplenium lobatum Pappe & Raws.	7	4	00100100000101
Asplenium lunulatum Swartz	7	7	10111110000100
Asplenium monanthes L.	7	4	10100100001000
Asplenium platyneuron (L.)Oakes	7	2	10100000000000
Asplenium protensum Schrad.	7	4	10110100000000
Asplenium prionites Kunze	7	3	00000110100000
Asplenium rutifolium (Berg.)Kunze	7	10	11110110001111
Asplenium sandersonii Hook.	9	2	00000000000011

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Asplenium simii Braithwaite & Schelpe	9	1	00100000000000
Asplenium splendens Kunze	7	6	00000110001111
Asplenium stoloniferum Bory	7	1	00010000000000
Asplenium theciferum (H.B.K.)Mett.	9	3	10100000000010
Asplenium varians Wall. ex Hook.			
subsp. fimbriatum (Kunze)Schelpe	7	2	00000100000100
Asplenium xflexuosum Schrad.	7	3	00110000000001
Ceterach cordatum (Thunb.)Desv.	7	4	00110100000010
ASTERACEAE 30, 81, 2,7			
Adenostemma perrottetii DC.	12	1	00000000100000
Anisochaeta mikanoides DC.	12	1	00000010000000
Artemisia afra Jacq. ex Willd.	12	5	01010010101000
Athanasia trifurcata (L.)L.	12	1	01000000000000
Athrixia phylicoides DC.	12	1	00000000000100
Berkheya bipinnatifida (Harv.)Roessl.	12	3	00010010100000
Berkheya echinacea (Harv.)O. Hoffm. ex Burtt Davy	12	1	00000000000100
Berkheya erysithales (DC.)Roessl.	12	1	00000010000000
Berkheya speciosa (DC.)O. Hoffm.	12	1	00000000100000
Blumea mollis (D. Don)Merr.	12	1	00000000100000
Brachylaena discolor DC.			
subsp. discolor	3	5	00001001110100
subsp. transvaalensis (Phill. & Schweik.)J. Paiva	2	3	00000000100011
Brachylaena elliptica (Thunb.)DC.	2	2	00011000000000
Brachylaena glabra (L.f.)Druce	1	2	00100010000000
Brachylaena neriifolia (L.)R. Br.	3	2	01100000000000
Brachylaena uniflora Harv.	2	1	00000010000000
Chrysanthemoides monilifera (L.)T. Norl.	4	10	11111011111000
Cineraria geraniifolia DC.	6	3	00010010001000
Cineraria lobata L'Herit.	6	2	00100000001000
Cineraria sp	6	2	00000010000010
Conyza pinnata (L.f.)Kuntze	12	2	00000000110000
Crassocephalum sp.	12	1	00000000110000
Dichrocephala integrifolia (L.f.)Kuntze	12	1	00000000000010
Euryops leiocarpus (DC.)B. Nord.	3	1	00000010000000
Felicia aculeata Grau	12	1	00100000000000
Felicia filifolia (Vent.)Burtt Davy	12	2	00010100000000
Felicia westae (Fourc.)Grau	12	1	00100000000000
Gazania rigens (L.)Gaertn.	12	1	00000000110000
Gerbera aurantiaca Sch. Bip.	12	1	00000000000100
Gerbera cordata (Thunb.)Less.	12	1	00100000000000
Gerbera jamesonii H. Bol. ex Adlam	12	1	00000000000100
Helichrysum appendiculatum (L.f.)Less.	12	1	00000000100000
Helichrysum cymosum (L.)D. Don	12	6	10111010100000
Helichrysum decorum DC.	12	2	00000000110000
Helichrysum kraussii Sch. Bip.	12	4	00000001110100
Helichrysum nudifolium (L.)Less.	12	4	00010000110100
Helichrysum odoratissimum (L.)Sweet	12	2	00000000100100

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Helichrysum panduratum O. Hoffm. var. transvaalense Moeser	12	1	00000000000100
Helichrysum petiolare Hilliard & Burtt	12	2	00110000000000
Helichrysum populifolium DC.	12	1	00000010000000
Helichrysum sp	12	1	00000000000010
Hippia frutescens (L.)L.	12	2	01100000000000
Inulanthera calva (Hutch.)Kallersjo	12	1	00000000000100
Metalasia muricata (L.)D. Don	3	1	00001000000000
Mikania natalensis DC.	5	7	00110010100111
Nidorella auriculata DC.	12	1	00000000100000
Osmitopsis osmitoides (Less.)Bremer	4	2	01100000000000
Phymaspermum acerosum (DC.)Kallersjo	12	1	00000000000100
Schistostephium heptalobum (DC.)Oliv. & Hiern	12	1	00000000000100
Senecio albanensis DC. var. doroniciflorus (DC.)Harv.	12	2	00000000110000
Senecio amabilis DC.	12	1	00100000000000
Senecio angulatus L.f.	6	2	00101000000000
Senecio bryoniifolius Harv.	6	2	00000010010000
Senecio cissampelinus (DC.)Sch. Bip.	5	3	00010100000001
Senecio crenatus Thunb.	12	1	00100000000000
Senecio deltoideus Less.	6	10	01111000111111
Senecio erubescens Ait.	12	2	00010000100000
Senecio helminthioides (Sch. Bip.)Hilliard	12	1	00000010000000
Senecio ilicifolius L.	12	1	00100000000000
Senecio inaequidens DC.	12	1	00000000100000
Senecio junodii Hutch. & Burtt Davy	4	1	00000000000010
Senecio macroglossus DC.	6	1	00001000000000
Senecio medley-woodii Hutch.	12	1	00000010000000
Senecio mikanioides Otto ex Harv.	6	6	00110000110110
Senecio panduriformis Hilliard	12	1	00000000000100
Senecio pterophorus DC.	6	4	00011000000010
Senecio quinquelobus (Thunb.)DC.	6	5	01111000000010
Senecio tamoides DC.	6	5	00010000001111
Tarchonanthus camphoratus L.	1	5	10111010000000
Tarchonanthus trilobus DC.	2	3	00000010000110
Tenrhynea phylicifolia (DC.)Hilliard & Burtt	12	2	00000010000100
Vernonia adoensis Sch. Bip. ex Walp.	3	1	00000000000100
Vernonia amygdalina Del.	12	1	00000000000100
Vernonia anisochaetoides Sond.	5	5	00111000110000
Vernonia angulifolia DC.	5	2	00000001100000
Vernonia aurantiaca (O. Hoffm.)N.E. Br.	5	1	00000000010000
Vernonia crataegifolia Hutch.	5	1	00000010000000
Vernonia mespilifolia Less.	5	3	00100100000001
Vernonia neocorymbosa Hilliard	5	2	00000010000100
Vernonia stipulacea Klatt	3	2	00000000000110
Vernonia wollastonii S. Moore	3	2	00000000000110
ATHYRIACEAE 2, 2, 1,0			
Athyrium scandicinum (Willd.)Presl.	7	3	00000000000111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Cystopteris fragilis (L.)Bernh.	8	3	00010100001000
BALANITACEAE 1, 1, 1,0			
Balanites maughamii Sprague	1	2	00000000110000
BALSAMINACEAE 1, 2, 2,0			
Impatiens hochstetteri Warb.	12	7	01110000001111
Impatiens sylvicola Burtt Davy & Greenway	12	2	00000000000011
BEGONIACEAE 1, 4, 4,0			
Begonia dregei Otto & Dietr.	12	1	00000010000000
Begonia homonyma Steud.	12	1	00000000000010
Begonia sp	4	2	00000000000110
Begonia sutherlandii Hook.f.	12	3	00000110001000
BIGNONIACEAE 1, 1, 1,0			
Tecomaria capensis (Thunb.)Spach	3	3	00000011000100
BLECHNACEAE 2, 6, 3,0			
Blechnum australe L.	7	6	11110100001000
Blechnum capense Burm.f.	7	6	11110010000010
Blechnum giganteum (Kaulf.)Schlechtd.	7	9	11110100001111
Blechnum punctulatum Swartz	7	8	11111100001010
Blechnum tabulare (Thunb.)Kuhn	7	9	11110110000111
Stenochlaena tenuifolia (Desv.)T. Moore	9	2	00000000110000
BORAGINACEAE 3, 3, 1,0			
Cordia caffra Sond.	1	5	00001011110000
Cynoglossum lanceolatum Forssk.	12	3	00110000000001
Ehretia rigida (Thunb.)Druce	3	4	00011110000000
BRASSICACEAE 3, 3, 1,0			
Cardamine africana L.	12	6	01110000001011
Helophila scandens Harv.	12	1	00000001000000
Lepidium ecklonii Schrad.	12	2	00110000000000
BURSERACEAE 1, 4, 4,0			
Commiphora africana (A. Rich.)Engl.	2	1	00000000010000
Commiphora harveyi (Engl.)Engl.	2	6	00001110110010
Commiphora woodii Engl.	2	3	00010110000000
Commiphora zanzibarica (Baill.)Engl.	2	1	00000000010000
BUXACEAE 1, 2, 2,0			
Buxus macowanii Oliv.	2	2	00001010000000
Buxus natalensis (Oliv.)Hutch.	3	2	00000011000000
CAMPANULACEAE 1, 1, 1,0			
Wahlenbergia undulata DC.	12	1	00000000010000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
CANELLACEAE 1, 1, 1,0			
Warburgia salutaris (Bertol.f.)Chiov.	12	1	00000000010000
CAPPARACEAE 6, 14, 2,3			
Bachmannia woodii (Oliv.)Gilg	3	2	00000010100000
Capparis brassii DC.	5	6	00001011110100
Capparis fascicularis DC.			
var. fascicularis	3	1	00000000010000
var. zeyheri (Turcz.)Toelken	3	3	00000001110000
Capparis sepiaria L.			
var. citrifolia (Lam.)Toelken	5	6	01101101010000
var. subglabra (Oliv.)DeWolf	5	1	00000000000100
Capparis tomentosa Lam.	3	4	00000011100010
Cladostemon kirkii (Oliv.)Pax & Gilg	3	1	00000000010000
Cleome sp	3	1	00000000010000
Maerua cafra (DC.)Pax	3	5	00001010100011
Maerua juncea Pax	3	1	00000000010000
Maerua nervosa (Hochst.)Oliv.	3	1	00000000010000
Maerua racemulosa (DC.)Gilg & Ben.	3	5	00110101100000
Thilachium africanum Lour.	2	1	00001000000000
CARYOPHYLLACEAE 1, 1, 1,0			
Drymaria cordata (L.)Willd.	12	2	00100010000000
CELASTRACEAE 12, 40, 3,3			
Allocassine laurifolia (Harv.)N.K.B. Robson	5	4	00000011110000
Cassine aethiopica Thunb.	1	7	00111110110000
Cassine crocea (Thunb.)Kuntze	2	2	00001010000000
Cassine eucleiformis (Eckl. & Zeyh.)Kuntze	2	8	11100010110011
Cassine maritima (H. Bol.)L. Bol.	3	1	00100000000000
Cassine papillosa (Hochst.)Kuntze	2	10	01111111110001
Cassine parvifolia Sond.	3	1	00100000000000
Cassine peraqua L.	1	7	11101110010000
Cassine tetragona (L.f.)Loes.	3	6	00111110001000
Catha edulis (Vahl)Forssk. ex Endl.	2	2	00010000000100
Hartogiella schinoides (Spreng.)Codd	2	3	11100000000000
Hippocratea africana (Willd.)Loes.	5	1	00000000000001
Hippocratea delagoensis Loes.	5	1	00000000010000
Hippocratea schlechteri Loes.	5	3	00000011100000
Maurocenia frangularia (L.)Mill.	2	1	10000000000000
Maytenus abbottii Van Wyk	3	1	00000010000000
Maytenus acuminata (L.f.)Loes.	2	9	11110110011010
Maytenus angularis (Sim)Van Wyk	3	1	00000010000000
Maytenus bachmannii (Loes.)Marais	3	1	00000010000000
Maytenus heterophylla (Eckl. & Zeyh.)N.K.B. Robson	2	13	11111110111111
Maytenus mossambicensis (Klotzsch)Blakelock			
var. mossambicensis	3	5	00000110101001
var. rubra (Harv.)Blakelock	3	3	00000010000110
Maytenus nemorosa (Eckl. & Zeyh.)Marais	2	7	00111110110000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Maytenus oleoides (Lam.)Loes.	2	1	10000000000000
Maytenus oleosa Van Wyk & Archer	2	1	00000010000000
Maytenus peduncularis (Sond.)Loes.	1	9	00110110101111
Maytenus procumbens (L.f.)Loes.	3	5	00101001110000
Maytenus senegalensis (Lam.)Exell	3	2	00000000110000
Maytenus undata (Thunb.)Blakelock	2	12	00111111111111
Pleurostylia capensis (Turcz.)Oliv.	1	4	00011110000000
Pseudosalacia streyi Codd	2	1	00000010000000
Pterocelastrus echinatus N.E. Br.	1	4	00000010001110
Pterocelastrus rostratus Walp.	2	3	01100010000000
Pterocelastrus sp	1	2	00000100001000
Pterocelastrus tricuspidatus (Lam.)Sond.	1	6	01111110000000
Putterlickia pyracantha (L.)Szyszyl.	3	3	10100010000000
Putterlickia retrospinosa Van Wyk & Mostert	5	1	00000010000000
Putterlickia verrucosa (E. Mey. ex Sond.)Szyszyl.	3	5	00010011110000
Salacia gerrardii Harv.	5	4	00000110110000
Salacia kraussii (Harv.)Harv.	5	1	00000000100000
CHRYSOBALANACEAE 1, 1, 1,0			
Parinari curatellifolia Planch. ex Benth.	1	3	00000000110100
CLUSIACEAE 2, 4, 2,0			
Garcinia gerrardii Harv. ex Sim	2	3	00000011010000
Garcinia livingstonei T. Anders.	2	2	00000000110000
Hypericum lalandii Choisy	3	3	00010000100010
Hypericum revolutum Vahl	3	2	00000000000011
COMBRETACEAE 2, 6, 3,0			
Combretum bracteosum (Hochst.)Brandis ex Engl.	5	1	00000000100000
Combretum collinum Fresen. subsp. suluense (Engl. & Diels)Okafor	2	1	00000000000100
Combrteum erythrophyllum (Burch.)Sond.	1	2	00001010000000
Combretum kraussii Hochst.	1	6	00001010010111
Combretum molle R. Br. ex G. Don	2	2	00000000100100
Quisqualis parviflora Gerr. ex Harv.	3	2	00000010000010
COMMELINACEAE 5, 8, 1,6			
Aneilema aequinoctiale (Beauv.)Kunth	10	3	00000000110100
Coleotrype natalensis C.B. Cl.	10	1	00000000100000
Commelina africana L.	12	10	10110010111111
Commelina benghalensis L.	12	3	00000001110000
Commelina eckloniana Kunth	12	3	00000000000111
Commelina livingstonii C.B. Cl.	12	1	00000000000100
Cyanotis pachyrrhiza Oberm.	12	1	00000000000100
Floscopa glomerata (Willd. ex Schult. & Schult.f.)Hassk.	12	2	00000000100100
CONNARACEAE 1, 1, 1,0			
Cnestis natalensis (Hochst.)Planch. & Sond.	5	6	00000110100111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
CONVOLVULACEAE 7, 15, 2,1			
Astripomoea malvacea (Klotzsch)A. Meeuse	6	1	00000000100000
Convolvulus farinosus L.	6	3	00110000000001
Convolvulus capensis Burm.f.			
var. bowieanus (Rendle)A. Meeuse	6	1	00100000000000
Convolvulus natalensis Bernh. apud Krauss	6	2	00000000110000
Cuscuta africana Willd.	6	2	00110000000000
Cuscuta kilimanjari Oliv.	6	1	00000000000001
Dichondria repens L.f.	12	2	00100000000001
Falkia repens L.f.	12	1	00100000000000
Hewittia sublobata (L.f.)Kuntze	6	1	00000000100000
Ipomoea wightii (Wall.)Choisy	6	5	00000010110011
Ipomoea cairica (L.)Sweet	6	1	00000000100000
Ipomoea ficifolia Lindl.	6	1	00000000100000
Ipomoea mauritiana Jacq.	6	1	00000000100000
Ipomoea sinensis (Desr.)Choisy	6	1	00000001000000
Ipomoea urbaniana (Damm.)Hallier f.	6	1	00000000010000
CORNACEAE 1, 1, 1,0			
Curtisia dentata (Burm.f.)C.A. Sm.	1	8	11110100001011
CRASSULACEAE 3, 20, 6,7			
Cotyledon orbiculata L.	4	3	00110010000000
Crassula alba Forssk.	12	1	00000000100000
Crassula cordata Thunb.	12	2	00110000000000
Crassula lactea Soland.	12	1	00100000000000
Crassula multicava Lem.	12	1	00000010000000
Crassula natalensis Schonl.	12	1	00000000000100
Crassula orbicularis L.	12	3	00110100000000
Crassula ovata (Mill.)Druce	12	1	00000010000000
Crassula pellucida L.			
subsp. alsinoides (Hook.f.)Toelken	12	3	00100010000100
subsp. marginalis (Dryand. in Ait.)Toelken	12	2	00110000000000
Crassula perforata Thunb.	12	2	00100010000000
Crassula rubricaulis Eckl. & Zeyh.	12	1	00100000000000
Crassula sarcocaulis Eckl. & Zeyh.	12	1	00000000000100
Crassula sarmentosa Harv.	12	2	00100010000000
Crassula spathulatha Thunb.	12	2	00110000000000
Crassula streyi Toelken	12	1	00000010000000
Crassula subulata L.	12	1	00100000000000
Crassula swaziensis Schonl.	12	1	00000000000100
Crassula umbraticola N.E. Br.	12	1	00000000001000
Kalanchoe rotundifolia (Haw.)Haw.	12	2	00000000100100
CUCURBITACEAE 7, 13, 1,9			
Coccinia adoensis (A. Rich.)Cogn.	6	1	00000000000010
Coccinia palmata (Sond.)Cogn.	6	5	00000010110110
Coccinia quinqueloba (Thunb.)Cogn.	6	2	00011000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Coccinia sessilifolia (Sond.)Cogn.	6	1	00000000000010
Coccinia variifolia A. Meeuse	6	2	00000000000011
Kedrostis foetidissima (Jacq.)Cogn.	6	2	00100000100000
Kedrostis nana (Lam.)Cogn.	6	3	00101100000000
Lagenaria sphaerica (Sond.)Naud.	6	2	00100010000000
Momordica balsamina L.	6	2	00000000110000
Oreosyce africana Hook.f.	6	1	00000000000001
Trochomeria hookeri Harv.	6	1	00000000000001
Zehneria parvifolia (Cogn.)J.H.Ross	6	2	00000010100000
Zehneria scabra (L.f.)Sond.	6	7	11110010001001
CUNONIACEAE 2, 2, 1,0			
Cunonia capensis L.	1	5	11110010000000
Platylophus trifoliatus (L.f.)D. Don	1	3	11100000000000
CUPRESSACEAE 1, 1, 1,0			
Widdringtonia cupressoides (L.)Endl.	2	6	11110000001010
CYATHEACEAE 1, 2, 2,0			
Cyathea capensis (L.f.)J.E. Sm.	7	6	11110000000011
Cyathea dregei Kunze	7	5	00000100001111
CYPERACEAE 11, 35, 3,2			
Carex aethiopica Schkuhr	11	6	11110000000011
Carex spicato-paniculata C.B. Cl.	11	2	00000000001100
Carpha glomerata (Thunb.)Nees	11	3	00110010000000
Cyperus albostriatus Schrad.	11	10	00011111110111
Cyperus crassipes Vahl	11	1	00000000010000
Cyperus denudatus L.f.	11	1	00000000010000
Cyperus immensus C.B. Cl.	11	1	00000000000100
Cyperus leptocladus Kunth	11	3	00000000110100
Cyperus natalensis Hochst.	11	2	00000000110000
Cyperus obtusiflorus Vahl	11	4	00010000110100
Cyperus pseudoleptocladus Kuekenth.	11	1	00000000000100
Cyperus sexangularis Nees	11	1	00000000000100
Cyperus tenax Boeck.	11	1	00000000010000
Cyperus tenellus L.f.	11	2	00110000000000
Epischoenus adnatus Levyns	11	1	00100000000000
Ficinia acuminata (Steud.)Nees	11	3	11001000000000
Ficinia fascicularis Nees	11	2	00110000000000
Ficinia leiocarpa Nees	11	1	00100000000000
Ficinia sp	11	1	00100000000000
Fimbristylis complanata (Retz.)Link	11	2	00000000110000
Fimbristylis hispidula (Vahl)Kunth	11	1	00000000010000
Fimbristylis obtusifolia (Lam.)Kunth	11	2	00000000110000
Isolepis costata (Boeck.)A. Rich.	11	2	00110000000000
Isolepis ludwigii Kunth	11	2	00110000000000
Isolepis prolifer R. Br.	11	1	00100000000000
Mariscus congestus (Vahl)C.B. Cl.	11	5	00010000101011

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Mariscus dregeanus Kunth	11	2	00000001100000
Mariscus sumatrensis (Retz.)J. Raynal	11	1	00000000010000
Schoenoplectus corymbosus (Roth. ex Roem. & Schult.)J. Raynal	11	1	00000000000100
Schoenoxiphium altum Kukkonen	11	1	00100000000000
Schoenoxiphium lanceum (Thunb.)Kuekenth.	11	5	11100010000010
Schoenoxiphium lehmannii (Nees)Steud.	11	8	11111010001100
Schoenoxiphium sparteum (Wahlenb.)C.B. Cl.	11	1	00000000001000
Scleria natalensis C.B. Cl.	11	3	00100010000010
Scleria angusta Nees ex Kunth	11	1	00000000100000
DAVALLIACEAE 3, 4, 1,3			
Arthropteris monocarpa (Cordem.)C. Chr.	7	1	00000000000100
Nephrolepis biserrata (Swartz)Schott	7	1	00000000100000
Nephrolepis exaltata (L.)Schott	7	1	00000010000000
Oleandra distenta Kunze	7	1	00000010000000
DENNSTAEDTIACEAE 4, 5, 1,3			
Blotiella glabra (Bory)Tryon	8	3	00100000000110
Blotiella natalensis (Hook.)Tryon	7	1	00100000000000
Histiopteris incisa (Thunb.)J. Sm.	8	5	11110000000010
Hypolepis sparsisora (Schrad.)Kuhn	8	7	11110000000111
Pteridium aquilinum (L.)Kuhn	8	10	11110000111111
DICHAPETALACEAE 1, 1, 1,0			
Tapura fischeri	1	2	00000001010000
DIOSCOREACEAE 1, 6, 6,0			
Dioscorea cotinifolia Kunth	6	5	00000010100111
Dioscorea crinita Hook.f.	6	1	00000000100000
Dioscorea dregeana (Kunth)Dur. & Schinz	6	4	00000110000101
Dioscorea mundtii Bak.	6	1	00100000000000
Dioscorea retusa Mast.	6	4	00011000000011
Dioscorea sylvatica (Kunth)Eckl.	6	7	00110000111110
DIPSACACEAE 1, 1, 1,0			
Scabiosa columbaria L.	12	2	00000000110000
EBENACEAE 2, 19, 9,5			
Diospyros austro-africana De Winter	3	3	00011000001000
Diospyros dichrophylla (Gand.)De Winter	1	5	00111110000000
Diospyros glabra (L.)De Winter	3	2	01100000000000
Diospyros inhacaensis F. White	1	2	00000000110000
Diospyros lycioides Desf.	3	8	00010010111111
Diospyros natalensis (Harv.)Brenan	2	5	00001011110000
Diospyros pallens (Thunb.)F. White	3	2	00101000000000
Diospyros rotundifolia Hiern	3	2	00000000110000
Diospyros scabrida (Harv. ex Hiern)De Winter	3	6	00011110110000
Diospyros simii (Kuntze)De Winter	3	4	01010110000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Diospyros villosa (L.)De Winter	5	6	00011111100000
Diospyros whyteana (Hiern)F. White	2	10	11110100011111
Euclea crispa (Thunb.)Guerke	2	8	00110110001111
Euclea divinorum Hiern	2	2	00000000110000
Euclea natalensis A. DC.	2	7	00001111110100
Euclea polyandra (L.f.)E. Mey. ex Hiern	3	1	00100000000000
Euclea racemosa Murray	2	3	01101000000000
Euclea schimperi (A. DC.)Dandy	2	7	01111100010100
Euclea undulata Thunb.	2	5	00111010010000
ERICACEAE 1, 1, 1,0			
Erica natalitia H. Bol.	3	1	00000010000000
ERYTHROXYLACEAE 2, 5, 2,5			
Erythroxylon delagoense Schinz	2	1	00000000100000
Erythroxylon emarginatum Thonn.	2	4	00001001110000
Erythroxylon pictum E. Mey. ex Sond.	3	5	00001110110000
Nectaropetalum capense (H. Bol.)Stapf & Boodle	3	1	00000010000000
Nectaropetalum zuluense (Schonl.)Corbishley	3	1	00000010000000
ESCALLONACEAE 1, 1, 1,0			
Choristylis rhamnoides Harv.	2	4	00010100000101
EUPHORBIACEAE 36, 67, 2,2			
Acalypha capensis (L.f.)Prain & Hutch.	12	1	00100000000000
Acalypha ecklonii Baill.	12	3	00110000100000
Acalypha glabrata Thunb.	3	5	00011011010000
Acalypha petiolaris Hochst.	3	1	00000000100000
Acalypha punctata Meisn.	4	1	00000000000010
Acalypha sonderiana Muell.Arg.	12	1	00000001000000
Acalypha wilmsii Pax ex Prain & Hutch.	3	1	00000100000000
Adenocline acuta (Thunb.)Baill.	6	7	01110100101001
Alchornea hirtella Benth.	2	1	00000000000010
Andrachne ovalis (Sond.)Muell. Arg.	3	5	00110100000101
Antidesma venosum E. Mey. ex Tul.	2	3	00000000110100
Bridelia cathartica Bertol.f.	2	2	00000000110000
Bridelia micrantha (Hochst.)Baill.	1	4	00000010110100
Cavacoa aurea (Cavaco)J. Leonard	1	1	00000001000000
Cleistanthus schlechteri (Pax)Hutch.	2	1	00000000010000
Clutia abyssinica Jaub. & Spach	3	2	00000010100000
Clutia affinis Sond.	3	4	00110000000011
Clutia alaternoides L.	4	3	10110000000000
Clutia hirsuta E. Mey. ex Sond.	4	1	00000000000100
Clutia laxa Eckl. ex Sond.	3	1	00100000000000
Clutia pulchella L.			
var. pulchella	3	6	11110110000000
var. obtusata Sond.	3	1	00000010000000
Croton gratissimus Burch.	3	1	00000000010000
Croton rivularis Muell. Arg.	3	2	00011000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Croton sylvaticus Hochst.	3	5	00000011100011
Croton zambesicus Muell. Arg.	3	1	00000000010000
Ctenomaria capensis (Thunb.)Harv. ex Sond.	6	6	00110010100101
Dalechampia capensis Spreng.f.	3	4	00001010100100
Dalechampia kirkii Prain	3	2	00000000110000
Dalechampia volubilis E. Mey. ex Baill.	3	1	00000000010000
Drypetes arguta (Muell. Arg.)Hutch.	2	4	00000011110000
Drypetes gerrardii Hutch.	1	4	00000010010101
Drypetes natalensis (Harv.)Hutch.	1	3	00000001110000
Erythrococca berberidea Prain	2	4	00000011110000
Erythrococca natalensis Prain	3	1	00000010000000
Erythrococca sp nov	3	1	00000010000000
Euphorbia grandidens Haw.	3	1	00000010000000
Euphorbia guienzii Boiss.	3	1	00000010000000
Euphorbia kraussiana Bernh.	4	9	00111110100111
Euphorbia tirucalli L.	4	2	00000010010000
Euphorbia triangularis Desf.	3	2	00001010000000
Excoecaria simii (Kuntze)Pax	3	4	00111010000000
Heywoodia lucens Sim	1	2	00000010100000
Hymenocardia ulmoides Oliv.	2	1	00000000010000
Lachnostylis hirta (L.f.)Muell. Arg.	2	1	00100000000000
Leidesia procumbens (L.)Prain	12	5	10111000000001
Macaranga capensis (Baill.)Benth. ex Sim	1	3	00000110100000
Margaritaria discoidea (Baill.)Webster			
subsp. discoidea	3	1	00000010000000
subsp. nitida (Pax)Webster	3	1	00000010000000
Micrococca capensis (Baill.)Prain	3	2	00000011000000
Phyllanthus maderapetensis L.	3	2	00000000110000
Phyllanthus myrtaceus Sond.	3	1	00000010000000
Phyllanthus reticulatus Poir.	3	1	00000000100000
Phyllanthus verrucosus Thunb.	3	1	00000000010000
Sapium ellipticum (Hochst.)Pax	1	1	00000000100000
Sapium integerrimum (Hochst.)J. Leonard	3	3	00000001110000
Securinega virosa (Roxb. ex Willd.)Pax & K. Hoffm.	3	2	00000000000110
Sphaerostylis natalensis (Sond.)Croizat	6	1	00000000000001
Spirostachys africana Sond.	2	1	00000000010000
Suregada africana (Sond.)Kuntze	2	7	00011111110000
Suregada procera (Prain)Croizat	2	2	00000010000001
Suregada zanzibariensis Baill.	3	1	00000000010000
Synadenium cupulare (Boiss.)L.C. Wheeler	12	1	00000001000000
Tragia sp	6	2	00100010000000
Tragia durbanensis Kuntze	6	1	00000000010000
Tragia meyeriana Muell.Arg.	6	1	00000000010000
Tragia rupestris Sond.	6	2	00000000110000
FABACEAE 43, 79, 1,8			
Abrus laevigatus E. Mey.	3	1	00000000000100
Abrus precatorius L.	3	1	00000000100000
Acacia ataxacantha DC.	3	4	00000010000111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Acacia karroo Hayne	2	7	00011010110011
Acacia kraussiana Meisn. ex Benth.	5	3	00000001110000
Acacia schweinfurthii Brenan & Exell	5	1	00000000010000
Albizia adianthifolia (Schumach.)W.F. Wight	1	3	00000001110000
Argyrolobium pilosum Harv.	3	2	00010100000000
Argyrolobium rupestre (Eckl. & Zeyh.)Walp.	3	1	00000000100000
Argyrolobium speciosum Eckl. & Zeyh.	12	1	00000000000100
Argyrolobium tomentosum (Andr.)Druce	3	6	00110110000011
Baphia racemosa (Hochst.)Bak.	1	1	00000001000000
Bauhinia galpinii N.E. Br.	3	3	00000000000111
Bauhinia tomentosa L.	3	1	00000000010000
Calpurnia aurea (Ait.)Benth.	3	7	00110100100111
Calpurnia sp	3	1	00000000000010
Canavalia bonariensis Lindl.	5	1	00000000100000
Cassia petersiana Bolle	3	2	00000000000101
Cordyla africana Lour.	1	1	00000000010000
Craibia zimmermannii (Harms)Dunn	1	2	00000000110000
Crotalaria capensis Jacq.	3	5	00100000110110
Crotalaria recta Steud. ex A. Rich.	3	2	00000000000110
Dalbergia armata E. Mey.	5	9	00001111110111
Dalbergia multijuga E. Mey.	3	2	00000110000000
Dalbergia nitidula Bak.	3	1	00000000010000
Dalbergia obovata E. Mey.	5	3	00001010010000
Desmodium repandum (Vahl)DC.	3	7	00110000101111
Desmodium setigerum (E. Mey.)Benth. ex Harv.	3	1	00000000100000
Dichrostachys cinerea (L.)Wight & Arn.	2	3	00000001110000
Dipogon lignosus (L.)Verdc.	6	4	11101000000000
Dolichos peglerae L. Bol.	6	1	00000000010000
Dumasia villosa DC.	6	4	00100000001101
Entada rheedii Spreng.	5	1	00000000100000
Entada spicata (E. Mey.)Druce	5	6	00010010100111
Eriosema salignum E. Mey.	12	2	00000000110000
Erythrina caffra Thunb.	1	5	00111100010000
Erythrina lysistemon Hutch.	1	6	00000010110111
Flemingia grahamiana Wight & Arn.	12	1	00000000000100
Glycine javanica L.	6	1	00000000100000
Indigofera garkeana Vatke	3	1	00000000000010
Indigofera micrantha E. Mey.	3	1	00000010000000
Indigofera natalensis H. Bol.	3	1	00000010000000
Indigofera spicata Forssk.	3	2	00000000110000
Indigofera swaziensis H. Bol.	3	1	00000000000100
Lotononis wyliei J.M. Wood	3	1	00000010000000
Macrotyloma axillare (E. Mey.)Verdc.	4	1	00000000100000
Millettia grandis (E. Mey.)Skeels	2	1	00000010000000
Mucunia coriacea Bak.	6	1	00000000000100
Neonotonia wightii (Arn.)Lackey	6	1	00000000000100
Otholobium caffrum (Eckl. & Zeyh.)C.H. Stirton	3	1	00000000001000
Otholobium fruticans (L.)C.H. Stirton	3	1	00100000000000
Pearsonia aristata (Schinz)Duemmer	12	1	00000000000100

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Pearsonia sessilifolia (Harv)Duemmer	12	1	00000000000100
Podalyria velutina Burch.	3	1	00000010000000
Pseudarthra hookeri Wight & Arn.	12	2	00000000100100
Psoralea pinnata L.	3	6	01110110000010
Rhynchosia capensis (Burm.)Schinz	3	1	10000000000000
Rhynchosia caribaea (Jacq.)DC.	6	10	00111110101111
Rhynchosia hirta (Andr.)Meikle & Verdc.	6	1	00000000000100
Rhynchosia komatiensis Harms	3	1	00000000000100
Rhynchosia monophylla Schltr.	6	1	00000000000100
Rhynchosia ovata Wood & Evans	3	1	00000000100000
Rhynchosia stenodon Bak.f.	6	1	00000000100000
Rhynchosia thorncroftii (Bak.f.)Burtt Davy	3	1	00000000000100
Rhynchosia totta (Thunb.)DC.	6	2	00000000110000
Schotia brachypetala Sond.	1	3	00000100100010
Schotia afra (L.)Thunb. var. afra	1	2	00101000000000
Schotia latifolia Jacq.	1	3	00111000000000
Sophora inhambanensis Klotzsch	3	1	00000000010000
Sophora tomentosa L.	3	1	00000000010000
Sphenostylis marginata E. Mey.	3	3	00000010100100
Tephrosia pondoensis (Codd)Shrire	3	1	00000010000000
Tephrosia shiluwanensis Schinz	3	2	00000010000100
Teramnus labialis (L.f.)Spreng.	6	1	00000000000001
Virgilia divaricata Adamson	1	1	00100000000000
Virgilia oroboides (Berg.)Salter			
subsp. ferruginea B.-E. van Wyk	1	1	00100000000000
subsp. oroboides	1	2	11000000000000
Umtiza listeriana Sim	2	1	00001000000000
Zornia capensis Pers.	12	1	00000000100000
FLACOURTIACEAE 11, 21, 1,9			
Aphloia theiformis (Vahl)Benn.	3	1	00000000000001
Casearia gladiiformis Mast.	3	1	00000010000000
Dovyalis caffra (Hook.f. & Harv.)Hook.f.	2	3	00001000010010
Dovyalis longispina (Harv.)Warb.	2	3	00000001110000
Dovyalis lucida Sim	2	6	00110110100100
Dovyalis rhamnoides (Burch. ex DC.)Harv.	3	8	00101111110010
Dovyalis rotundifolia (Thunb.)Thunb. & Harv.	2	3	00111000000000
Dovyalis sp	3	1	00000000010000
Dovyalis zeyheri (Sond.)Warb.	2	5	00010100001101
Gerrardina foliosa Oliv.	2	1	00000010000000
Homalium dentatum (Harv.)Warb.	1	3	00000010000011
Homalium rufescens Benth.	3	1	00000010000000
Kiggelaria africana L.	1	10	11110111000111
Pseudoscolopia polyantha Gilg.	3	1	00000010000000
Rawsonia lucida Harv. & Sond.	3	7	00000110110111
Scolopia mundii (Eckl. & Zeyh.)Warb.	1	10	11110110111100
Scolopia oreophila (Sleum.)Killick	2	1	00000100000000
Scolopia zeyheri (Nees)Harv.	1	8	00111110110001
Trimeria grandifolia (Hochst.)Warb.	2	10	00111110101111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Trimeria trinervis Harv.	2	3	00011100000000
Xylotheca kraussiana Hochst.	3	4	00000101110000
FLAGELLARIACEAE 1, 1, 1,0			
Flagellaria guineensis Schumach.	6	5	00001011110000
GENTIANACEAE 2, 3, 1,5			
Chironia laxa Gilg	12	1	00000010000000
Chironia pegleriae Prain	12	1	00000000001000
Neurotheca schlechteri Gilg ex Bak. & N.E. Br.	12	1	00000000010000
GERANIACEAE 3, 6, 2,0			
Geranium ornithopodon Eckl. & Zeyh.	12	3	00010010100000
Monsonia natalensis Knuth	3	1	00000010000000
Pelargonium alchemilloides (L.)L'Herit.	4	2	00010000100000
Pelargonium cordifolium (Cav.)Curtis	4	2	00110000000000
Pelargonium papilionaceum (L.)L'Herit.	4	1	00100000000000
Pelargonium zonale (L.)L'Herit.	4	2	00110000000000
GESNERIACEAE 1, 12, 12,0			
Streptocarpus confusus Hilliard	12	1	00000000000010
Streptocarpus cyaneus S. Moore	12	2	00000000000110
Streptocarpus gardenii Hook.	12	1	00000000001000
Streptocarpus haygarthii N.E. Br. ex C.B. Cl.	12	1	00000010000000
Streptocarpus micranthus C.B. Cl.	12	1	00000000000010
Streptocarpus parviflorus Hook.f.	12	2	00000000000011
Streptocarpus polyanthus Hook.	12	2	00000010000100
Streptocarpus porphyrostachys Hilliard	12	1	00000010000000
Streptocarpus primulifolius Gand.	12	1	00000010000000
Streptocarpus pusillus Harv. ex C.B. Cl.	12	1	00000000001000
Streptocarpus rexii (Hook.)Lindl.	12	4	00111100000000
Streptocarpus wilmsii Engl.	12	1	00000000000010
GLEICHENIACEAE 2, 3, 1,5			
Dicranopteris linearis (Burm.f.)Underw.	8	1	00000000000100
Gleichenia polypodioides (L.)J.E. Sm.	8	6	11110010000010
Gleichenia umbraculifera (Kunze)T. Moore	8	2	00000100001000
GREYIACEAE 1, 1, 1,0			
Greyia radlkoferi Szyszyl.	2	1	00000000000100
HALORAGACEAE 1, 1, 1,0			
Laurembergia repens Berg.	12	4	00110010000001
HAMAMELIDACEAE 1, 3, 3,0			
Trichocladus crinitus (Thunb.)Pers.	3	3	01100010000000
Trichocladus ellipticus Eckl. & Zeyh. ex Walp.	3	6	00111110000001
Trichocladus grandiflorus Oliv.	3	3	00000010000110

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
HYMENOPHYLLACEAE 2, 6, 3,0			
Hymenophyllum capense Schrad.	9	3	10100000000010
Hymenophyllum marlothii Brause	9	1	00100000000000
Hymenophyllum peltatum (Poir.)Desv.	9	1	00100000000000
Hymenophyllum polyanthos Swartz	9	1	00000000000010
Hymenophyllum tunbridgense (L.)J.E. Sm.	9	4	11100000000010
Trichomanes pyxidiferum L.	9	7	00110010001111
HYPOXIDACEAE 1, 3, 3,0			
Hypoxis membranacea Bak.	10	1	00000010000000
Hypoxis rooperi S. Moore	10	1	00000000100000
Hypoxis sp	10	1	00100000000000
ICACINACEAE 3, 6, 2,0			
Apodytes dimidiata E. Mey. ex Arn.	1	13	11111110111111
Apodytes sp nov	3	1	00000010000000
Cassinopsis ilicifolia (Hochst.)Kuntze	3	6	01110100001100
Cassinopsis tinifolia Harv.	3	1	00000010000000
Pyrenacantha grandiflora Baill.	5	2	00000000000011
Pyrenacantha scandens Planch. ex Harv.	6	4	01100000110000
ILLECEBRACEAE 1, 3, 3,0			
Silene bellidioides Sond.	12	1	00100000000000
Silene burchellii Otth	12	1	00000000100000
Silene undulata Ait.	12	2	00110000000000
IRIDACEAE 7, 8, 1,1			
Anomatheca laxa (Thunb.)Goldbl.	10	2	00000000100010
Aristea ecklonii Bak.	10	4	00010010000011
Aristea ensifolia Muir	10	2	01100000000000
Chasmanthe aethiopica (L.)N.E. Br.	10	2	10100000000000
Crocosmia aurea Planch.	10	3	00000100100100
Dietes iridioides (L.)Sweet ex Klatt	10	11	01111110101111
Gladiolus sempervirens G.J. Lewis	10	1	00100000000000
Melasphaerula ramosa (L.)N.E. Br.	10	1	00100000000000
JUNCACEAE 1, 2, 2,0			
Juncus capensis Thunb.	11	2	00110000000000
Juncus lomatophyllus Spreng.	11	6	01110000100011
LAMIACEAE 10, 33, 3,3			
Endostemon obtusifolius (E. Mey.ex Benth.)N.E.Br.	12	5	00000010100111
Leonotis leonurus (L.)R. Br.	4	4	10110000000010
Leonotis ocymifolia (Burm.f.)Iwarsson var raineriana (Visiani)Iwarsson	4	2	00000000001100
Leucas glabrata (Vahl)SM.	4	1	00000000000010
Plectranthus ambiguus (H. Bol.)Codd	4	2	00010010000000
Plectranthus ciliatus E. Mey. ex Benth.	12	3	00110010000000
Plectranthus dolichopodus Briq.	12	2	00000000001001

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Plectranthus ecklonii Benth.	12	2	00010010000000
Plectranthus fruticosus L'Herit.	4	6	01110000000111
Plectranthus grandidentatus Guerke	4	1	00000000000100
Plectranthus hadiensis (Forssk.)Schweinf. ex Spreng.	12	1	00000010000000
Plectranthus hereroensis Engl.	12	1	00000000000001
Plectranthus hilliardiae Codd	12	1	00000010000000
Plectranthus laxiflorus Benth.	12	5	00110000000111
Plectranthus madagascariensis	12	1	00100000000000
Plectranthus rubropunctatus Codd	12	1	00000000000100
Plectranthus saccatus Benth.			
var. saccatus	12	1	00000010000000
var. longitubus Codd	12	1	00000010000000
Plectranthus strigosus Benth.	12	3	00011010000000
Plectranthus swynnertonii S. Moore	12	1	00000000000001
Plectranthus verticillatus (L.f.)Druce	12	5	00110000100101
Plectranthus zuluensis T. Cooke	12	1	00000010000000
Pycnostachys reticulata (E. Mey.)Benth.	3	5	00000010100111
Salvia scabra L.f.	12	1	00001000000000
Satureja reptans Killick	12	1	00000000001000
Solenostemon latifolius (Hochst. ex Benth)J.K. Morton	4	1	00000000000001
Stachys aethiopica L.	12	9	11111010110010
Stachys caffra E. Mey. ex Benth.	12	1	00000000001000
Stachys graciliflora Presl	12	3	00110010000000
Stachys grandifolia E. Mey. ex Benth.	12	3	00010000000101
Stachys scabrida Skan	12	1	00100000000000
Stachys thunbergii Benth.	12	1	00100000000000
Tetradenia brevispicata (N.E. Br.)Codd	3	1	00000000000100
LAURACEAE 4, 9, 2,3			
Cassytha ciliolata Nees	9	2	00100000000001
Cryptocarya latifolia Sond.	2	2	00000110000000
Cryptocarya liebertiana Engl.	1	2	00000000000011
Cryptocarya myrtifolia Stapf	2	1	00000010000000
Cryptocarya woodii Engl.	2	6	00011110100010
Cryptocarya wyliei Stapf	3	1	00000010000000
Dahlgrenodendron natalense (J.H. Ross)J.J.M. v.d.Merwe & Van Wyk	2	1	00000010000000
Ocotea bullata (Burch.)Baill.	1	6	11110100001000
Ocotea kenyensis (Chiov.)Robyns	1	3	00000000000111
LECYTHIDACEAE 1, 1, 1,0			
Barringtonia racemosa (L.)Roxb.	2	1	00000000100000
LILIACEAE 22, 42, 1,9			
Agapanthus praecox Willd.	10	4	00110110000000
Aloe arborescens Mill.	4	7	00110010001111
Aloe aristata Haw.	4	1	00000000001000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Aloe ciliaris Haw.	4	1	00001000000000
Aloe longibracteata Pole Evans	4	1	00000000000100
Aloe umfoloziensis Reynolds	4	1	00000000100000
Anthericum saundersiae Bak.	10	1	00000000100000
Behnia reticulata (Thunb.)Didr.	6	8	00011111000111
Bulbine latifolia (L.f.)Roem. & Schult.	10	3	00110010000000
Chlorophytum comosum (Thunb.)Jacq.	10	10	01111110101011
Chlorophytum modestum Bak.	10	2	00000101000000
Dracaena hookerana K. Koch	4	8	00011011110110
Drimiopsis maculata Lindl.	10	2	00000010100000
Drimiopsis maxima Bak.	10	1	00000010000000
Eriospermum natalense Bak.	10	1	00000000010000
Eucomis bicolor Bak.	10	1	00000000001000
Eucomis pole-evansii N.E. Br.	10	1	00000000000010
Frullania sp	10	1	00000000100000
Gasteria acinacifolia (Jacq.)Haw.	10	2	00100010000000
Gloriosa superba L.	6	4	00000000110011
Ledebouria cooperi (Hook.f.)Jessop	10	1	00000000000010
Littonia modesta Hook.	6	3	00000000001011
Myrsiphyllum asparagoides (L.)Willd.	6	9	01111000011111
Myrsiphyllum scandens (Thunb.)Oberm.	6	5	11100000001010
Myrsiphyllum volubile (Thunb.)Oberm.	6	1	00100000000000
Ornithogalum dubium Houtt.	10	1	00100000000000
Ornithogalum graminifolium Thunb.	10	2	00011000000000
Ornithogalum longibracteatum Jacq.	10	4	01111000000000
Protasparagus aethiopicus (L.)Oberm.	6	4	11110000000000
Protasparagus africanus (Lam.)Oberm.	12	4	10011000000100
Protasparagus angusticladus (Jessop)Oberm.	6	1	00000000000100
Protasparagus falcatus (L.)Oberm.	6	7	00000011110111
Protasparagus macowanii (Bak.)Oberm.	4	4	01111000000000
Protasparagus nodulosus Oberm. ms.	12	1	00001000000000
Protasparagus racemosus (Willd.)Oberm.	4	2	00000000000101
Protasparagus setaceus (Kunth)Oberm.	6	11	01111011110111
Protasparagus sp (A. virgatus Bak.)	6	4	00000010100101
Protasparagus suaveolens (Burch.)Oberm.	6	2	00011000000000
Sansevieria hyacinthoides (L.)Druce	12	4	00001000100010
Smilax kraussiana Meisn.	5	6	00000010110111
Trachyandra ciliata (L.f.)Kunth	10	1	00100000000000
Tulbaghia violacea Harv.	10	1	00100000000000
LINDSAEACEAE 1, 1, 1,0			
Lindsaea ensifolia Swartz	8	1	00000000100000
LOBELIACEAE 3, 8, 2,7			
Cyphia digitata (Thunb.)Willd.	6	1	00100000000000
Cyphia heterophylla Presl. ex Eckl. & Zeyh.	6	1	00100000000000
Cyphia sylvatica Eckl.			
var. salicifolia (Presl.)E. Wimm.	6	1	00001000000000
Lobelia anceps L.f.	12	2	00110000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Lobelia cuneifolia Link & Otto	12	1	00100000000000
Lobelia patula L.f.	12	4	01110000001000
Lobelia pteropoda (Presl.)A. DC.	12	1	00000000000010
Monopsis stellarioides (Presl.)Urb.	12	2	00010000000010
LOGANIACEAE 4, 13, 3,3			
Anthocleista grandiflora Gilg	1	3	00000000000111
Buddleja auriculata Benth.	3	4	00010100001100
Buddleja dysophylla (Benth.)Radlk.	3	2	00010100000000
Buddleja saligna Willd.	2	6	01111110000000
Buddleja salviifolia (L.)Lam.	3	7	01110100001011
Nuxia congesta R. Br. ex Fresen.	2	4	00001010000011
Nuxia floribunda Benth.	1	8	01111110000011
Strychnos decussata (Pappe)Gilg	1	7	00101011110010
Strychnos henningsii Gilg	2	5	00010111010000
Strychnos madagascariensis Poir.	2	4	00000010110000
Strychnos mitis S. Moore	2	4	00001010010001
Strychnos spinosa Lam.	3	4	00000010110100
Strychnos usambarensis Gilg	2	3	00000111000000
LOMARIOPSIDACEAE 1, 2, 2,0			
Elaphoglossum acrostichoides (Hook.& Grev.)Schelpe	9	5	10110000000011
Elaphoglossum angustatum (Schrad.)Hieron.	9	5	01100010001010
LORANTHACEAE 3, 6, 2,0			
Erianthemum dregei (Eckl. & Zeyh.)V. Tieghem	3	4	00000010100101
Helixanthemum woodii	3	1	00000010000000
Tapinanthus kraussianus (Meisn.)V. Tieghem	3	4	00000011110000
Tapinanthus natalitius (Meisn.)Danser subsp zeyheri (Harv.)Wiens	3	1	00000000100000
Tapinanthus prunifolius (E. Mey.ex Harv.)V. Tieghem	5	1	00010000000000
Tapinanthus sp	3	1	00100000000000
LYCOPODIACEAE 1, 6, 6,0			
Lycopodium cernuum L.	8	4	00100010000011
Lycopodium clavatum L.	8	4	00110000000011
Lycopodium gnidioides L.f.	9	7	01110110000110
Lycopodium ophioglossoides Lam.	9	1	00000000000010
Lycopodium saururus Lam.	8	1	00000000001000
Lycopodium verticillatum L.f.	9	5	00010110001010
LYTHRACEAE 1, 1, 1,0			
Rhynchocalyx lawsonioides Oliv.	2	1	00000010000000
MALPIGHIACEAE 2, 2, 2,0			
Acridocarpus natalitius Juss.	5	3	00000011100000
Sphedamnocarpus galphimiifolius (Juss.)Szyszyl.	6	3	00000000000111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
MALVACEAE 5, 15, 3,0			
Abutilon grantii A. Meeuse	12	1	00000001000000
Abutilon sonneratianum (Cav.)Sweet	12	5	00111000100001
Hibiscus calyphyllus Cav.	4	1	00000010000000
Hibiscus diversifolius Jacq.	4	2	00100000100000
Hibiscus ludwigii Eckl. & Zeyh.	12	1	00100000000000
Hibiscus pedunculatus L.f.	4	4	00100010000011
Hibiscus surattensis L.	12	1	00000000100000
Hibiscus tiliaceus L.	2	2	00000000110000
Hibiscus trionum L.	12	1	00000000100000
Pavonia columella Cav.	12	5	00110010000110
Pavonia praemorsa (L.f.)Cav.	12	1	00001000000000
Sida dregei Burtt Davy	12	3	00100010000001
Sida rhombifolia L.	12	3	00010010100000
Sida ternata L.f.	12	3	00110000000001
Thespesia acutiloba (Bak.f.)Exell. & Mendona	12	1	00000000010000
MARATTIACEAE 1, 1, 1,0			
Marattia fraxinea J.E. Sm. ex J.F. Gmel.	7	6	00100110000111
MELASTOMACEAE 1, 2, 2,0			
Memecylon bachmannii Engl.	2	1	00000010000000
Memecylon natalense Markg.	2	1	00000010000000
MELIACEAE 3, 6, 2,0			
Ekebergia capensis Sparrm.	1	11	00111110111111
Ekebergia pterophylla (C. DC.)Hofmeyr	2	4	00000110100110
Trichilia dregeana Sond.	1	4	00000110100001
Trichilia emetica Vahl	1	4	00000000110011
Turraea floribunda Hochst.	2	4	00000011110000
Turraea obtusifolia Hochst.	2	3	00001001100000
MELIANTHACEAE 2, 5, 2,5			
Bersama lucens (Hochst.)Szyszyl.	2	5	00000111110000
Bersama swinnyi Phill.	2	1	00000010000000
Bersama transvaalensis Turrill	2	3	00000000000111
Bersama tysoniana OLiv.	2	4	00000110000110
Melianthus villosus H. Bol.	4	1	00000000001000
MENISPERMACEAE 3, 5, 1,7			
Cissampelos capensis L.f.	6	2	10100000000000
Cissampelos hirta Klotzsch	6	1	00000000100000
Cissampelos torulosa E. Mey. ex Harv.	6	9	00111100110111
Stephania abyssinica (Dill. & Rich.)Walp.	6	2	00000000000110
Tinospora caffra (Miers)Troupin	6	3	00000001110000
MESEMBRYANTHEMACEAE 4, 6, 1,5			
Aptenia cordifolia (L.f.)Schwant.	12	3	00111000000000
Carpobrotus dimidiatus (Haw.)L. Bol.	12	2	00000000110000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Carpobrotus edulis (L.)L. Bol.	12	1	00001000000000
Delosperma calycinum L. Bol.	12	1	00001000000000
Delosperma sp	12	1	00000010000000
Mesembryanthemum aitonis Jacq.	12	1	00001000000000
MORACEAE 3, 14, 4,7			
Bosquiea phoberos Baill.	1	1	00000000100000
Ficus bizanae Hutch. & Burtt Davy	2	1	00000010000000
Ficus burtt-davyi Hutch.	3	8	00111111110000
Ficus capreifolia Del.	5	1	00000000100000
Ficus craterostoma Warb. ex Mildbr. & Burr.	1	5	00000110100011
Ficus ingens (Miq.)Miq.	1	3	00000100101100
Ficus lutea Vahl	2	1	00000000010000
Ficus natalensis Hochst.	1	3	00001000110000
Ficus polita Vahl	1	2	00000001010000
Ficus sur Forssk.	1	8	00110110100111
Ficus sycomorus L.	1	1	00000000100000
Ficus thonningii Blume	2	2	00000010000100
Ficus trichopoda Bak.	1	1	00000000100000
Morus mesozygia Stapf	1	1	00000000010000
MUSACEAE 1, 1, 1,0			
Ensete ventricosum (Welw.)E.E. Cheesm.	4	1	00000000000001
MYRICACEAE 1, 3, 3,0			
Myrica pilulifera Rendle	3	4	00000100001110
Myrica quercifolia L.	3	1	00100000000000
Myrica serrata Lam.	3	8	01110010101110
MYRSINACEAE 4, 4, 1,0			
Embelia ruminata (E. Mey. ex A. DC.)Mez	5	3	00000011100000
Maesa lanceolata Forssk.	2	6	00010010100111
Myrsine africana L.	3	9	10110110001111
Rapanea melanophloeos (L.)Mez	1	11	11110110101111
MYRTACEAE 3, 13, 4,3			
Eugenia albanensis Sond.	1	1	00000000100000
Eugenia capensis (Eckl. & Zeyh.)Harv. ex Sond.	2	4	00001001110000
Eugenia erythrophylla Strey	2	1	00000010000000
Eugenia gueinzii Sond.	2	2	00000000110000
Eugenia natalitia Sond.	2	7	00000110110111
Eugenia umtamvunensis Van Wyk	3	1	00000010000000
Eugenia verdoorniae Van Wyk	3	1	00000010000000
Eugenia zeyheri Harv.	2	2	00011000000000
Eugenia zuluensis Duemmer	2	3	00000010110000
Heteropyxis natalensis Harv.	2	1	00000000000100
Syzygium cordatum Hochst.	1	8	00101010110111
Syzygium gerrarrdii (Harv. ex Hook.f.)Burtt Davy	1	4	00000010000111
Syzygium guineense (Willd.)DC>	2	3	00000000100011

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
NYCTAGINACEAE 2, 2, 2,0			
Commicarpus africanus (Lour.)Dandy	6	3	00000001110000
Pisonia aculeata L.	5	2	00000000110000
OCHNACEAE 1, 7, 7,0			
Ochna arborea Burch. ex DC.			
var. arborea	2	8	00111110110100
var. oconnorii (Phill.)Du Toit	2	2	00000000000011
Ochna gamostigmata Du Toit	3	1	00000000000100
Ochna holstii Engl.	2	5	00000100010111
Ochna inermis (Forssk.)Schweinf.	2	1	00000000010000
Ochna natalitia (Meisn.)Walp.	3	7	00000111110110
Ochna serrulata (Hochst.)Walp.	3	5	00110110001000
OLACACEAE 1, 2, 2,0			
Ximenia americana L.	3	1	00000000010000
Ximenia caffra Sond.	3	2	00000000110000
OLEACEAE 4, 17, 4,3			
Chionanthus foveolata (E. Mey.)Stearn			
subsp. foveolata	2	8	11111100000110
subsp. major (Verdoorn)Stearn	2	1	00000000000010
subsp. tomentellus (Verdoorn)Stearn	2	2	00100010000000
Chionanthus pegleriae (C.H. Wr.)Stearn	1	6	00110110110000
Jasminum abyssinicum Hochst. ex DC.	6	1	00000000000010
Jasminum angulare Vahl	6	2	00101000000000
Jasminum fluminense Vell.	6	1	00000000000010
Jasminum multipartitum Hochst.	6	2	00000000110000
Jasminum streptopus E. Mey.			
var. streptopus	5	2	00000001010000
var. transvaalensis(S. Moore)Verdoorn	5	5	00000010010111
Olea capensis L.			
subsp. capensis	2	7	11111110000000
subsp. enervis (Harv. ex C.H. Wr.)Verdoorn	1	2	00000011000000
subsp. macrocarpa (C.H. Wr.)Verdoorn	1	12	11110111110111
Olea europaea L.			
subsp. africana (Mill.)P.S. Green	1	8	11111100000110
Olea exasperata Jacq.	3	2	00101000000000
Olea woodiana Knobl.	1	6	00001011110010
Schrebera alata (Hochst.)Welw.	3	3	00000010000110
OLINIACEAE 1, 3, 3,0			
Olinia emarginata Burtt Davy	1	2	00000100001000
Olinia radiata J. Hofmeyr & Phill.	3	3	00000110010000
Olinia ventosa (L.)Cufod.	1	7	11111110000000
ONAGRACEAE 1, 1, 1,0			
Epilobium hirsutum L.	12	2	00110000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
ORCHIDACEAE 27, 53, 2,0			
Acrolophia cochlearis Schltr. & H. Bol.	10	1	00000000100000
Aerangis mystacidii (Reichb.f.)Schltr.	9	2	00000000100001
Angraecum burchellii Reichb.f.	9	1	00100000000000
Angraecum conchiferum Lindl.	9	3	00110000000010
Angraecum pusillum Lindl.	9	3	01101000000000
Angraecum sacciferum Lindl.	9	3	00110000000010
Ansellia gigantea Reichb.f.	9	2	00000000000100
Bonatea speciosa (L.f.)Willd.	10	2	00100000100000
Brownleea coeruleea Harv. ex Lindl.	10	3	00010010000100
Bulbophyllum sandersonii Reichb.f.	9	3	00000000000111
Calanthe sylvatica (Thouars)Lindl.	10	2	00100000000001
Corymborkis corymbis Thouars	10	1	00000010000000
Cyrtorchis arcuata (Lindl.)Schltr.	9	4	00100010100001
Cyrtorchis praetermissa Summerh.	9	2	00000000000011
Disperis fanniniae Harv.	10	3	00000100001100
Disperis lindleyana Reichb.f.	10	3	00110000000001
Disperis micrantha Lindl.	10	1	00010000000000
Disperis thorncroftii Schltr.	10	3	00100000101000
Eulophia meleagris Reichb.f.	10	1	00010000000000
Eulophia streptopetala Lindl.	10	2	00000000100100
Habenaria arenaria Lindl.	10	2	00100000000010
Habenaria malacophylla Reichb.f.	10	2	00010100000000
Holothrix aspera (Lindl.)Reichb.f.	10	1	10000000000000
Holothrix orthoceras (Harv.)Reichb.f.	10	3	00010010001000
Holothrix parviflora (Lindl.)Reichb.f.	10	1	00100000000000
Huttonaea pulchra Harv.	10	3	00010100001000
Jumellea filicornoides (De Wild.)Schltr.	9	1	00000000000001
Liparis bowkeri Harv.	10	2	00000000001001
Liparis capensis Lindl.	10	1	00100000000000
Liparis remota J. Stewart & Schelpe	10	2	00100010000000
Microcoeli exilis Lindl.	9	3	00000001110000
Monadenia bracteata (Swartz)Dur. & Schinz	10	1	00100000000000
Mystacidium caffrum (H. Bol.)H. Bol.	9	2	00000100000001
Mystacidium capense (L.f.)Schltr.	9	3	00100001000010
Mystacidium flanaganii (H. Bol.)H. Bol.	9	3	00010001100000
Mystacidium gracile (Reichb.f.)Harv.	9	1	00010000000000
Mystacidium venosum Harv. ex Rolfe	9	2	00000010000001
Oberonia disticha (Lam.)Schltr.	9	1	00000000000001
Oeceoclades lonchophylla (Reichb.f)Garay & Taylor	10	1	00000000010000
Platylepis glandulosa (Lindl.)Reichb.f.	10	1	00000000100000
Polystachya albescens Ridley subsp. imbricata (Rolfe)Summerh.	9	1	00000000000001
Polystachya concreta (Jacq.)Garray & Sweet	9	2	00000000000101
Polystachya ottoniana Reichb.f.	9	8	01110100001111
Polystachya pubescens Reichb.f.	9	2	00010000100000
Polystachya transvaalensis Schltr.	9	2	00000100000010
Polystachya zambesiaca Rolfe	9	1	00000000000001
Satyrium ligulatum Lindl.	10	2	00110000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Satyrium neglectum Schltr.	10	1	00000000000001
Satyrium parviflorum Swartz	10	3	00010100000001
Stenoglottis fimbriata Lindl.	9	6	00010100001111
Tridactyle bicaudata (Lindl.)Schltr.	9	3	00101010000000
Tridactyle tricuspis (H. Bol.)Schltr.	9	3	00000000000111
Tridactyle tridentata (Harv.)Schltr.	9	1	00000010000000
OSMUNDACEAE 2, 2, 1,0			
Osmunda regalis L.	7	5	00100010001011
Todea barbara (L.)T. Moore	7	6	11100010000110
OXALIDACEAE 1, 4, 4,0			
Oxalis incarnata L.	12	2	00101000000000
Oxalis purpurea L.	12	4	11101000000000
Oxalis semiloba Sond.	12	1	00000000100000
Oxalis stellata Eckl. & Zeyh. var. gracilior Salter	12	1	00100000000000
PASSIFLORACEAE 1, 3, 3,0			
Adenia digitata (Harv.)Engl.	5	1	00000000000100
Adenia gummifera (Harv.)Harms	5	6	00000011110011
Adenia hastata (Harv.)Schinz	5	1	00000001000000
PEDALIACEAE 1, 1, 1,0			
Ceratotheca triloba (Bernh.)Hook.f.	12	2	00000000100100
PERIPLOCACEAE 4, 5, 1,3			
Cryptolepis capensis Schltr.	6	1	00000000000001
Cryptolepis oblongifolia (Meisn.)Schltr.	12	2	00000010000100
Mondia whitei (Hook.f.)Skeels	5	2	00000000100001
Petopentia natalensis (Schltr.)Bullock	3	1	00000010000000
Tacazzea apiculata Oliv.	5	1	00000000100000
PHYTOLACCACEAE 1, 2, 2,0			
Phytolacca americana L.	4	2	10100000000000
Phytolacca octandra L.	4	4	00110010000010
PIPERACEAE 2, 4, 2,0			
Peperomia blanda (Jacq.)H.B.K.	12	4	00000010100110
Peperomia retusa (L.f.)A. Dietr.	9	7	11110000000111
Peperomia tetraphylla (G. Forst.)Hook. & Arn.	9	8	01110110001101
Piper capense L.f.	4	5	01100000000111
PITTOSPORACEAE 1, 1, 1,0			
Pittosporum viridiflorum Sims	1	11	01111110011111
PLUMBAGINACEAE 2, 3, 1,5			
Limonium scabrum (Thunb.)Kuntze	12	1	00100000000000
Plumbago auriculata Lam.	4	4	00111000000010

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Plumbago zeylanica L.	4	1	00000000000010
POACEAE 34, 57, 1,7			
Agrostis lachnantha Nees	11	2	00100000000100
Aristida junciformis Trin. & Rupr.	11	1	00000000100000
Brachiaria chusqueoides (Hack.)Clayton	11	4	00100001110000
Brachypodium flexum Nees	11	7	01111000001011
Cymbopogon validus (Stapf)Stapf ex Burtt Davy	11	4	00000000110100
Dactyloctenium australe Steud.	11	3	00000001110000
Dactyloctenium geminatum Hack.	11	1	00000000010000
Digitaria diversinervis (Nees)Stapf	11	3	00000001110000
Digitaria eriantha Steud.	11	1	00001000000000
Digitaria natalensis Stent	11	2	00000000110000
Ehrharta calycina J.E. Sm.	11	4	01110000100000
Ehrharta capensis Thunb.	11	1	10000000000000
Ehrharta erecta Lam.			
var.erecta	11	4	00110000000110
var. natalensis Stapf	11	3	00100000101000
Ehrharta rehmannii Stapf	11	1	00100000000000
Ehrharta subspicata Stapf	11	1	00100000000000
Ehrharta villosa F.	11	1	00001000000000
Eragrostis capensis (Thunb.)Trin.	11	2	00000000110000
Eragrostis curvula (Schrad.)Nees	11	2	00000000110000
Eulalia villosa (Thunb.)Nees	11	2	00000000100100
Eustachys paspaloides (Vahl)Lanza & Mattei	11	2	00000000110000
Festuca africana (Hack.)Clayton	11	1	00100000000000
Hyparrhenia filipendula (Hochst.)Stapf	11	1	00000000100100
Imperata cylindrica (L.)Raeuschel	11	2	00000000110000
Ischaemum fasciculatum Brongn.	11	3	00000000110100
Loudetia simplex (Nees)C.E. Hubb.	11	1	00000000000100
Microstegium nudum (Trin.)A.Camus	11	3	00100000000011
Miscanthus capensis (Nees)Anderss.	11	1	00000000001000
Oplismenus hirtellus (L.)Beauv.	11	11	01111110101111
Panicum aequinerve Nees	11	5	00011000111000
Panicum deustum Thunb.	11	9	00111011110110
Panicum ecklonii Nees	11	5	00010010001110
Panicum laticomum Nees	11	3	00000001110000
Panicum maximum Jacq.	11	6	00010001110110
Panicum obumbratum Stapf	11	1	00010000000000
Panicum subalbidum Kunth	11	1	00100000000000
Paspalum scrobiculatum L.	11	1	00000000000001
Perotis patens Gand.	11	2	00000000110000
Phragmitis australis (Cav.)Steud.	11	1	00000000100000
Phragmitis mauritianus Kunth	11	1	00000000000100
Prosphytochloa prehensilis (Nees)Schweick.	11	4	00010010000011
Pseudobromus silvaticus K. Schum.	11	2	00000000000011
Sacciolepis curvata (L.)Chase	11	1	00000000100000
Setaria megaphylla (Steud.)Dur. & Schinz	11	5	00000000111101
Setaria sphacellata (Schumach.)Moss	11	6	00000000111111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Setaria verticillata (L.)Beauv.	11	1	00000001000000
Sporobolus fourcadii Stent	11	1	00100000000000
Sporobolus mauritianus (Steud.)Dur. & Schinz	11	1	00000000010000
Sporobolus subtilis Kunth	11	1	00000000010000
Sporobolus virginicus (L.)Kunth	11	2	00000000110000
Stenotaphrum secundatum (Walt.)Kuntze	11	3	00101000100000
Stipa dregeana Steud.			
var. dregeana	11	6	11101100001000
var. elongata (Nees)Stapf	11	3	00111000000000
Stipagrostis zeyheri (Nees)De Winter	11	2	00001000100000
Trachypogon spicatus (L.f.)Kuntze	11	2	00000000110000
Trichopteryx dregeana Nees	11	1	00000000000100
Urelytrum agropyroides (Hack.)Hack.	11	2	00000000110000
PODOCARPACEAE 1, 3, 3,0			
Podocarpus falcatus (Thunb.)R.Br.ex Mirb.	1	9	01111100101011
Podocarpus henkelii Stapf ex Dallim. & Jacks.	1	2	00000100001000
Podocarpus latifolius (Thunb.)R.Br.ex Mirb.	1	10	11110110001111
POLYGALACEAE 1, 9, 9,0			
Polygala confusa Macowan	12	1	00000000001000
Polygala esterae Chod.	3	1	00000010000000
Polygala fruticosa Berg.	3	1	00100000000000
Polygala hottentotta Presl	4	2	00000000100100
Polygala myrtifolia L.	3	4	10110000001000
Polygala ohlendorfiana Eckl. & Zeyh.	3	3	00010010100000
Polygala serpentaria Eckl. & Zeyh.	3	1	00000010000000
Polygala sp	12	2	00010100000000
Polygala virgata Thunb.	3	5	00010000101110
POLYGONACEAE 3, 3, 1,0			
Oxygonum dregeanum Meisn.	12	1	00000000100000
Polygonum salicifolium Willd.	12	5	00110010100100
Rumex sagittatus Thunb.	6	8	01110010001111
POLYPODIODACEAE 6, 11, 1,8			
Loxogramme lanceolata (Swartz)Presl	9	1	00000000000010
Microgramma lycopodioides (L.)Copel.	9	1	00000010000000
Microsorium ensiforme (Thunb.)Schelpe	9	2	01100000000000
Microsorium punctatum (L.)Copel.	9	3	00000010110000
Microsorium scolopendrium (Burm.f.)Copel.	9	2	00000010110000
Pleopeltis excavata (Bory ex Willd.)Sledge	9	2	00000000000011
Pleopeltis macrocarpa (Bory ex Willd.)Kaulf.	9	10	11111010001111
Pleopeltis schraderi (Mett.)Tardieu-Blot	9	6	00110110001010
Pleopodium simianum Schelpe & N.C. Anthony	9	2	00110000000000
Polypodium polypodioides (L.)Hitchc.	9	9	00011110101111
Polypodium vulgare L.	8	3	00010100001000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
PORTULACACEAE 1, 1, 1,0			
Portulacaria afra Jacq.	3	1	00000010000000
PRIMULACEAE 1, 1, 1,0			
Samolus valerandi L.	12	2	00001000100000
PROTEACEAE 2, 3, 1,5			
Brabejum stellatifolium L.	2	1	10000000000000
Faurea macnaughtonii Phill.	1	3	00100010000010
Faurea speciosa (Welw.)Welw.	2	2	00000000000110
PSILOTACACEAE 1, 1, 1,0			
Psilotum nudum (L.)Beauv.	8	2	00000010100000
PTAEROXYLACEAE 1, 1, 1,0			
Ptaeroxylon obliquum (Thunb.)Radlk.	2	6	00011110010010
RANUNCULACEAE 4, 8, 2,0			
Clematis brachiata Thunb.	5	8	00110010101111
Knowltonia cordata H. Rasm.	12	2	00110000000000
Knowltonia bracteata Harv. ex Zahlbr.	12	1	00000100000000
Knowltonia filia (L.f.)Dur. & Schinz			
subsp. scaposa H. Rasm.	12	1	00100000000000
Knowltonia vesicatoria (L.f.)Sims			
subsp. grossa H. Rasm.	12	3	11100000000000
subsp. humilis H. Rasm.	12	1	00100000000000
Ranunculus multifidus Forssk.	12	7	01110010101001
Thalictrum rhynchocarpum Dill. & Rich.	12	6	00010100001111
RHAMNACEAE 6, 8, 1,3			
Berchemia discolor (Klotzsch)Hemsl.	2	1	00000000010000
Berchemia zeyheri (Sond.)Grubov	2	2	00000000000110
Helinus integrifolius (Lam.)Kuntze	3	6	00011010110010
Phylica buxifolia L.	3	1	10000000000000
Phylica paniculata Willd.	3	2	00000010000100
Rhamnus prinoides L'Herit.	2	8	01110100001111
Scutia myrtina (Burm.f.)Kurz	3	13	11111111111011
Ziziphus mucronata Willd.	1	5	00010001110100
RHIZOPHORACEAE 2, 5, 2,5			
Bruguiera gymnorrhiza (L.)Lam.	2	1	00000000100000
Cassipourea flanaganii (Schinz)Alston	2	2	00010100000000
Cassipourea gerrardii (Schinz)Alston	2	8	00010111010111
Cassipourea gummiflua Tul.	2	3	00000011100000
Cassipourea malosana (Bak.)Alston	2	1	00000010000000
ROSACEAE 5, 9, 1,8			
Alchemilla capensis Thunb.	12	2	00110000000000
Alchemilla rehmannii Engl.	12	2	00000000000011

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Cliffortia linearifolia Eckl. & Zeyh.	3	3	00010000001010
Cliffortia serpyllifolia Cham. & Sclechtd.	3	2	00010010000000
Leucosidea sericea Eckl. & Zeyh.	2	5	00010100001101
Prunus africana (Hook.f)Kalkm.	1	7	00110110000111
Rubus pinnatus Willd.	5	9	11110010001111
Rubus rigidus J.E. Sm.	5	1	00000000100000
Rubus rosifolius J.E. Sm.	3	1	00000010000000
RUBIACEAE 31, 66, 2,1			
Alberta magna E. Mey.	2	2	00000010100000
Anthospermum herbaceum L.f.	12	1	00000000100000
Breonadia salicina (Vahl)Hepper & Wood	2	3	00000000000111
Burchellia bubalina (L.f.)Sims	2	8	01111110101000
Canthium ciliatum (Klotzsch)Kuntze	3	9	00111111001110
Canthium gueinzii Sond.	5	6	00000011100111
Canthium inerme (L.f.)Kuntze	2	13	11111111110111
Canthium mundianum Cham. & Schlechtd.	2	7	11110101000010
Canthium pauciflorum (Klotzsch)Kuntze	2	6	00111101001000
Canthium setiflorum Hiern	3	1	00000000010000
Canthium spinosum (Klotzsch)Kuntze	2	4	00101010010000
Canthium sp nov	3	1	00000010000000
Canthium suberosum Codd	2	1	00000010000000
Catunaregam spinosa (Thunb.)Tirvengadum	3	5	00000111110000
Cephalanthus natalensis L.	5	3	00000000000111
Coddia rudis (E. Mey. ex Harv.)Verdc.	3	4	00011010010000
Coffea racemosa Lour.	3	1	00000000010000
Conostomium natalense (Hochst.)Brem.	3	2	00000010001000
Galium mucroniferum Sond.	12	1	01000000000000
Galium thunbergianum Eckl. & Zeyh.	12	1	00000000001000
Galopina circaeoides Thunb.	12	11	01111110101111
Gardenia thunbergia L.f.	3	5	00111110000000
Hyperacanthus amoenus (Sims)Bridson	3	7	00011110100110
Kraussia floribunda Harv.	3	3	00000000110100
Lagynias lasiantha (Sond.)Bullock	3	2	00000001010000
Mitriostigma axillare Hochst.	3	3	00000011100000
Otiophora cupheoides N.E. Br.	3	1	00000000000010
Oxyanthus speciosus DC. subsp. gerrardii (Sond.)Bridson	2	6	00010110000111
Pachystigma cymosum Robyns	3	1	00000010000000
Pachystigma macrocalyx (Sond.)Robyns	3	3	00000010100010
Pavetta barbertonensis Brem.	3	1	00000000000001
Pavetta bowkeri Harv.	3	1	00000010000000
Pavetta capensis (Houtt.)Brem. subsp. komghensis (Brem.)Kok	3	3	00010010010000
Pavetta cooperi Harv. & Sond.	3	3	00000100001100
Pavetta galpinii Brem.	3	2	00000010000100
Pavetta gerstneri Brem.	3	1	00000000010000
Pavetta gracilifolia Brem.	3	1	00000000010000
Pavetta inandensis Brem.	3	1	00000010000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Pavetta kotzei Brem.	3	1	00010000000000
Pavetta lanceolata Eckl.	2	8	00011110110011
Pavetta natalensis Sond.	3	1	00000010000000
Pavetta revoluta Hochst.	3	4	00001001110000
Pavetta sp	3	1	00000000010000
Pentanisia prunelloides (Eckl. & Zeyh.)Walp.	12	1	00000000000010
Pentas micrantha Bak.	12	1	00000000000001
Plectroniella armata (K. Schum.)Robyns	1	1	00000000010000
Psychotria capensis (Eckl.)Vatke	3	11	00111111110111
Psychotria zombamontana (Kuntze)Petit	2	2	00000000000110
Psydrax livida (Hiern)Bridson	2	2	00000000000101
Psydrax locuples (K. Schum.)Bridson3	2	1	00000000000100
Psydrax obovata (Eckl. & Zeyh.)Bridson subsp. obovata	1	11	01111111110101
Rothmannia capensis Thunb.	2	8	01110110000111
Rothmannia globosa (Hochst.)Keay	2	8	00101111110100
Rubia cordifolia L.	12	2	00000010100000
Rubia petiolaris DC.	12	3	00110000000010
Tarenna junodii (Schinz)Brem.	3	1	00000000010000
Tarenna littoralis (Hiern)Bridson	3	2	00000000110000
Tarenna pavettoides (Harv.)Sim	3	3	00000110100000
Tarenna supra-axillaris (Hemsl.)Brem.	3	1	00000000010000
Tricalysia capensis (Meisn.)Sim	2	6	00000110010111
Tricalysia lanceolata (Sond.)Burtt Davy	2	6	00001110010110
Tricalysia sonderiana Hiern	2	3	00000001110000
Vangueria cyanescens Robyns	2	1	00000000000010
Vangueria esculenta S. Moore	2	1	00000100000000
Vangueria infausta Burch.	2	1	00000000110000
Vangueria randii S. Moore subsp. chartacea (Robyns)Verdc.	2	3	00000001110000
RUTACEAE 7, 10, 1,4			
Calodendrum capense (L.f.)Thunb.	1	11	01111110111011
Clausena anisata (Willd.)Hook.f. ex Benth.	2	12	00111111111111
Oricia bachmannii (Engl.)Verdoorn	3	2	00000110000000
Teclea gerrardii Verdoorn	2	3	00000001110000
Teclea natalensis (Sond.)Engl.	2	9	00011111110011
Toddalia asiatica (L.)Lam.	5	2	00000000000101
Vepris undulata (Thunb.)Verdoorn & C.A. Sm.	1	10	01111110110011
Zanthoxylum davyi (Verdoorn)Waterm.	1	7	00110110000111
Zanthoxylum capense (Thunb.)Harv.	2	11	00111111110111
Zanthoxylum thorncroftii (Verdoorn)Waterm.	2	1	00000000000100
SALVADORACEAE 1, 1, 1,0			
Azima tetracantha Lam.	3	3	00101010000000
SANTALACEAE 3, 3, 1,0			
Colpoon compressum Berg.	3	7	01111010011000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Osyridicarpos schimperianus (Hochst. ex A. Rich.)A. DC.	5	4	00010010000101
Rhoiacarpos capensis (Harv.)A. DC.	3	1	00001000000000
SAPINDACEAE 8, 12, 1,5			
Allophylus decipiens (Sond.)Radlk.	2	4	00111100000000
Allophylus dregeanus (Sond.) De Winter	2	3	00000110100000
Allophylus melanocarpus (Sond.)Radlk.	2	7	00000011111110
Allophylus natalensis (Sond.)De Winter	2	5	00001101110000
Allophylus transvaalensis Burtt Davy	2	3	00000000000111
Atalaya natalensis R.A. Dyer	2	1	00000010000000
Blighia unijugata Bak.	1	1	00000000010000
Deinbollia oblongifolia (E. Mey. ex Arn.)Radlk.	3	5	00001011110000
Dodonaea angustifolia L.f.	3	3	00100010010000
Hippobromus pauciflorus (L.f.)Radlk.	2	7	00111110100010
Pancovia golungensis (Hiern)Exell & Mendonca	3	2	00000000110000
Pappea capensis Eckl. & Zeyh.	2	3	00001000010010
SAPOTACEAE 7, 13, 1,9			
Bequaertiodendron magaliesmontanum (Sond.)Heine & J.H. Hemsl.	2	1	00000000000100
Bequaertiodendron natalense (Sond.)Heine & J.H. Hemsl.	2	4	00000010110010
Chrysophyllum viridifolium J.M. Wood & Franks	2	3	00000011010000
Inhambanella henriquesii (Engl. & Warb.)Dubard	1	1	00000000010000
Manilkara concolor (Harv. ex C.H. Wr.)Gerstner	1	2	00000000110000
Manilkara discolor (Sond.)J.H. Hemsl.	1	2	00000000110000
Manilkara nicholsonii Van Wyk	2	1	00000010000000
Mimusops caffra E. Mey. ex A. DC.	1	4	00001001110000
Mimusops obovata Sond.	1	7	00011011110010
Mimusops zeyheri Sond.	1	3	00000000000111
Sideroxylon inerme L.	1	9	01111111110000
Vitellariopsis dispar (N.E. Br.)Aubrev.	2	1	00000000010000
Vitellariopsis marginata (N.E. Br.)Aubrev.	2	2	00000010010000
SCHIZAEACEAE 1, 1, 1,0			
Mohria caffrorum (L.)Desv.	7	7	00110100001111
SCROPHULARIACEAE 10, 19, 1,9			
Alectra orobanchoides Benth.	12	1	00000000000001
Anastrabe integerrima E. Mey. ex benthy.	2	2	00001010000000
Bowkeria cymosa Macowan	2	1	00000000000010
Bowkeria verticillata (Eckl. & Zeyh.)Schinz	3	3	00010100001000
Dermatobotrys saundersii H. Bol.	9	2	00000010100000
Diclis reptans Benth.	12	6	00110000101011
Halleria lucida L.	2	11	11110110101111
Harveya capensis Hook.	12	1	00100000000000
Harveya huttonii Hiern	12	2	00010000000010
Harveya stenosiphon Hiern	12	1	00100000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Nemesia denticulata (Benth.)Fourc.	12	2	00000001100000
Nemesia macrocarpa (Ait.)Druce	12	1	10000000000000
Nemesia melissifolia Benth.	12	3	00110000001000
Nemesia petiolina Hiern	12	1	01000000000000
Sutera aethiopica (L.)Kuntze	4	1	00100000000000
Sutera cordata (Thunb.)Kuntze			
var. cordata	12	1	00100000000000
var. hirsutior (Benth.)Hiern	12	1	00100000000000
Sutera floribunda (Benth.)Kuntze	12	4	00001000101010
Teedia lucida Rudolphi	4	2	00110000000000
SELAGINACEAE 1, 1, 1,0			
Tetraselago natalensis (Rolfe)Junell	12	1	00000000000100
SELAGINELLACEAE 1, 3, 3,0			
Selaginella dregei (Presl)Hieron.	8	3	00000000000111
Selaginella kraussiana (Kunze)A. Br. ex Kuhn	8	6	00110100000111
Selaginella mittenii Bak.	8	2	00000000000011
SIMAROUBACEAE 1, 1, 1,0			
Kirkia acuminata Oliv.	1	1	00000000000100
SOLANACEAE 2, 10, 5,0			
Solanum aculeastrum Dun.	4	3	00101000000001
Solanum aculeatissimum Jacq.	12	4	00110000000011
Solanum americanum Mill.	4	1	00001000000000
Solanum didymanthum Dun.	4	1	00000010000000
Solanum geniculatum E. Mey.	5	2	00100000000010
Solanum giganteum Jacq.	4	6	01110000001011
Solanum hermannii Dun.	4	1	00100000000000
Solanum retroflexum Dun.	4	2	00010010000000
Solanum terminale Forssk.	5	2	00000010000001
Withania somnifera (L.)Dun.	3	3	00010000100010
STERCULIACEAE 3, 6, 2,0			
Cola greenwayi Brenan	2	1	00000000010000
Cola natalensis Oliv.	1	3	00000011010000
Dombeya pulchra N.E. Br.	3	1	00000000000100
Dombeya rotundifolia (Hochst.)Planch.	1	2	00000000100100
Dombeya tiliacea (Endl.)Planch.	2	2	00001010000000
Sterculia murex Hemsl.	2	2	00000000000110
STRELITZIACEAE 1, 4, 4,0			
Strelitzia alba (L.f.)Skeels	2	1	00100000000000
Strelitzia caudata R.A. Dyer	2	2	00000000000101
Strelitzia nicolai Regel & Koern.	2	4	00001010110000
Strelitzia reginae Ait.	12	1	00001000000000

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
THELYPTERIDACEAE 2, 9, 4,5			
Macrothelypteris torresiana (Gaud.)Ching	7	1	00000010000000
Thelypteris bergiana (Schlechtd.)Ching	7	6	01110000000111
Thelypteris confluens (Thunb.)Morton	7	4	00110000001001
Thelypteris dentata (Forssk.)E. St.John	7	3	00000100100010
Thelypteris gueinziana (Mett.)Schelpe	7	5	00100110000110
Thelypteris interrupta (Willd.)K. Iwats.	7	2	00100000000100
Thelypteris knysnaensis N.C. Anthony & Schelpe	7	1	00100000000000
Thelypteris madagascariensis (Fee)Schelpe	7	3	00000100000101
Thelypteris pozoi (Lagasca)Morton	7	6	00110100000111
THYMELAEACEAE 6, 11, 1,8			
Dais cotinifolia L.	2	5	00000110001011
Englerodaphne pilosa Burtt Davy	3	2	00010100000000
Englerodaphne ovalifolia (Meisn.)Phill.	3	1	00000010000000
Gnidia denudata Lindl.	3	2	01100000000000
Gnidia polyantha Gilg	3	1	00000000000010
Gnidia pulchella Meisn.	3	2	00010010000000
Gnidia woodii C.H. Wr.	3	1	00000010000000
Passerina falcifolia C.H. Wr.	3	1	00100000000000
Passerina rigida Wikstr.	3	3	00001000110000
Peddiea africana Harv.	2	8	00000111110111
Struthiola pondoensis Gilg ex C.H. Wr.	3	1	00000010000000
TILIACEAE 3, 8, 2,7			
Grewia caffra Meisn.	5	3	00000001110000
Grewia lasiocarpa E. Mey. ex Harv.	3	3	00001110000000
Grewia occidentalis L.	3	13	11111111110111
Sparrmannia africana L.f.	4	2	01100000000000
Sparrmannia ricinocarpa (Eckl. & Zeyh.)Kuntze	4	3	00010000001001
Triumfetta annua L.	12	1	00000000000010
Triumfetta pilosa Roth	3	3	00000010100100
Triumfetta rhomboidea Jacq.	3	2	00000000100100
TRIMENIACEAE 1, 1, 1,0			
Xymalos monospora (Harv.)Baill.	1	6	00010110000111
TYPHACEAE 1, 1, 1,0			
Typha capensis (Rohrb.)N.E.Br.	11	1	00000000100100
ULMACEAE 3, 4, 1,3			
Celtis africana Burm.f.	1	13	11111101111111
Celtis durandii Engl.	1	2	00000010100000
Chaetacme aristata Planch	3	7	00011111110000
Trema orientalis (L.)Blume	2	6	00000010110111
URTICACEAE 9, 12, 1,3			
Australina capensis Wedd.	12	1	00100000000000
Didymodoxa caffra (Thunb.)Friis & Wilmot-Dear	12	2	00010000000001

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Droguetia burchellii N.E. Br.	12	4	01111000000000
Droguetia thunbergii N.E. Br.	12	1	01000000000000
Laportea alatipes Hook.f.	12	2	00000000000011
Laportea grossa (Wedd.)Chew	12	2	00100010000000
Laportea peduncularis (Wedd.)Chew	12	10	00111010111111
Obetia tenax (N.E. Br.)Friis	12	1	00000010000000
Pilea rivularis WEdd.	12	1	00000000000001
Pouzolzia parasitica (Forswsk.)Schwienf.	3	1	00000000000001
Urera cameroonensis Wedd.	3	3	00000011100000
Urtica lobulata Blume	12	1	00010000000000
VELLOZIACEAE 2, 2, 1,0			
Talbotia elegans Balf.	10	1	00000000001000
Xerophyta retinervis Bak.	10	1	00000000000100
VERBENACEAE 5, 7, 1,4			
Avicennia marina (Forssk.)Vierh.	2	1	00000000100000
Clerodendron glabrum E. Mey.	2	9	00110011110111
Clerodendron myricoides (Hochst.)Vatke	2	2	00000001000100
Clerodendron suffruticosum Guerke	2	1	00000000000100
Lantana mearnsii Moldenke	3	1	00000000000100
Lippia javanica (Burm.f.)Spreng.	3	3	00000010100100
Priva meyeri Jaub. & Spach	3	2	00010000010000
VIOLACEAE 1, 3, 3,0			
Rinorea angustifolia (Thouars)Baill.	2	2	00000010000001
Rinorea domatiosa Van Wyk	2	1	00000010000000
Rinorea ilicifolia (Welw. ex Oliv.)Kuntze	3	2	00000000110000
VISCACEAE 1, 4, 4,0			
Viscum nervosum Hochst. ex A. Rich.	3	1	00000000000010
Viscum obovatum Harv.	3	1	00000000100000
Viscum obscurum Thunb.	3	5	00110110000010
Viscum rotundifolium L.f.	3	1	00100000000000
VITACEAE 4, 14, 3,5			
Cayratia gracilis (Guill. & Perr.)Suesseng.	6	1	00000000000001
Cissus fragilis E. Mey. ex Kunth	5	2	00000010100000
Cissus quadrangularis L.	5	1	00000000010000
Cyphostemma anatomicum (C.A. Sm.)Wild & Drum.	5	3	00000000000111
Cyphostemma cirrhosum (Thunb.)Descoings ex Wild &Drum.	6	6	00011001110001
Cyphostemma hypoleucum (Harv.)Descoings ex Wild & Drum.	6	2	00100010000000
Cyphostemma sp nov	5	1	00000010000000
Cyphostemma woodii (Gilg & Brandt)Descoings	5	1	00000000000100
Rhoicissus digitata (L.f.)Gilg & Brandt	5	7	01111010110000
Rhoicissus revoilii Planch.	5	6	00010100010011
Rhoicissus rhomboidea (E. Mey. ex Harv.)Planch.	5	8	00000111110111

FAMILY Genus species	GF	Fre	PGSAETUHRMCSMN eVomLrmaiLaaaE nBCaCMtwBCPbKT
Rhoicissus sp	5	2	00000000110000
Rhoicissus tomentosa (Lam.)Wild & Drum.	5	10	01101111100111
Rhoicissus tridentata (L.f.)Wild & Drum.	5	12	01111110111111
VITTARIACEAE 1, 1, 1,0			
Vittaria isoetifolia Bory	9	3	00100010000010
ZAMIACEAE 1, 2, 2,0			
Encephalartos altensteinii Lehm.	3	1	00001000000000
Encephalartos villosus Lem.	3	2	00001010000000
ZYGOPHYLLACEAE 1, 2, 2,0			
Zygophyllum morgsana L.	4	1	00100000000000
Zygophyllum uitenhagense Sond.	12	1	00001000000000

Chapter 5

COMPOSITION AND BIOGEOGRAPHY OF FOREST PATCHES IN THE INLAND MOUNTAINS OF THE SOUTHERN CAPE

CONTENTS

ABSTRACT

Patterns in species richness of 23 small, isolated forests in the inland mountains of the southern Cape were studied. Species richness of woody plants and vines of the Baviaanskloof-Kouga forests was higher than in the western mountain complexes, where species richness in the more southern Rooiberg and Kamanassie mountains was higher than in the Swartberg range. The Rooiberg, a dry mountain with small forests far away from the coastal source area, had more species than, and contained many species which are absent from, the larger, moister forests of the Kamanassie which are closest to the coastal source areas. Neither altitude nor distance from the source area, the forests south of the coastal mountains, nor long-distance dispersal adequately explained the variation in species richness. The variations are best explained in terms of dispersal corridors along the Gouritz and Gamtoos river systems which connect the coastal forests with the inland mountains. The distribution patterns of four species groups in relation to the geomorphological history of the two river systems provide relative dates for the expansion and contraction of temperate forest, subtropical forest and subtropical transitional thicket in the southern Cape.

INTRODUCTION

The forest map of southern Africa (Anonymous 1987) shows interesting zones of forest distribution along the mountain chains. In the southern Cape, inland (north) of the coastal mountains, the Swartberg, Rooiberg, Kamanassie, Kouga and Baviaanskloof mountains are surrounded by semi-arid to arid valleys and lowlands. Forests in the inland mountains are very small and isolated and are in sharp contrast to the large and widespread forests along the coast. Their distribution, composition and conservation status are unknown, and they are affected by controlled fires which are applied in the management of the catchments and by natural fires.

Only two river systems connect the inland areas with the coast: the Gouritz river in the west and the Gamtoos river in the east. Several studies have successfully used geomorphological evidence to reconstruct the biogeography of floras and taxa (Kaul et al. 1988; Moore 1988) and the phylogeny of families and genera e.g. of freshwater fishes (Skelton 1986). Smith (1981) considered the geological and palaeogegraphical history of the landmasses around Tasmania as well as colonist ability and altitudinal range of species in a study of the origin of the Tasmanian high mountain flora.

Taxa move from source areas along different pathways to colonize new sites (Brown and Gibson 1983). If they move along a corridor which contains a wide variety of sites or habitats, the composition of the community in the new site will be very similar to the community at the source. If they move through a filter which contains a limited variety of sites or habitats, the community at the new site will contain a limited component of the source community. If they move along a sweepstakes route which cuts across areas with totally different environments, the community in the new site will contain only species which will survive long distance dispersal across unsuitable areas. Island biogeographic theory was evoked to explain the extinction and colonization of animal species on oceanic islands of different size and distance away from the source areas (MacArthur and Wilson 1967) and recently for plants on islands of fynbos in the southern Cape forests (Bond et al. 1988). Dispersal is only of significance if the organism can establish a viable population upon arrival in the new area (Brown and Gibson 1983). Physical and biological barriers to successful colonization by forest plants are insufficient moisture (arid valleys), extreme temperature (mountain tops, frost in valleys), disturbance patterns (fire in fynbos) and absence of long distance dispersal agents (migrant frugivorous birds). However, human-induced changes in the vegetation and environment during historical times may eliminate or confuse the evidence required to elucidate the biogeographical patterns.

Axelrod and Raven (1978) and Deacon (1983) reconstructed the palaeofloras of Africa. They speculated that the temperate forest which covered the southern tip of Africa during the Palaeocene was replaced by subtropical forest during the Oligocene-Miocene and subsequently by fynbos and arid shrublands during the Late Pleistocene. The general increasing aridity in the southern Cape region since the Miocene (Deacon 1983) suggests further that over time the inland forest patches became increasingly isolated. Hypothetically the current species composition of the isolated inland forests would thus consist of species which have survived in suitable refuge sites, species with tolerance ranges which would enable them to survive in the changed environment, and species which have colonized from suitable forest source areas.

The objectives of this study were to

* determine the patterns in species richness and composition of the forest communities in the different inland mountain complexes of the southern Cape.
* explain the observed patterns in terms of
    + habitat preferences of species;
    + species-area and species-distance relationships;
    + long-distance dispersal;
    + dispersal corridors in relation to the geomorphological history of the landscapes in the region.
* aid interpretation of vegetation changes in the coastal forests from the dating of forest expansion and contraction in the inland mountains.

STUDY AREA

The study covers the Cape Folded Belt between Ladismith and Riversdale in the west and Humansdorp in the east (Figure 1). A site in the Groendal Wilderness

Area northwest of Uitenhage was included as a riverine site in the coastal mountains which appeared to be similar to the sites in the inland mountains. The dominant feature of the main study area is the sub-parallel mountain ranges and the intermontane lowland belts which run approximately east-west (Lenz 1957). In the west the Swartberg range, the highest range in the study area (up to 2250 m), forms the northern boundary. The Baviaanskloof-Kouga mountain complex forms the northern boundary to the east. It consists of several parallel ranges with relatively narrow east-trending valleys. The coastal Langeberg-Outeniqua-Tsitsikamma ranges form the southern boundary. A number of smaller, almost isolated mountains occur between the Swartberg and the Langeberg-Outeniqua ranges: Rooiberg-Gamka Hill between Calitzdorp and Ladismith, and Kamanassie between Oudtshoorn and Uniondale. The Oudtshoorn basin is a large semi-arid lowland between the Swartberg, Rooiberg, Outeniqua and Kamanassie mountains which is filled by hills of Cretaceous conglomerates (Lenz 1957). The relatively narrow Langkloof valley separates the Tsitsikamma mountains from the Kouga mountains. Groendal is a hilly landscape between the Great Winterhoek and Elandsberg mountains. A relatively dry coastal plain occurs to the southeast of Groendal.

Three river systems link the coastal area with the inland mountains and are important for the interpretation of the forest flora. The Gouritz River breaches the Langeberg-Outeniqua ranges west of Mossel Bay through the Gouritz Poort. Inland it is formed by the confluence south of the Rooiberg of the Olifants river which drains the Oudtshoorn basin, the Gamka river which flows through the Swartberg north of Calitzdorp and which drains the Karoo west of Beaufort West, and the Groot river which drains the area to the west of the Rooiberg. Tributaries of these rivers breach the Swartberg range through several poorts such as Seven Weeks Poort, Gamka Poort, Meirings Poort and Cheridouws Poort. A poort is a relatively narrow, steep-walled opening cutting almost perpendicular across a topographic barrier, through which the open areas on either side are

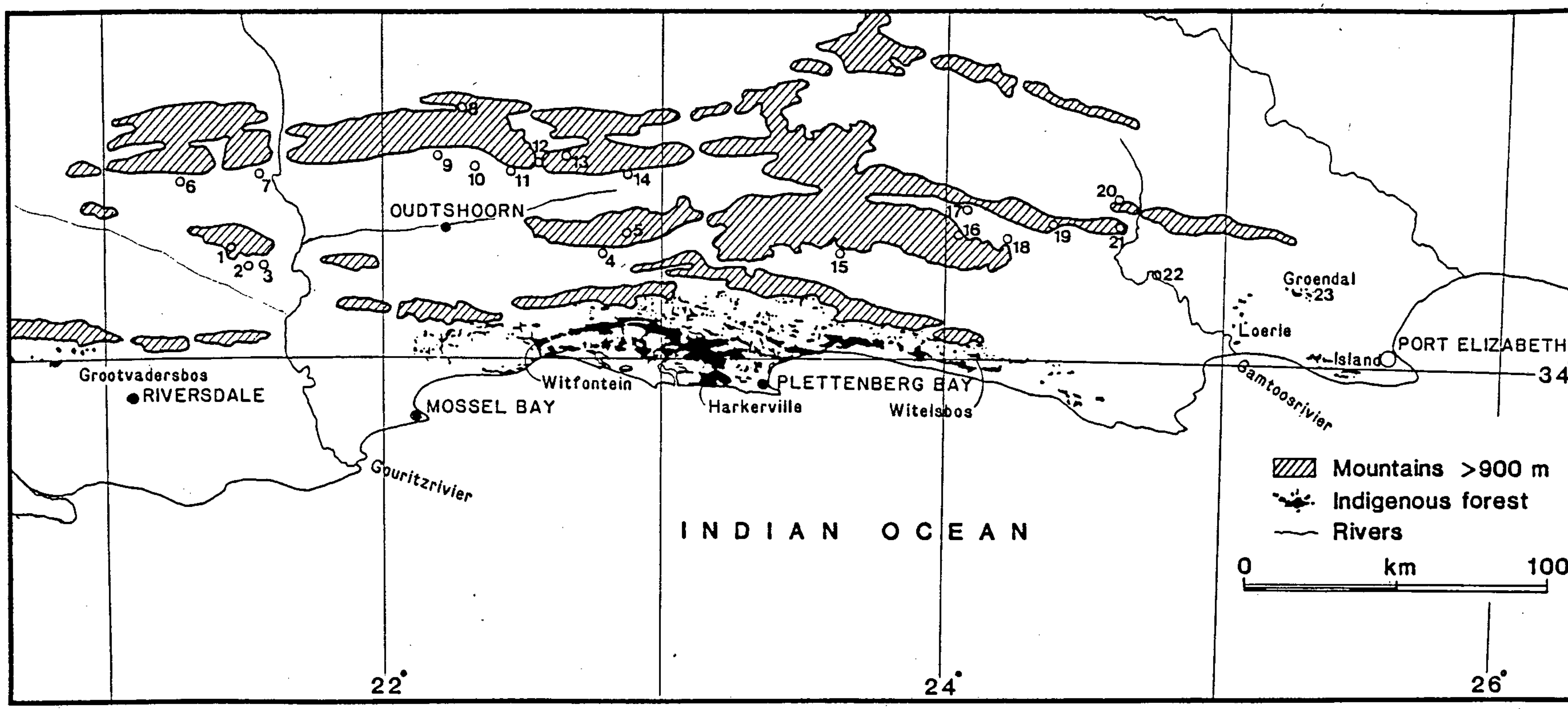

Figure 1 The study area of the southern Cape inland mountains in relation to the widespread forests south of the coastal ranges. The numbers represent the following study sites in the respective mountain complexes: Rooiberg - 1 Bosrivier upper; 2 Bosrivier lower; 3 Assegaaibosrivier; Kamanassie - 4 Kluesrivier; 5 Meulrivier upper; Swartberg - 6 Waterkloof; 7 Seweweeks Poort; 8 Swartberg Poort; 9 Swartberg Pass; 10 Rust-en-Vrede; 11 Huisrivier upper; 12 Meirings poort; 13 Tierkloof; 14 Cheridouws Poort; Kouga - 15 Sapreerivier; Baviaanskloof - 16 Doringkloof; 17 Diepnekkloof; 18 Geelhoutbos; 19 Assegaaikloof; 20 Witrivierkloof upper; 21 Witrivierkloof lower; 22 Grootrivier Poort; Groendal - 23 Zungarivier.

connected, usually by a river (Lenz 1957). The Keurbooms river east of Knysna does not fully breach the gap between the Outeniqua and Tsitsikamma ranges southwest of Uniondale. A low, narrow ridge separates its origin from the Kamanassie river which drains the southern slopes of the Kamanassie mountain and runs in a northwesterly direction to join the Olifants river. The Gamtoos river east of Humansdorp is formed by the confluence of the Baviaanskloof and Groot rivers. The Witrivier is a small stream which joins the Groot river north of the Groot River Poort at Cambria. The Zunga (or Swartkops) river runs from Groendal towards the southeast coast at Port Elizabeth.

Geologically the mountains owe their existence to their heavily folded structure and the resistance of the quartzitic Table Mountain Sandstones to weathering. Softer sandstones and shales of the Bokkeveld Series eroded more readily to form the syncline valleys (Lenz 1957; Theron 1962; Toerien 1979).

The few weather stations in the area all occur in the lowlands. Data are available for short periods for a number of raingauges across the Swartberg (along the Pass and in the east) and Kamanassie mountains. Rainfall increases linearly with increase in elevation and rain shadow effects are apparent on north slopes. In the Swartberg Pass area annual rainfall declined rapidly from 725 mm at 1 600 m to 210 mm at 884 m on the northern foothills to 182 mm at 686 m in Prince Albert on the edge of the Great Karoo (Bond 1981). Annual rainfall on the southern foothills is 411 mm at 640 m (Cango Caves) and 570 mm at 762 m (Rust-en-Vrede) (Weather Bureau 1986, unpublished data). In Swartberg East, near Blesberg between the Tierkloof and Cheridouw Poort sites, annual rainfall ranged from 766 mm on the northern midslope, 847 mm on the crest, 798 mm on the upper south slope to 572 mm on the southern foothills (unpublished data). In the Kamanassie annual rainfall near the crest ranged between 815 mm on the southern side and 682 mm on the northern side, and declined to 239 mm on the southern foothill and 169 mm on the northern foothill (Kamanassie Policy Memorandum). Rainfall data for Rooiberg are unreliable but appear to be lower than the Kamanassie, also as judged from the appearance of the fynbos vegetation on the southern slopes. Rainfall in the lowlands range between 220 mm at Van Wyksdorp (305 m) on the southern footslopes of the Rooiberg, 244 mm at Oudtshoorn (335 m), 482 mm at Joubertina (544 m) in the Langkloof, 321 mm at Studtis (760 m) in the western end of Baviaanskloof, and 536 mm on the southern foothills of Groendal (229 m) (Weather Bureau 1986, unpublished data).

Reliable information on temperature regimes is less available. Diurnal and seasonal temperature variation is large. Mean maximum temperature for the warmest month is 31,8°C for Oudtshoorn and 27,8°C for Uitenhage and the mean minimum temperature for the coldest month is 3,5°C and 5,8°C for the two towns respectively. The mean number of days per annum with frost is 7,3 and 1,4 for the two towns (Weather Bureau 1986). Snow occurs five or six times per annum on the Swartberg and may lie for more than two weeks (Bond 1981).

The main vegetation types of the area have been described by Acocks (1953), Taylor (1979), Bond (1981) and Cowling (1984) and in unpublished reports. Mountain fynbos and grassy fynbos cover most of the mountains and are interspersed with small patches of evergreen forest in protected gullies and valleys. Karroid broken veld cover the low-lying valleys of the Little Karoo and subtropical transitional thicket extends south of Groendal and occurs in parts of Baviaanskloof.

METHODS

I visited 23 forested gorges, gullies and riverine sites to represent the variety of sites encountered in the inland mountains (Figure 1; Table 1). In this study I stretched my earlier definition of a forest (Geldenhuys *et al.* 1988) in order to accomodate scattered bush clumps and isolated trees of species which are usually associated with forest, such as was observed in Seweweeks Poort, Meirings Poort and Cheridouws Poort. For each study site I compiled a list of all plant species which were associated with the forest communities. Emphasis was placed on the recording of all tree and shrub species, but taxa of other growth forms were recorded as completely as possible.

The size of each forest (Table 1) was estimated in the field. Most forests consisted of a long, narrow stand along the stream or river. The length of the stream which was covered in the survey was estimated from 1:50 000 topographic maps and the mean width of the forest was estimated in the field. Altitude was read from the maps. Disturbance factors affecting the forest communities were recorded where obvious or important. These included fire of differing frequency, flooding of rivers, landslides and wind.

The relationship between the number of woody species (plus vines) or the number of herbaceous species in a forest and altitude, forest area and direct distance (km) to the nearest source area was determined by means of stepwise multiple regression (STSC 1986). Log transformations were used for all variables. The southern Cape forests and "The Island" coastal forest west of Port Elizabeth (Figure 1) were considered to be the nearest source areas.

The distribution of taxa, mainly woody species, in the inland mountains was represented by means of tables which indicate the frequency of species in each particular mountain range or similar sites within a range. The sites were grouped on the basis of assumed dispersal barriers and corridors, as follows: Swartberg sites in three sub-groups, i.e. on the northern slopes, at high altitudes and on the southern slopes; Rooiberg; Kamanassie; Baviaanskloof-Kouga; Groot River Poort, including the lower site of the Witrivierkloof; and the Groendal site. The most likely dispersal mechanisms for these species are indicated and are based on Palgrave (1977) and my own observations (Chapter 3).

RESULTS

SPECIES RICHNESS

The species are listed in the Appendix and summarized by growth forms for the different sites (Table 2). Woody plants and vines form the bulk of the species.

TABLE 1 List of forested sites visited in the inland mountains of the southern Cape.

Study site	Grid reference	Altitude m	Forest area (ha); Forest habitat
1 Bosrivier upper	33°41'S 21°30'E	500	2,0; Closed/open gorge, riverine/slopes, south
2 Bosrivier lower	33°43'S 21°30'E	330	1,0; Closed/open gorge, riverine, south
3 Assegaaibosrivier	33°43'S 21°34'E	300	4,0; Closed/open gorge, riverine, south
4 Kluesrivier	33°39'S 22°48'E	980	12,0; Closed/open gorge, riverine/slopes, south
5 Meulrivier upper	33°38'S 22°53'E	1 100	8,0; Closed/open gorge, riverine/slopes, south
6 Waterkloof	33°27'S 21°17'E	700	1,0; Closed/open gorge, riverine, south
7 Seweweeks Poort	33°25'S 21°24'E	650	2,0; Open gorge, riverine
8 Swartberg Poort	33°19'S 22°04'E	950	0,5; Open/closed gorge, riverine, north
9 Swartberg Pass	33°21'S 22°05'E	1 300	0,3; Closed gorge, riverine, south
10 Rust-en-Vrede	33°24'S 22°21'E	850	1,5; Closed gorge, riverine/slopes, south
11 Huisrivier upper	33°25'S 22°29'E	1 170	1,0; Closed valley, riverine, south
12 Meirings Poort	33°25'S 22°34'E	600	3,0; Open gorge, riverine/slopes
13 Tierkloof	33°24'S 22°39'E	1 200	0,2; Closed/open gorge, riverine, north
14 Cheridouws Poort	33°27'S 22°54'E	720	1,0; Closed valley, open gorge, riverine
15 Sapreerivier	33°40'S 23°36'E	580	3,0; Closed valley, open gorge, riverine/slopes
16 Doringkloof	33°37'S 24°03'E	650	8,0; Closed gorge, riverine, north
17 Diepnekkloof (Bosrug)	33°33'S 24°04'E	600	4,0; Closed/open gorge, riverine, south
18 Geelhoutbos	33o38'S 24o15'E	300	2,0; Closed/open gorge, riverine/slopes, north
19 Assegaaikloof	33°39'S 24°22'E	280	2,0; Closed/open gorge, riverine, south
20 Witrivierkloof upper	33°36'S 24°31'E	1 170	0,2; Closed gorge, riverine, south
21 Witrivierkloof lower	33°39'S 24°31'E	240	4,0; Closed/open gorge, riverine/slopes, south
22 Grootrivier Poort	33°43'S 24°38'E	140	1,0; Open gorge, riverine/slopes, west
23 Zungarivier (Chase's kloof)	33°41'S 25°14'E	150	15,0; Open valley, alluvial/slopes, west

TABLE 2 Number of species by growth forms for the forest sites in the inland mountains of the southern Cape

MOUNTAIN RANGE and study area	Number of species					
	Trees Shrubs	Lianes Vines	Ferns	Geophytes Graminoids	Forbs Soft shrubs	TOTAL
ROOIBERG						
Bosrivier upper	21	4	12	3	3	43
Bosrivier lower	30	6	7	5	6	54
Assegaaibosrivier	32	8	12	5	8	65
KAMANASSIE						
Kluesrivier	24	7	15	5	13	64
Meulrivier upper	13	4	8	5	3	33
SWARTBERG						
Waterkloof	13	5	12	5	7	42
Seweweekspoort	16	3	4	0	3	26
Swartbergpoort	15	4	7	2	4	32
Swartbergpas	10	1	13	4	1	29
Rust-en-Vrede	18	4	10	3	6	41
Huisrivier upper	11	1	5	1	2	20
Meiringspoort	21	4	2	2	2	31
Tierkloof	14	1	4	1	2	22
Cheridouwspoort	18	4	5	1	3	31
BAVIAANSKLOOF/KOUGA						
Sapreerivier	35	7	12	3	4	61
Doringkloof	42	10	10	2	8	72
Diepnekkloof (Bosrug)	31	5	7	5	6	54
Geelhoutbos	27	6	6	7	1	47
Assegaaikloof	35	7	4	4	5	55
Witrivierkloof upper	8	1	10	3	2	24
Witrivierkloof lower	53	7	16	10	10	96
Grootrivierpoort	52	13	7	8	6	86
GROENDAL						
Zungarivier (Chase's kloof)	76	15	12	12	12	127
TOTAL	118	29	38	22	43	250

Species numbers vary greatly between the sites. In general there is a decline in species richness from east to west and from south to north. The mean number of species per site in the Baviaanskloof-Kouga complex is double the number in the Swartberg range. Note however that the mean number of species, particularly woody species, in the Rooiberg forests is higher than the number in the Kamanassie forests.

RELATIONSHIP BETWEEN SPECIES RICHNESS AND ALTITUDE, FOREST AREA AND DISTANCE FROM SOURCE

The number of woody species (plus vines) is significantly correlated with altitude and forest area (Table 3). Altitude alone explains 74% of the variation in number of woody species. The number of herbaceous species is significantly correlated only with forest size, but this regression model explains only 18% of the observed variation.

TABLE 3 Analysis of variance for the stepwise multiple regression of the dependence of the (log) number of woody species and vines in a forest on its altitude and area.

Independent variable	Coefficient	Standard error	t-value	Significance level
Constant	3.132426	0,221281	14,1559	0,0000
Log Altitude (m)	-0,635723	0,078427	-8,1059	0,0000
Log Area (ha)	0,195371	0,043653	4,4756	0,0002

R^2(adjusted for Df) = 0,8582; Standard error of the estimate = 0,09751

DISTRIBUTION OF TAXA IN DIFFERENT MOUNTAIN COMPLEXES

Only 10% of the species occur in more than 50% of the sites and these are mostly trees and shrubs (Table 4). The pattern of occurrence of species in the different mountain ranges became clearer when the pattern was considered in relation to the spread of species in both the inland and coastal forests.

Widespread species in the inland mountains

Species which occur in more than 50% of the sites occur in most sites of all the different mountain groups (Table 5). The Kamanassie sites lack several

TABLE 4 Absolute and relative frequencies by which species of different growth forms occur in the 23 forested study sites in the inland mountains of the southern Cape.

Frequency of occurrence		Number of species				
Absolute	Relative %	Trees & shrubs	Climbers	Ferns	Herbs	
					Monocots	Dicots
1 - 2	1 - 10	48	14	16	6	28
3 - 4	11 - 20	20	6	7	9	9
5 - 7	21 - 30	24	4	4	4	3
8 - 9	31 - 40	9	1	4	1	1
10 - 11	41 - 50	2	1	3	1	1
12 - 13	51 - 60	4	-	-	-	1
14 - 16	61 - 70	6	2	2	1	-
17 - 18	71 - 80	1	1	2	-	-
19 - 20	81 - 90	4	-	-	-	-

species which have a preference for drier habitats although those species occur in the high altitude sites of the Swartberg. Those which do occur in the Kamanassie are confined to the lower end of Kluesrivier.

Species with limited spread in study area but widespread along coast

Very few of the widespread species of the coastal forests which occur with limited spread in the inland mountains do occur in the Swartberg range (Table 6). Those which do occur there are confined to the southern sites. Note again that very few of these species occur in the Kamanassie. However, two of the Kamanassie species are absent from the Rooiberg, i.e. Rapanea melanophloeos and Diospyros whyteana. Ocotea bullata is confined to the Kamanassie and one site in the Rooiberg. Many of the Rooiberg species are absent from the Kamanassie. The majority of the species occur in Groendal and Grootrivier Poort and in one or more sites of the Baviaanskloof-Kouga, and many of these are absent from the Kamanassie or Rooiberg. Note the decrease in number of species from Groendal through Grootrivier Poort to the Baviaanskloof.

TABLE 5 Distribution of widespread species of the forested sites in the inland mountain ranges of the southern Cape.

Species[1]	Mountain range							
	Swartberg[2] N	Swartberg[2] U	Swartberg[2] S	Rooi-berg	Kama-nassie	Baviaa-kloof	Groot-rivier	Groendal
	Number of sites[3]							
	3	2	4	3	2	6	2	1
<u>Moist sites</u>								
o Ilex mitis	2	2	4	3	2	4	1	1
o Halleria lucida	3	2	3	3	2	4	1	1
o Kiggelaria africana	2	2	3	2	2	5	2	1
o Maytenus acuminata	3	1	2	3	2	6	1	1
+ Cunonia capensis	2	1	3	3	2	4	1	1
o Myrsine africana	3	2	3	2	1	1	1	
o Pterocelastrus tricuspidatus	1		1	3	2	5	2	1
# Secamone alpini	1		2	3	2	4	2	1
o Zanthedeschia aethiopica	3	2	2	3		3	1	
# Blechnum australe	2	2	4	2	2	4	1	1
# B. capense	2	1	3	2	2	3	1	1
# B. punctulatum	3		4	3	2	4	2	
# Todea barbara	1	1	3	2	2	4	1	1
<u>Dry sites</u>								
o Olea europaea subsp africana	2	1	4	3		4	2	1
o Maytenus heterophylla	1	1	3	2		5	2	1
o Cussonia spicata	2		4	3		3	1	1
+ Buddleja salviifolia	3	1	3	1		3		1
o Rhus rehmanniana	2	2	1	2	2	5		1
o Rhus lucida	3	1	3	3	1	1		
+ Dipogon lignosus	2	1	2	3	1	6	1	1
o Colpoon compressum	2		4	2	1	2	2	1
o Diospyros dichrophylla			3	3	1	3	2	1
o Protasparagus aethiopicus	2		4	3	1	3		1
+ Pelargonium zonale	2		4	3	1	3		

[1] Fruit/seed dispersal mechanisms: o = bird/mammal; + = small/large dry seed not dispersed by wind; # = wind-dispersal.
[2] N = north; U = upper; S = south.
[3] Maximum number of sites compared to number of sites for each species.

TABLE 6 Distribution of species with a limited spread in the study area but which occur widespread in the coastal forests of the southern Cape

Species[1]	Mountain range							
	Swartberg[2]			Rooi-berg	Kama-nassie	Baviaa-kloof	Groot-rivier	Groendal
	N	U	S					
	Number of sites[3]							
	3	2	4	3	2	6	2	1
o Ocotea bullata				1	2			
o Olinia ventosa				3	2	3	2	1
o Cassine peraqua				3	2	2	2	1
o Rapanea melanophloeos			1		2	2	2	1
o Diospyros whyteana					2	1	2	1
o Carissa bispinosa				3		3	2	1
+ Nuxia floribunda				3		4	2	1
o Curtisia dentata				3		1	2	1
o Allophylus decipiens				2		4	2	1
o Scutia myrtina				3			1	1
o Grewia occidentalis				2		4	2	1
+ Buddleja saligna			1	2		2	1	1
o Canthium inerme				2		1	2	1
o Olea capensis capensis				1		1	2	
o Sideroxylon inerme				1		3	2	1
o Pittosporum viridiflorum						5	2	1
o Ficus burtt-davyii			2			5	2	1
o Celtis africana						4	2	1
o Ficus sur						4	2	1
+ Gonioma kamassi						3	2	1
o Podocarpus falcatus						1	2	1
o Apodytes dimidiata						1	2	1
o Vepris lanceolata						2	1	1
o Dovyalis rhamnoides						1	1	1
o Clausena anisata						1	1	1
o Ekebergia capensis						1	1	1
o Capparis sepiaria						1	2	1
o Cassine aethiopica						1	2	1
o Canthium mundianum						1	1	
o Putterlickia pyracantha						4	2	
+ Calodendrum capense							1	1
o Podocarpus latifolius							1	1
o Rothmannia capensis							1	1
o Psydrax obovata and others							1	1
o Ochna arborea								1
o Olea capensis macrocarpa								1
o Cassine papillosa and others								1

[1] Fruit/seed dispersal mechanisms: o = bird/mammal; + = small/large dry seed not dispersed by wind; # = wind-dispersal. [2] N = north; U = upper; S = south.
[3] Maximum number of sites compared to number of sites for each species.

<u>Species with limited/disjunct distribution in, or absent from, the coastal forests</u>

These species fall in two groups: those which are confined to the western ranges, i.e. Swartberg, Rooiberg and Kamanassie; and those which are confined to the eastern ranges (<u>Table</u> 7). Note again the decrease in number of species from Groendal through Grootrivier Poort to the Baviaanskloof.

TABLE 7 Distribution in study area of species which occur with a limited or disjunct distribution in, or which are absent from the coastal forests of the southern Cape.

Species[1]	Mountain range							
	Swartberg[2]			Rooi-berg	Kama-nassie	Baviaa-kloof	Groot-rivier	Groendal
	N	U	S					
	Number of sites[3]							
	3	2	4	3	2	6	2	1
<u>Species of coastal forests</u>								
o Pterocelastrus rostratus		1	2	2				
o Diospyros glabra	1		2					
# Brachylaena neriifolia	1	1	3	2	2			
o Hippobromus pauciflorus						2	2	1
+ Schotia latifolia						4	2	1
# Brachylaena glabra						2	1	1
+ Plumbago auriculata						2	2	1
o Ochna serrulata							2	1
o Canthium ciliatum							1	1
o C. pauciflorum								1
o Strychnos decussata								1
+ Trichocladus ellipticus								1
<u>Species outside coastal forests</u>								
o Diospyros scabrida						4	1	1
o Pavetta lanceolata							1	1
o Teclea natalensis							2	
+ Ptaeroxylon obliquum								1
o Pleurostylia capensis								1
o Eugenia zeyheri								1
o Chaetacme aristata								1

[1] Fruit/seed dispersal mechanisms: o = bird/mammal; + = small/large dry seed not dispersed by wind; # = wind-dispersal. [2] N = north; U = upper; S = south.
[3] Maximum number of sites compared to number of sites for each species.

Endemic species of the region

Nine woody species are endemic to the study area, or have their main distribution in the southern Cape. Of these only Virgilia divaricata occurs widespread in the study area (Table 8). Laurophyllus capensis, which has a wide distribution in the coastal areas, is confined to a few sites in the Groendal area where it grows in association with V. divaricata.

TABLE 8 Distribution in the study area of endemic species of the region

Species[1]	Mountain range							
	Swartberg[2]			Rooi-berg	Kama-nassie	Baviaa-kloof	Groot-rivier	Groendal
	N	U	S					
	Number of sites[3]							
	3	2	4	3	2	6	2	1
+ Lachnostylis bilocularis			1	2				
+ Virgilia divaricata			1		2	2	1	1
+ Calpurnia villosa			1				1	
+ Widdringtonia schwarzii						2		
o Smellophylum capense						4	2	1
+ Loxostylis alata						1	2	1
+ Atalaya capensis							1	
+ Sterculia alexandrii								1
+ Laurophyllus capensis								1

[1] Fruit/seed dispersal mechanisms: o = bird/mammal; + = small/large dry seed not dispersed by wind; # = wind-dispersal.
[2] N = north; U = upper; S = south.
[3] Maximum number of sites compared to number of sites for each species.

SEED DISPERSAL MECHANISMS

The majority of woody species (Table 5 to 8) have fleshy fruits or seeds which are dispersed by frugivorous birds and/or mammals. Of those with dry propagules, only the ferns, Secamone alpini and the two Brachylaena species are readily dispersed by wind. Cunonia capensis, Nuxia floribunda, Buddleja saligna and B.

salviifolia carry small seeds in capsules which may be blown over short distances in strong wind. Gonioma kamassi, Ptaeroxylon obliquum and some of the other species have winged seeds which are not well suited for wind-dispersal. Note that the majority of endemic species (Table 8) have dry seeds which are not particularly adapted to dispersal over distances.

DISCUSSION

The forests in the inland mountains of the southern Cape contain 118 tree and woody shrub species, 24 of which are not included in the 140 species of the coastal forests (Chapter 3). The difference in number of species of the herbaceous growth forms between the two areas is much larger. I have observed, both in the study area and in the coastal forests, that most of the woody species sprout after fire whereas most herbaceous understorey plants are reseeders and have to recolonize from undisturbed sites. I assumed that woody plants are more persistent in suitable habitats, create the micro-habitat for forest understorey plants, and have therefore almost confined my interpretation of the patterns in species richness and composition to them.

HABITAT PREFERENCES OF SPECIES

Habitat preferences of species along an altitudinal gradient do not explain the major differences in species composition of forests in different parts of the inland mountains. The decrease in species richness of woody plants and vines with increasing altitude suggests that many species cannot grow at high altitude. The majority of the widespread coastal species with a limited spread in the inland sites are indeed confined to the low-lying mountain valleys and riverine sites. However, those species are also absent from similar sites on the northern side of the Swartberg range, and many are absent from similar sites of the southern Swartberg, the Kamanassie and the Rooiberg (Table 6).

Where habitat preferences have been attached to some species, their demonstrated wide tolerances do not explain their absence from certain forests. The widespread species of the inland moist sites (Table 5) occur both at high and low altitudes and in sites which are relatively dry. In several sites they are not confined to the moist, cool sites along the streams, but grow on steep, exposed slopes and often shallow, rocky sites far above the streams, for example in the Kamanassie, the upper Bosrivier, Meirings Poort and Sapreerivier sites. Only inland widespread species of both dry and moist sites grow in the northern Swartberg sites (Table 5), often where the streams open up to the north into the arid Great Karoo.

SPECIES-AREA RELATIONSHIPS AND LONG-DISTANCE DISPERSAL

Species-area relationships and long-distance dispersal explain very little of the observed patterns of species richness.

Forest area is a significant variable in the regression models which explains the richness of both woody and herbaceous species but in both cases account for a relatively small portion of the variation. Direct distance from the source areas ranges between 30 and 80 km but is an insignificant variable in the regression models. For example, the Kamanassie forests are some of the largest in the study area, are the closest to the coastal forests, particularly the large forests north of Knysna, and represent the moistest sites. Yet they contain fewer species than the Rooiberg forests and lack several species which are present in the Rooiberg. The Rooiberg is a drier mountain, has small forests and its closest source areas are scattered forests between Mossel Bay and George to the southeast and some Langeberg forests west of Riversdale.

The distribution patterns of very few species support claims of long-distance dispersal despite the fact that the majority of tree and shrub species have fleshy fruits or seeds, many of which I have observed are eaten by birds in the coastal forests.

* Rapanea melanophloeos and Ficus burtt-davyii occur in one and two sites respectively in the Swartberg range which could be attributed to long-distance dispersal. Ocotea bullata may have been dispersed into the Rooiberg and Kamanassie from relatively nearby forests with O. bullata which exist on the northern slopes of the Langeberg (Garcia pass near Riversdale) and Outeniqua mountains (Robinson pass near Mossel Bay and near Noll west of Uniondale).

* Most of the species which are present in the Rooiberg but absent from the Kamanassie are generally well-dispersed by birds. Their absence from the Kamanassie and the limited distribution in the study area of other similarly well-dispersed species of the coastal forests such as Apodytes dimidiata, the two Podocarpus species, the two Olea capensis subspecies, Psydrax obovata and Canthium mundianum casts doubt on the relevance of long-distance dispersal in the study area.

* Several species which release minute dry seeds from dry capsules but which are not effectively dispersed by wind show distribution patterns which are similar to the patterns of frugivorous species. Examples are Cunonia capensis, Nuxia floribunda, Buddleja saligna and B. salviifolia. Their dispersal by birds or mammals is very unlikely.

* The absence of suitable dispersal vectors may be the reason for the insignificance of long-distance dispersal. I have visited the sites during different seasons over several years but have seen a single Rameron pigeon (Columba arquatrix) in the Swartberg Pass forest. No studies exist to indicate the migration patterns of frugivorous birds in the southern Cape. It has been suggested that the Rameron pigeon migrates up and down the coast (Phillips 1927). I doubt whether the Rameron pigeon will fly from the coast where food sources are more readily available to the inland mountain forests where their food sources are more limited and possibly irregularly available. Small flocks of Red-winged starlings (Onychognathus morio) were often seen in the vicinity of the inland forests, but rarely seen along the coast.

DISPERSAL BARRIERS AND CORRIDORS

The parallel mountain ranges are obvious barriers to the dispersal of forest taxa from the coast to the inland forests. The mountain ridges experience strong, cold winds and extreme temperatures. Ice often forms in the sheltered gullies near the top (personal observation). Frequent controlled and natural fires in the fynbos on the mountain slopes prevent the establishment of forest species in the exposed sites and confine or eliminate existing forests. This was observed in most of the sites or was evident in the small sizes of trees near the forest edge in more protected sites.

Dry lowlands and valleys of the Little Karoo minimize the number of species which are able to cross them by means of establishment in small bush clumps in a stepping stone fashion.

The obvious dispersal corridors are the Zunga river, the Gamtoos river through the Groot River Poort and Baviaanskloof, the Keurbooms river and the Gouritz Poort. The first two river systems are effective corridors for stepping stone dispersal. The sites along the Zunga river are the endpoint of the subtropical transitional thicket and riverine forests which are connected with the Alexandria and other coastal forests. Many streams run into the Baviaanskloof river from the mountain ridges to its north and south and provide refuge sites for forest species. The Baviaanskloof shares many of the species which occur in the Groot River Poort and Witrivierkloof and at Groendal. The remaining two rivers are not effective corridors. The Keurbooms river are not open up to the Kamanassie mountains. The Gouritz Poort contains no sheltered sites for forest establishment and north of the poort is an arid lowland. It is not connected with any nearby forests to the south of the poort. It may have been an effective dispersal corridor in earlier, moister periods, but not under the present climate.

FOREST MIGRATION IN RELATION TO CLIMATIC CHANGE

I suggest that the main cause for the variation in species richness in the inland mountains is different degrees of mixing during the contraction and expansion of the different floras due to climatic and landscape changes since the Palaeocene. I have only used the tree and woody shrub species for this interpretation because I assume they are the key elements which create the specific micro-habitats for herbaceous elements of the understorey of particular vegetation units. Certain understorey species should therefore correlate with the distribution pattern of particular groups of tree species. Factors such as the altitudinal gradient, forest size, site preferences and dispersal corridors and mechanisms are merely contributing to this variation within a particular mountain range. In this study at least four floras can be recognized from the distribution patterns of the species as listed in <u>Tables</u> 5 to 8: temperate or austral forest relicts; subtropical forest; subtropical transitional thicket and karroid riverine woodland.

<u>Temperate forest</u>

I suggest that most of the widespread inland species of moist sites (<u>Table</u> 5) represent relicts of the temperate austral forests or high-altitude forests of tropical latitudes which covered the southern tip of Africa during the Palaeocene, rather than recent dispersal events. Those temperate forests were eliminated with the northward drift of the African continent (Axelrod and Raven 1978; Deacon 1983). Those species grow in forests on all the mountain complexes in the study area, and are the only species which grow in sheltered sites on the northern slopes of the Swartberg range. They are also the main species of the forests in the cool, sheltered kloofs and gorges of the inland mountain ranges in the southwestern Cape (personal observation). Many of them occur in the isolated Afromontane forests of southern and eastern Africa (Killick 1963; Chapman and White 1970; Dowsett-LeMaire 1988). The poorts through the Swartberg range breached the ranges by the early Tertiary (Lenz 1957) and would have allowed dispersal of other well-dispersed species through the poorts from south to north, if they were present by that time. Even if it is argued that in more recent times the frugivorous tree species may have been dispersed to the northern side of the Swartberg by birds, the argument does not account for the presence of Cunonia capensis with its small, dry seeds. The wide habitat tolerances of these species enabled them to survive and to occur widespread the study area and in southern Africa (Chapter 4).

Species which could be added to the list of temperate forest species are Pterocelastrus rostratus, Diospyros glabra and Brachylaena neriifolia. Their eastern distribution limits in the study area (Table 7) coincide with the longitude of their eastern limits in the coastal forests (Chapter 6). Their distribution pattern suggest a more continuous distribution at some early period which were afterwards fragmented into their present pattern.

Subtropical forest

I suggest that the widespread coastal forest species with limited spread in the inland sites (Table 6) represent elements of the subtropical forest which replaced the temperate forests since the Oligocene-Miocene (Axelrod and Raven 1978; Deacon 1983). Most of these species occur also in the coastal forests of the southwestern Cape (Chapter 3; McKenzie 1978). These forests have expanded from the east. The eastern orientation of the Zunga and Gamtoos rivers and the Baviaanskloof-Kouga valleys suggests that they would have been more readily colonized by the expanding subtropical forests. The Gouritz river breached the Langeberg-Outeniqua range during the late Cretaceous as a subsequent poort, i.e. it developed along a relatively weaker part of the range by a headward eroding stream (Lenz 1957). With widespread forest along the coast south of the Outeniqua-Langeberg mountains and with a more humid climate (Hendey 1983) the Gouritz river could have been a suitable dispersal corridor for some species to enter the southern sides of the Rooiberg. The Rooiberg-Gamka mountain range forms a loose connection to the southeast with the Outeniqua range and may have had sheltered sites on the southwestern side. Today several species of the western fynbos element, e.g. Mimetes cucullatus, that are characteristic of the wetter coastal ranges also occur on the Rooiberg, Gamka range and the adjacent Outeniqua range (Taylor 1979; J H J Vlok personal communication 1988). They support the dispersal route suggested for the forest species, although the fynbos migration relates to Late Pleistocene times and different environmental conditions which would not support forest.

The nature of the deposits in the Oudtshoorn Basin suggests that the climate during the Late Cretaceous was similar to the present semi-arid climate and the Olifants river portion of the breach between Rooiberg and Gamka Hill occurred as late as Plio-Pleistocene (Lenz 1957). This semi-arid climate and the late breach would have prevented the spread of subtropical forest towards the Swartberg. The absence of a direct corridor between the Keurbooms river and the Kamanassie accounts for the absence from the Kamanassie of several Knysna forest species, which are present in the Rooiberg (Table 6).

Some of the widespread as well as disjunctly distributed coastal species are confined to the Groendal, Grootrivier Poort and lower Witrivierkloof sites (Table 6 and 7, Appendix). I suggest two possible explanations for this pattern.

* Firstly, most of these species have relatively large fruits or seeds which require specialized dispersal vectors. The seeds of some species such as Podocarpus latifolius and Calodendrum capense loose viability fast when they dry out, and of other species such as Olea capensis subsp macrocarpa and Cassine papillosa have long germination periods due to woody seed coats (Geldenhuys 1975) and are then liable to predation by rodents (personal observation). However, others with similar seed types occur further into the Baviaanskloof-Kouga complex such as Ekebergia capensis and Podocarpus falcatus (both are dispersed by bats).

* Secondly, a more likely explanation is that the subtropical forests expanded in different waves and that each wave contained a different set of species. The expansion and contraction could be related to successive periods of high and low sea levels respectively, which in turn were associated with humid and arid periods respectively (Hendey 1983). During later periods of forest expansion along the coast some areas, particularly the more arid inland areas, may not have suited the colonization by forest species.

+ For example, Podocarpus falcatus occurs as far west as Swellendam and P. latifolius as far west as the Cape Peninsula (Von Breitenbach 1986). Both grow in small forest patches near the southern exit of the Gouritz river through the Langeberg-Outeniqua ranges. Both are well-dispersed in the southern Cape coastal forests (Geldenhuys 1980; Chapter 3) but have a limited entry in the Baviaanskloof and are absent from the Rooiberg and Kamanassie. I suggest that they represent a relatively late southwestern expansion of the subtropical forests when barriers of semi-arid lowlands inland of the coastal mountains prevented their spread inland. This implies that the two Podocarpus species have a tropical origin and are not part of the austral flora as has often been suggested (e.g. Levyns 1964). Their large fruit size have a tropical affinity (Givnish 1980) in contrast to the small fruit size of austral podocarps of Australia, New Zealand and Chili (personal observation). I suggest that the fossil podocarp pollens from some southwestern Cape sites (e.g. Coetzee 1986) may represent austral podocarps which became extinct with the regression of the early temperate forests and before the present species arrived in the area.

+ Some species represent the spread of subtropical transitional thicket (Cowling 1984; Everard 1987). Species such as Ptaeroxylon obliquum, Diospyros scabrida and Pavetta lanceolata have not yet reached the southern Cape coastal forests. Others have reached the southern Cape but were cut off by the Late Pleistocene-Holocene marine transgression e.g. Hippobromus pauciflorus, Schotia latifolia and Plumbago auriculata (Chapter 6).

+ Some coastal dune forest species, such as Strychnos decussata and Eugenia zeyheri, require specialized sites which prevented their spread inland. For example, S. decussata grows on a terrace along the Zunga river in a site similar to where the species grows in Nature's Valley along the southern Cape coast (Geldenhuys 1986).

+ Some species, such as Trichocladus ellipticus, represent relicts of a retreating forest flora (Chapter 6).

Subtropical transitional thicket and karroid woodland

The widespread inland species of drier sites (Table 5) are generally associated with subtropical transitional thicket (Cowling 1984; Everard 1987). They have probably become mixed with the more tolerant moist forest elements with the increasing aridity since the Miocene-Pliocene (Deacon 1983). They occur in few of the sites at higher altitudes. They are more prominent in the bush clumps and subtropical transitional thicket of the more arid lowlands and riverine sites in the drier, open valleys of the Baviaanskloof and Karoo. They occur in the drier parts of moist sites such as where streams from the mountains open up into the dry valleys, or on the drier slopes above the streams, or along open valleys or gorges such as Meiringspoort. Seeds of several of the species were found along the krantzes above the study sites and I presumed that Red-winged starlings dispersed the seeds from the lowlands or other nearby sites. Many of these species are, however, absent from the Kamanassie sites although they are present in the lowlands further away from the mountain. The higher (Eo-Oligocene) and lower (Mio-Pliocene) surfaces on the southern side of the Kamanassie (Lenz 1957) could account for this absence. At Boomplaas Cave, between my Swartberg Pass and Rust-en-Vrede sites, Scholtz (1986) indicated from charcoal assemblages that *A. karroo* only became dominant in the late Holocene during more mesic conditions. This species was absent from charcoal layers older than 12 000 years although it was a much preferred firewood. It became a major component of woodland in the valley near the cave since 5 000 ago after an initial spread into the valley in the early Holocene (Deacon *et al.* 1983).

ENDEMIC SPECIES

The endemic species represent two major groups: forest margin species such as *Virgilia divaricata* (Phillips 1926), *Laurophyllus capensis* (Phillips 1931; Chapter 3) and *Widdringtonia schwarzii* (Löckhoff 1963); and species of drier sites such as *Lachnostylis bilocularis* and *Loxostylis alata* (Palmer and Pitman 1972). The sites in which the forest margin species mature suggest that they can only persist with less frequent fires than under which fynbos persist. This has been shown for L. capensis (Vlok and De Ronde 1989). Trees of V. divaricata (Phillips 1926) and Widdringtonia schwarzii (Löckhoff 1963) are killed by fires and depend on reseeding for regeneration. All except Smellophylum capense have dry seeds which do not appear to be readily dipersed. I assume that these species have evolved in this region. I suspect that they formed part of specific vegetation units but became separated and isolated to a lesser or greater degree as a result of their poor dispersability and sensitivity to frequent fires.

* The distribution of Virgilia (Van Wyk 1986) corresponds with the distribution pattern of the subtropical forest species which expanded during the Oligocene-Miocene. I suggest that V. divaricata was the parent species from which the other species evolved because of its presence in both the inland and coastal forests. Its absence from Rooiberg but presence in Kamanassie suggests that the species became established at a relatively late stage of expansion of subtropical forest. Its crossing of the gap north of the Keurbooms river towards the Kamanassie could perhaps be explained by dispersal of the resistant seeds by primates, particularly the baboon (Papio ursinus) and Vervet monkey (Cercopithecus aethiops). I have seen both these primates in stands of Acacia karoo and the alien wattle A mearnsii which have seeds very similar to V. divaricata, and I have seen seeds of V. divaricata in the faeces of the baboon in the coastal mountains. Two stages of spread of V. divaricata is possible. Van Wyk (1986) mentioned two forms of the species: a form of drier localities such as in Seweweeks Poort, Baviaanskloof and Groendal which I consider the first stage; and the form of the coastal forests between Humansdorp and George as the second stage.

* Lachnostylis bilocularis was recorded in the Rooiberg and Meiringspoort but also occurs in various localities between Ladismith and Uniondale (Palmer and Pitman 1972). In Meiringspoort the tree grows in the southern part of the gorge up to a particularly narrow part of the gorge and does not grow north of it. Its distribution suggests that it occurred more widespread before. The related L. hirta occurs in the coastal forests over a somewhat wider range (Palmer and Pitman 1972). I suggest that L. hirta spanned the Gouritz river valley during less arid periods of the Oligocene-Miocene with a wider distribution in the dry,

forested coastal areas. _L_. _bilocularis_ evolved inland as an adaptation to dry, open sites and eventually became limited to the present localities when the lowlands became even drier. Both species have dry seeds in dry capsules and are poorly dispersed. _Calpurnia_ _villosa_ has a similar but more restricted distribution to _L_. _bilocularis_ which also centers on the Gouritz river and its tributaries in the Oudtshoorn basin (Palmer and Pitman 1972). The specimen in Grootrivier Poort could be my misidentification in the field of _C_. _aurea_.

CONCLUSIONS

The systematic survey of forests in the inland mountain ranges in relation to the geomorphological evolution of dispersal corridors which link them with the coastal forests has provided a means to postulate relative dates for the expansion and contraction of floristic elements of both the inland and coastal forests. However, several assumptions made in this study require to be verified, such as the following:

* Dispersal distances by wind of the small, dry seeds of _Cunonia_ _capensis_ and _Nuxia_ _floribunda_.
* Flight patterns of frugivorous birds between the coastal and inland forests, and the feeding behaviour of those birds.
* The phylogenetic relationships of species of genera such as _Lachnostylis_ and _Virgilia_, and of provenances of several other species such as _Ilex_ _mitis_ and the _Podocarpus_ species.

Disturbance regimes in the study area have changed over time. The current human-induced disturbances of the vegetation exert extreme pressures on the forests which persisted in refuge sites in marginal environments. The forest patches should be treated as rare "species" to allow the natural processes of population migration, settlement and adaptation to continue.

* Burning patterns during controlled block burns in catchments which contain forest patches should be reconsidered. The forests should not be used as fire breaks as have been done in several cases. Fires should be burnt down the slopes as would occur with natural fires (see Chapter 2) and not from the

bottom of the valleys.

* Smaller alluvial sites along the rivers and the area surrounding the exit of streams from the mountains should not be cultivated, grazed or burnt.

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Appendix

SPECIES LIST FOR FORESTS IN INLAND MOUNTAINS OF THE SOUTHERN CAPE

The nomenclature follows Schelpe and Anthony (1986) for the ferns and Gibbs Russell et al. (1985, 1987) for the gymnosperms and flowering plants. The forest sites are as follows:

ROOIBERG: 1 = Bosrivier upper; 2 = Bosrivier lower; 3 = Assegaaibosrivier
KAMANASSIE: 4 = Kluesrivier; 5 = Meulrivier upper
SWARTBERG: 6 = Waterkloof; 7 = Seweweekspoort; 8 = Swartbergpoort (Prins Albert); 9 = Swartberg Pass (Hotel site); 10 = Rust-en-Vrede waterfall; 11 = Huisrivier upper; 12 = Meiringspoort; 13 = Tierkloof; 14 = Cheridouwpoort
KOUGA-BAVIAANSKLOOF: 15 = Sapreerivier; 16 = Doringkloof; 17 = Bosrug; 18 = Geelhoutbos; 19 = Assegaaikloof; 20 = Witrivier upper; 21 = Witrivier lower; 22 = Grootrivierpoort
GROENDAL: 23 = Zungarivier

TREES AND SHRUBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Ilex mitis	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1		1		1	1		1	19
Halleria lucida	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1			1	1		1	19
Kiggelaria africana	1		1	1	1	1		1	1	1	1	1		1	1	1	1	1		1	1	1	1	19
Maytenus acuminata	1	1	1	1	1			1		1	1	1	1	1	1	1	1	1	1	1		1	1	19
Olea europaea africana	1	1	1			1	1	1	1	1		1		1	1	1	1	1			1	1	1	17
Cunonia capensis	1	1	1	1	1					1	1	1	1	1	1	1		1		1	1		1	16
Maytenus heterophylla		1	1				1		1	1		1		1	1	1	1	1	1		1	1	1	15
Rhus rehmanniana		1	1	1	1	1			1		1		1	1	1	1	1	1	1				1	15
Pterocelastrus tricuspidatus	1	1	1	1	1		1	1							1	1	1	1	1		1	1	1	15
Colpoon compressum		1	1	1		1	1			1		1	1	1	1	1					1	1	1	14
Cussonia spicata	1	1	1			1	1	1		1		1		1	1	1	1					1	1	14
Diospyros dichrophylla	1	1	1	1			1			1		1			1			1	1		1	1	1	13
Myrsine africana	1	1		1		1		1	1	1	1	1	1	1	1								1	13
Buddleja salviifolia			1				1	1	1	1		1	1	1	1	1	1						1	12
Rhus lucida	1	1	1	1		1		1	1	1		1	1	1	1									12
Olinia ventosa	1	1	1	1	1											1	1		1		1	1	1	11
Nuxia floribunda	1	1	1													1	1	1	1		1	1	1	10
Carissa bispinosa	1	1	1												1	1			1		1	1	1	9
Grewia occidentalis	1	1													1	1	1	1		1	1	1		9
Cassine peraqua	1	1	1	1	1										1	1					1	1		9
Allophylus decipiens	1	1												1	1	1		1		1	1	1		9
Ficus burtt-davyi										1		1			1	1	1	1	1		1	1		9
Myrica serrata	1	1	1		1	1	1						1	1							1			9
Brachylaena neriifolia			1	1	1	1	1				1	1	1	1										9
Rapanea melanophloeos				1	1					1					1	1					1	1	1	8
Pittosporum viridiflorum															1	1	1	1	1		1	1	1	8
Buddleja saligna	1	1				1										1	1					1	1	7
Curtisia dentata	1	1	1																1		1	1	1	7
Sideroxylon inerme		1															1	1	1		1	1	1	7
Virgilia divaricata			1	1		1									1	1					1		1	7
Smellophyllum capense																1	1	1	1		1	1	1	7

TREES AND SHRUBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Schotia latifolia																1	1	1	1		1	1	1	7
Celtis africana																1	1	1	1		1	1	1	7
Ficus sur																1	1	1	1		1	1	1	7
Euclea undulata				1				1		1		1			1			1			1			7
Psoralea sp cf pinnata				1			1	1			1		1	1	1									7
Maytenus oleoides		1					1	1					1	1	1									6
Acacia karroo							1					1				1			1	1		1		6
Diospyros whyteana				1	1										1						1	1	1	6
Canthium inerme	1	1																	1		1	1	1	6
Diospyros scabrida var cordata																1	1	1	1		1		1	6
Putterlickia pyracantha																1	1	1	1		1	1		6
Euclea schimperi var daphnoides															1	1	1	1				1	1	6
Gonioma kamassi																1	1		1		1	1	1	6
Azima tetracantha																1	1	1				1	1	5
Plumbago auriculata																1		1			1	1	1	5
Hippobromus pauciflorus																		1	1		1	1	1	5
Scutia myrtina	1	1	1																		1		1	5
Tarchonanthus camphoratus		1										1		1	1								1	5
Pterocelastrus rostratus		1		1			1			1	1													5
Olea capensis capensis	1														1						1	1		4
Brachylaena glabra																1				1	1		1	4
Podocarpus falcatus																		1			1	1	1	4
Vepris lanceolata																	1		1			1	1	4
Apodytes dimidiata																			1		1	1	1	4
Loxostylis alata																			1		1	1	1	4
Cussonia paniculata											1		1	1		1								4
Ocotea bullata	1			1	1																			3
Lachnostylis bilocularis			1	1									1											3
Rhus longispina		1	1														1							3
Cassine reticulata																1	1		1					3
Dovyalis rhamnoides																			1			1	1	3
Clausena anisata																			1		1		1	3
Ochna serrulata																					1	1	1	3
Ekebergia capensis															1							1	1	3
Capparis sepiaria var citrifolia																			1		1	1		3
Acokanthera oppositifolia																			1			1	1	3
Cassine aethiopica																			1		1	1		3
Diospyros glabra							1	1				1												3
Chrysanthemoides monilifera			1		1		1																	3
Buddleja sp																1	1							2
Scolopia mundii				1																			1	2
Rhus lancea			1										1											2
Calpurnia villosa											1										1			2
Canthium mundianum																		1				1		2
Widdringtonia schwarzii															1	1								2
Pappea capensis																1			1					2
Maytenus undata																1	1							2

TREES AND SHRUBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Rhamnus prinoides															1								1	2
Calodendrum capense																						1	1	2
Rothmannia capensis																					1		1	2
Chionanthus foveolatus																					1		1	2
Maytenus nemorosa																						1	1	2
Psydrax obovata																					1		1	2
Canthium ciliatum																						1	1	2
Teclea natalensis																					1	1		2
Pavetta lanceolata																						1	1	2
Podocarpus latifolius																					1		1	2
Euclea racemosa													1			1								2
Widdringtonia cupressoides				1											1									2
Trichocladus ellipticus																							1	1
Chaetacme aristata																							1	1
Ochna arborea																							1	1
Canthium pauciflorum																							1	1
Olea capensis macrocarpa																							1	1
Eugenia zeyheri																							1	1
Pleurostylia capensis																							1	1
Euclea schimperi																							1	1
Maytenus mossambicensis																							1	1
Cassine papillosa																							1	1
Rhus chirindensis																							1	1
Strychnos decussata																							1	1
Ptaeroxylon obliquum																							1	1
Sterculia alexandrii																							1	1
Laurophyllus capensis																							1	1
Scolopia zeyheri																							1	1
Maytenus peduncularis																							1	1
Cassine tetragona																						1		1
Crotalaria capensis																						1		1
Atalaya capensis																					1			1
Cassine eucleiformis																					1			1
Zanthoxylum capense																					1			1
Cassine parvifolia																					1			1
Ehretia amoena																			1					1
Rhus sp cf refracta																	1							1
Rhus glauca														1										1
Carissa haematocarpa								1																1
Heteromorpha trifoliata			1																					1
LIANES AND VINES																								
Dipogon lignosus	1	1	1	1		1		1			1	1		1	1	1	1	1	1	1	1		1	17
Secamone alpini	1	1	1	1	1					1		1		1	1	1		1	1		1	1	1	15
Protasparagus aethiopicus	1	1	1	1		1	1	1		1		1		1	1	1	1						1	14
Clematis brachiata			1				1						1	1	1	1	1	1	1				1	10
*Cynanchum ellipticum			1	1		1									1	1		1				1	1	8
Kedrostis nana var schlechteri		1	1			1		1							1	1							1	7
Myrsiphyllum scandens		1	1	1			1				1					1								6

LIANES AND VINES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Protasparagus setaceus					1											1			1		1	1	1	6
Rubus pinnatus						1		1		1	1		1											5
Rhoicissus digitata																1					1	1	1	4
Rhynchosia caribaea																		1	1		1	1		4
Senecio angulatus				1																		1	1	3
Pelargonium sp		1	1													1								3
Secamone filiformis																					1	1	1	3
Zehneria scabra																	1		1			1		3
Rumex frutescens																	1		1					2
Senecio deltoideus																						1	1	2
Coccinea palmata																					1	1		2
Microglossa mespilifolia																			1			1		2
Oncinema lineare					1				1															2
Rhoicissus tomentosa																							1	1
Cissampelos torulosa																							1	1
Senecio sp1																							1	1
Senecio sp2																							1	1
Adenocline arcuta																						1		1
Thunbergia dregeana																						1		1
Tylophora lycioides																	1							1
Senecio quinquelobus						1																		1
Protasparagus sp				1																				1

* cf Anisotoma cordifolia in Waterkloof

FERNS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Blechnum australe	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1			1		1	18
Blechnum punctulatum	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1			1	1	1		18
Blechnum capense		1	1	1	1	1	1	1		1	1		1		1	1				1	1		1	15
Todea barbara		1	1	1	1	1	1	1	1	1					1	1	1			1	1		1	15
Pteris dentata	1	1	1			1					1				1	1	1	1			1		1	11
Blechnum giganteum			1	1		1			1	1	1						1	1		1	1			10
Cheilanthes multifida			1			1		1						1	1	1	1		1		1	1		10
Gleichenia polypodioides			1	1		1							1	1	1					1	1	1		9
Asplenium aethiopicum		1		1	1		1		1	1							1				1			8
Cheilanthes viridis			1			1				1						1			1		1	1	1	8
Rumohra adiantiformis	1			1	1				1	1					1						1		1	8
Cyathea capense				1	1	1			1	1										1				6
Hypolepis sparsisora		1	1	1		1										1							1	6
Thelypteris bergiana		1	1													1		1			1		1	6
Blechnum inflexum						1			1	1		1			1									5
Polystichum pungens	1			1	1				1															4
Asplenium lunulatum	1			1					1														1	4
Adiantum capillus-veneris															1	1		1			1			4
Thelypteris interrupta																1		1				1	1	4
Ceterach cordatum																	1		1		1	1		4
Histiopteris incisa									1											1			1	3
Cheilanthes hirta	1																				1	1		3
Asplenium rutifolium																					1		1	2
Asplenium splendens										1											1			2
Asplenium protensum				1					1															2

FERNS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Pellaea pteroides	1									1														2
Elaphoglossum acrostichoides									1											1				2
Blechnum tabulare															1				1					2
Asplenium adiantum-nigrum var solidum	1																							1
Pleopeltis macrocarpa	1																							1
Cheilanthes capensis	1																							1
Cheilantus parviloba			1																					1
Microsorium ensiforme				1																				1
Lycopodium gnidioides				1																				1
Dryopteris calolepis									1															1
Ctenitis lanuginosa											1													1
Osmunda regalis															1									1
Asplenium monanthes																				1				1
GEOPHYTES AND GRAMINOIDS																								
Zanthedeschia aethiopica	1	1	1					1	1	1	1	1	1	1	1		1	1			1			14
Ehrharta sp1			1	1	1				1	1						1	1	1				1	1	10
Ficinia sylvatica		1	1	1		1			1							1	1			1	1			9
Schoenoxiphium lanceum			1	1	1	1	1				1											1		7
Carex aethiopica						1												1			1	1	1	5
Stipa dregeana				1	1													1				1	1	5
Dietes iridioides					1													1	1			1	1	5
Schoenoxiphium lehmannii	1																	1				1	1	4
Panicum deustum																			1		1	1	1	4
Chlorophytum comosum																		1	1		1	1		4
Commelina africana var lancispatha																	1		1			1	1	4
Ehrharta sp cf ramosa/gigantea					1	1			1			1												4
Ehrharta sp2	1	1				1									1									4
Haemanthus albiflos		1	1					1							1									4
Ornithogalum longibracteata																	1				1		1	3
Aristea ensifolia				1																	1		1	3
Cyperus albostriatus																						1	1	2
Oplismenus hirtellus																							1	1
Scadoxus puniceus																					1			1
Gladiolus robustus																					1			1
Agapanthus sp																					1			1
Disperis lindleyana																					1			1
FORBS AND SOFT SHRUBS																								
Pelargonium zonale	1	1	1	1		1	1	1		1		1		1	1	1	1							13
Stachys aethiopica		1	1	1				1	1						1		1		1		1	1		10
Crassula pellucida subsp marginalis				1		1		1		1						1	1				1	1		8
Pelargonium ribifolia		1	1	1		1							1	1	1									7
Knowltonia vesicatoria subsp humilis	1	1	1			1					1									1				6
Pelargonium scabrida										1	1	1	1	1										5

FORBS AND SOFT SHRUBS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
Peperomia retusa	1		1							1											1			4
Clutia pulchella		1	1																1		1			4
Protasparagus macowanii				1	1		1																1	4
Hypoestes sp cf verticillatus																	1		1		1	1		4
Euphorbia kraussiana																1						1	1	3
Oxalis purpurea					1																1		1	3
Gerbera cordata																					1	1	1	3
Galopina circaeoides																		1			1		1	3
Nemesia mellissifolia				1				1									1							3
Sp cf Acalypha																	1						1	2
Streptocarpus rexii																				1			1	2
Isoglossa prolixa																			1				1	2
Stachys hispida				1	1																			2
Solanum retroflexum						1				1														2
Helichrysum petiolare				1		1																		2
Lobelia sp			1				1																	2
Peperomia tetraphylla				1						1														2
Crassula nemorosa		1													1									2
Solanum giganteum																							1	1
Cyrtorchis arcuata																							1	1
Leidesia procumbens																							1	1
Didymodoxa caffra																							1	1
Pavonia praemorsa																						1		1
Leonotis ocymifolia																					1			1
Plectranthus verticillatus																					1			1
Jatropha capensis																				1				1
Zygophyllum morgsana																1								1
Clutia natalensis																	1							1
Polygala myrtifolia																1								1
Peucedanum sp																1								1
Solanum tomentosum																1								1
Galium thunbergianum						1																		1
Aloe sp				1																				1
Centella erianthe				1																				1
Cardamine africana				1																				1
Ceropegia sp				1																				1
Abutilon sonneratianum			1																					1

Chapter 6

DISJUNCTIONS AND DISTRIBUTION LIMITS OF FOREST SPECIES IN THE SOUTHERN CAPE

CONTENTS

ABSTRACT

A total of 206 species reach their distribution limits within the southern Cape forests, or have disjunct distributions within this area and wider distributions outside. Biological variables (growth form, dispersal type) and habitat variables (forest type, moisture tolerance) are not significantly correlated with the drop-out of species, but all distribution variables (spread and abundance in study area, geographic origin) are. Species with a western distribution limit are concentrated in the Mossel Bay - George area. It is suggested that these western limits and the disjunctions west of Gouritz river and in the Knysna and Tsitsikamma forests relate to the major forest decline with the onset of the Late Pliocene marine regression. Species tolerant of drier conditions are concentrated in disjunct localities of dry high or scrub forest in the drier valleys around Mossel Bay and Plettenberg Bay, at Nature's Valley, on the dunes around Sedgefield, and in the coastal areas of eastern Tsitsikamma. This pattern is attributed to the elimination of coastal dune forest and eastern Cape subtropical transitional thicket on the Agulhas Bank during the marine transgression after the Last Glacial Maximum.

INTRODUCTION

The southern Cape forests contain many species which have disjunct distributions in the area but wide distributions outside. Also many species find their distribution limits within the area. This has attracted the attention of plant geographers and ecologists in order to clarify the palaeoecology of the region (such as Phillips 1927a, 1931; Geldenhuys 1981, 1986). Several studies have attempted to establish the geomorphological and climatological history of the region (Phillips 1927b; Butzer and Helgren 1972; Helgren and Butzer 1977; Scholtz 1986; Thwaites and Jacobs 1987).

A southward attenuation of forest species is evident in several parts of southern Africa (McKenzie 1978; Tinley 1985; Cawe 1986). This attenuation can be explained either by means of range expansion through long distance dispersal or by means of range contraction or division through vicariance events such as climatic change or marine transgressions (Cowling 1986). Forest tree and shrub species are largely bird-dispersed (Knight and Siegfried 1983; Chapter 3) and dispersal distances are generally assumed to be relatively long (White 1983; Cowling 1986). After the Late Cretaceous - Palaeocene, widespread temperate forest in southern Africa was replaced by subtropical forest which was later replaced by expanding grassland, woodland and shrubland due to climatic deterioration and increasing aridity (Axelrod and Raven 1978; Deacon 1983). Meanwhile the climate fluctuated between warm, moist periods during marine transgressions and cool, dry periods during regressions (Hendey 1983) which continued into the Holocene (Scholtz 1986). This suggests that much mixing of vegetation types could have occurred. The question is whether the disjunctions and distribution limits are related to the vicariance events, and if so, whether they were caused during the Tertiary or during the last Glacial-Interglacial cycle.

The objectives of this study are to

* list the species of the southern Cape forests which have a disjunct distribution or which reach the limit of their distribution within the area, as well as their distribution patterns,

* establish which common biological, habitat and distributional characteristics of the species determine their specific distribution patterns, and
* interpret their distribution in relation to the known geomorphological and climatological history of the region.

STUDY AREA

The study covers the area between the Gouritz River in the west and the Kromme River in the east, and the Indian Ocean coastline in the south and crests of the east-west trending coastal Cape Folded Mountains in the north (Figure 1; Chapter 1). The mountains are up to 1600 m above mean sea level (a.s.l.) and between 10 and 37 km from the coast. They separate the moist coastal region from the dry Little Karoo inland. To the south undulating foothills separate the mountains from the level coastal platform at 180 to 240 m a.s.l. The platform ends in a steep coastal scarp. Many rivers run south from the mountains to form deep, narrow incisions through the coastal foreland. In several places, east-west tributaries form wider valleys along softer geological substrates. Several rivers form estuaries on the coast. Several east-facing embayments have formed along the coast. Rocks of the Cape Supergroup (mainly of supermature quartzitic sandstones, with subordinate shales) underlie most of the area. Pre-Cape and Cretaceous rocks (granite, quartzites, shales and schists), and unconsolidated deposits of recent age occupy smaller areas (Toerien 1979).

Mean annual rainfall ranges from 400 mm around Mossel Bay to about 1200 mm in three localities. Rain falls all year with maxima in early and late summer. The mean daily maximum temperature ranges between 23,8°C for February to 18,2°C for August, and the mean daily minimum between 19,7°C and 8,9°C (Chapter 1). Frost occurs infrequently. Bergwinds during winter and cold fronts during spring and autumn further contribute to the very equable climate.

Acocks (1953) recognised several vegetation types in the area. Knysna Forest (Veld type 4; Phillips 1931), the subject of this study, comprises both high

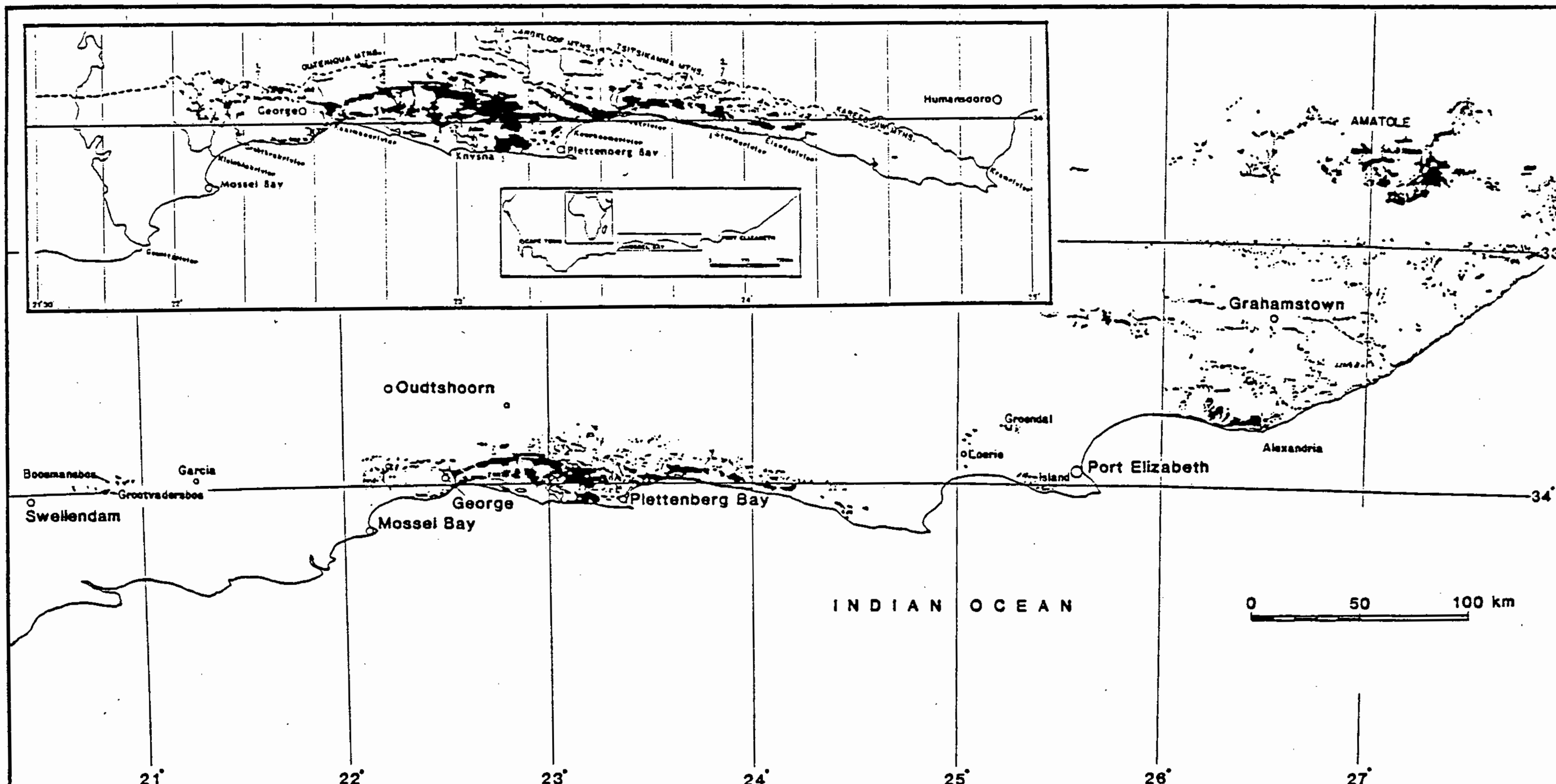

Figure 1 The distribution of forests in the study area.

and scrub forest, covers a total area of 60 561 ha (Chapter 1) and contains 465 vascular plant species (Chapter 3). The forests are surrounded by several types of shrubland: a large area of False Macchia or Mountain Fynbos (Veld Type 70) along the mountains and coastal foreland. Towards the western and eastern extremes of the study area the coastal foreland widens, receives less rain and is covered by drier vegetaion types: Coastal Macchia (Veld Type 47), Coastal Renosterbos (Veld Type 46) and Valley Bushveld (Veld Type 23). McKenzie (1978) and Cowling (1983, 1984, 1986) studied the forest and other vegetation to the west and east of the study area.

The forests are relatively isolated from forests to the east and west (Figure 1).

METHODS

I used the annotated list of species for the southern Cape forests (Chapter 3) as basis for this study. This list contains details of the 206 species which have their distribution limits in the study area, or which occur in disjunct localities in this area (Appendix 1). I used the biological (growth form, dispersal type), habitat (forest type, moisture tolerance) and distribution (spread and abundance in the southern Cape, geographic origin as in Chapter 7) characteristics of these species to determine the causes for their disjunctions and distribution limits. I used the Chi-square test of goodness of fit to determine the significance of the differences between the observed and expected frequencies in the categories of each variable. The expected frequencies are based on the ratios of the frequencies for those categories in the total southern Cape forest flora (465 species). For geographic origin, 18 species confined to the southern Cape were excluded from the analysis.

The sites of disjunctions and distribution limits of the species are concentrated in different localities of the study area. I grouped the species according to these localities in order to seek common reasons for their limits and disjunctions.

RESULTS

BIOLOGICAL, HABITAT AND DISTRIBUTION CHARACTERISTICS

The observed and expected frequencies for the categories which represent biological, habitat and distribution variables, and the Chi-square test statistics for those variables are shown in Table 1. The biological and habitat variables do not contribute significantly to the drop-out of species. However, there is a tendency for more forb species to be limited in their distribution. All distribution variables significantly affected the number of limited species. Although some common and widespread species have their distribution limits in the area, proportionately many more rare and occasional species reach their limits here. The eastern Cape has significantly contributed to the number of limited species (particularly herbaceous species excluding ferns). A significant Chi-square value (24,17 with 10 df, P = 0,0072) was calculated for the goodness of fit test for a two-way comparison of geographic origin and moisture tolerance. This indicated that proportionately more eastern Cape species tolerant of dry conditions and fewer afromontane species with wide moisture tolerances (particularly ferns) have reached their limits in the area.

LOCALITIES OF DISJUNCTIONS AND GEOGRAPHIC LIMITS

A southwestern attenuation of species is strongly evident within the study area: 158 species reach their western limit and only 23 species reach their eastern limit here (Table 2). Fifty-four percent of the species with a western limit are concentrated in the George - Mossel Bay area. Species with an eastern limit are concentrated in the eastern part of the study area, particularly in the mountain forests. Disjunct species are concentrated in several localities. Species tolerant of drier conditions are concentrated in dry high or scrub forest in the drier valleys east of Mossel Bay, at Plettenberg Bay and at Nature's Valley, on the dunes around Sedgefield, and in the coastal areas of eastern Tsitsikamma between the Kromme and Elands rivers. Species of moist sites or which have wide moisture tolerances are concentrated in the high forests of the Tsitsikamma coastal platform and in the main forest north of Knysna.

TABLE 1 Observed and expected frequencies for categories of variables which characterize disjunct species and species with distribution limits in the southern Cape. The expected frequencies are based on the ratio of the frequencies over the categories for the total southern Cape forest flora. The Chi-square values for the test of goodness of fit test are indicated. The degrees of freedom are one less than the number of categories of each variable

Variable	Categories	Frequencies		Chi-square		
		Observed	Expected	Categories	Variable	P-value
Growth form	Tree	34	38	0,421		
	Shrub	29	36	1,361		
	Climber	31	27	0,593		
	Fern	15	23	2,783		
	Epiphyte	9	11	0,364		
	Geophyte	15	12	0,750		
	Gramonoid	15	15	0,000		
	Forb	58	44	4,455	10,726	0,151
Dispersal type	Large fleshy	15	16	0,063		
	Small fleshy	40	49	1,653		
	Large dry	10	9	0,111		
	Small dry	83	78	0,321		
	Pappus/wool	20	16	1,000		
	Spores	30	38	1,684	4,831	0,437
Forest type	High forest	89	97	0,660		
	Scrub forest	66	56	1,786		
	Forest gap	36	29	1,690		
	Forest margin	15	24	3,375	7,510	0,057
Moisture tolerance	Moist	36	44	1,455		
	Moist - dry	63	71	0,901		
	Dry	107	91	2,813	5,169	0,075
Abundance	Common	18	21	0,429		
	Scattered	103	126	4,198		
	Rare	85	59	11,458	16,085	0,00032
Geographic spread	Widespread	54	94	17,021		
	Sporadic	89	77	1,870		
	Occasional	63	35	22,400	41,291	1,08E-9
Geographic origin	Western Cape	25	29	0,552		
	Eastern Cape	75	49	13,796		
	Afromontane	28	42	4,667		
	Southern African transgressor	60	68	0,941	19,956	0,00017

TABLE 2 The geographic limits in the southern Cape of disjunct, occasional and widespread species of the forest flora

Growth form	Type of distribution[*]	Number of species: Key locality[+] in longitudinal map zone									TOTAL
		MB	G	S	K	PB	GR	ER	KR	U	
Trees/ shrubs	==>	7	12	-	3	-	-	1	5	-	28
	<==	-	-	-	-	-	1	1	4	-	6
	0==>	-	1	-	4	5	3	4	-	-	17
	0=0=>	1	1	2	3	1	3	-	1	-	5
	<=0=>	2	2	-	-	1	-	1	1	-	4
	0	-	1	-	-	-	1	-	-	1	3
Lianes/ vines	==>	7	3	1	3	1	2	-	1	1	19
	<==	-	-	2	-	-	1	-	1	-	4
	0==>	-	2	2	-	1	1	-	-	-	6
	<=0=>	1	1	-	-	1	1	-	-	-	1
	0	-	1	-	-	-	-	-	-	-	1
Herbs	==>	17	23	1	7	1	3	4	2	5	63
	<==	-	-	1	1	-	-	9	-	1	12
	0==>	-	-	2	1	2	-	-	-	-	5
	0	-	-	2	2	-	1	-	-	8	13
Ferns	==>	9	3	-	1	-	1	-	-	-	14
	<==	-	-	-	1	-	-	-	-	-	1
	0==>	-	-	-	1	-	-	-	-	-	1
	<=0=>	-	-	-	-	1	-	-	2	-	2
	0	-	1	-	-	1	-	-	-	-	1
TOTAL		45	51	13	27	15	18	20	17	16	206

[*] ==> : western distribution limit; <== : eastern distribution limit; 0==> : disjunct locality as western limit; 0=0=> : two or more disjunct localities as western limit; <==0 : disjunct locality as eastern limit; <=0=> : disjunct localities in area but widespread outside both to east and west; 0 : endemic in area or disjunct in area and distribution outside study area unknown.

[+] MB = Mossel Bay; G = George; S = Sedgefield; K = Knysna; PB = Plettenberg Bay; GR = Groot river; ER = Elands river; KR = Kromme river; U = Unknown limits in study area.

Widespread and sporadic species at their geographic limits

Western limits

Widespread and sporadic species with a western distribution limit in the study area fall in three groups. The first group occurs in the eastern extreme of the area and will be discussed together with the disjunct species which occur along the coast. The second group comprises mostly species with a sporadic to occasional spread and a scattered to rare abundance, which grow in scrub forest or disturbed forest. They are concentrated in the Knysna - Groot river area. The exceptions are the tree Zanthoxylum davyi which occurs sporadically and scattered as far west as the Knysna area, and the sedge Scleria natalensis which is common in moist gaps in the Tsitsikamma as far west as Nature's Valley. The third group comprises widespread species with a common or scattered abundance and are concentrated in the George - Mossel Bay area.

Eastern limits

Species which reach their eastern limit in the study area form two groups. The first group is concentrated in the moist to wet mountain forests in the Elands river - Kromme river area. It includes one typical temperate forest remnant tree (Platylophus trifoliatus) and several forest margin and gap shrubs (Cassine parvifolia, Diospyros glabra, Gnidia denudata and Osmitopsis osmitoides), an understorey vine (Myrsiphyllum scandens) and a low-level epiphytic fern (Hymenophyllum marlothii). The second group comprises herbaceous species of scrub forest, forest margin and gap which are associated mainly with drier sites along the coast or with the surrounding fynbos.

Disjunct species in high forest

Species with a disjunct occurrence in the high forest with a wide distribution outside the study area are mainly trees and shrubs and are concentrated in two main areas. The Goudveld - Gouna - Diepwalle forest north of Knysna contains Psychotria capensis, Rothmannia globosa and Trichocladus ellipticus in small, confined populations, and a relatively extensive population of Faurea macnaughtonii (Phillips 1927). The fern Pleupodium simianum and the geophyte Disperis thorncroftii are known from single collections in the Diepwalle forest. Both F. macnaughtonii and P. capensis have expanding populations, i.e. with good recruitment in the area.

The Tsitsikamma forests contain several disjunct species of which some have relatively extensive populations and others consist of a few known individuals. Prunus africana has a declining population in the Bloukrans gorge (Geldenhuys 1981). Brachylaena glabra occurs sporadically in the large forests of the coastal platform and river slopes, but regenerates profusely on the forest margin in some areas. A similar expanding population also occurs inland on the same longitude in Doringkloof and other forested gorges in the Baviaanskloof mountains (Chapter 5). Schefflera umbellifera occurs extensively from the mountain to the coast along the Elands river. Profuse regeneration occurs in gaps and along the forest margin in localized parts of its range, and the adult sub-populations suggest that they regenerated after major disturbances, probably by fire, of the forests in which they grow. It is however, surprising that the tree has not managed to spread further to the east or west of the Elands river. Chionanthus peglerae and Dovyalis lucida in Witelsbos, Kwaaibrandbos and Koomansbos on both sides of the Elands river and Canthium ciliatum in Lottering forest occur as scattered individuals.

Two disjunct species occur west of George. Canthium pauciflorum occurs as a few individuals in a small platform forest west of George and a single record near Knysna. Pterocelastrus rostratus is a common understorey tree in the mountain and foothill forests west of George as far as the western Cape. It stops abruptly in forests west of the Malgas river below the Outeniqua pass north of George. From here it forms a major break in its distribution and continues as an uncommon species in disjunct localities in the eastern Cape, Transkei and Natal (Moll 1981; Von Breitenbach 1986). In the southern Cape inland mountains P. rostratus occurs up to the same longitude, from the west

(Chapter 5).

Disjunct species along the coast

The species which form disjunct populations along the coast occur in either coastal dune forests or in subtropical transitional thicket, or in both, to the east of the study area. Coastal forest species which are more common in the coastal forests west of Port Elizabeth and at Alexandria further to the east occur in several disjunct localities. In the eastern extreme of the study area several species occur as a few individuals: Canthium spinosum, Clerodendrum glabrum, Cyphostemma hypoleucum, Dovyalis rotundifolia, Erythrina caffra and Gardenia thunbergia. The latter two occur scattered in some platform forest west of the Elands river in Blueliliesbush State Forest. Two typical dune forest species occur in healthy, expanding populations around Nature's Valley with satellite populations towards Knysna (Geldenhuys 1986): Strychnos decussata and Strelitzia alba, closely related to S. nicolai. Maytenus undata is known from a single collection at Nature's Valley. Syzygium cordatum at Nature's Valley, Hibiscus diversifolius at various localities and Thelypteris interrupta in the Bitou river valley and at the eastern extreme of the study area, are typical riverine and estuarine species. Acokanthera oblongifolia at Knysna and Klein Brak River and Diospyros pallens at Sedgefield and Wilderness occur as a few individuals.

Several species typical of eastern Cape subtropical transitional thicket (Cowling 1984; Everard 1987) are important elements of scrub forest in low-lying, drier valleys which end in wide estuaries along the coast. Calpurnia aurea subsp sylvatica, Jasminum angulare, Plumbago auriculata, Rhus refracta, R. rehmanniana, Schotia afra var afra and S. latifolia occur scattered in various scrub forest patches in the Bitou river valley east of Plettenberg Bay and their populations show a mixture of immature and mature individuals. Small clumps of the herbs Aptenia cordifolia and Plectranthus madagascariensis occur on dry slopes in the Keurbooms river valley. Hippobromus pauciflorus forms almost single-species canopies on dry slopes in Nature's Valley (Geldenhuys 1986) and occurs as a few individuals in forest patches along the

Kromme river at the eastern extreme of the study area. In the Kromme river Cussonia spicata and Loxostylis alata also occur as a few individuals. Cussonia spicata and Schotia afra var afra also occur at Klein Brak River and in scrub between Mossel Bay and the Gouritz river.

DISCUSSION

VICARIANCE VERSUS LONG-DISTANCE DISPERSAL

Vicariance is much more important than long-distance dispersal in shaping the patterns of disjunctions and distribution limits in the southern Cape forests. Firstly, all the identified species groups contain species which have well-dispersed fleshy fruits as well as species with dry seeds in dry capsules for which dispersal distances over more than a few kilometers are highly unlikely. For example, in the Goudveld - Gouna - Diepwalle group of species, only Psychotria capensis can possibly have been dispersed over long distances. Secondly, the species of the groups also occur together in forest and thicket vegetation outside the study area which suggest that they have a common history of range expansion and contraction. One example is the species of the Bitou river valley. Thirdly, the limits of some species occur at a similar longitude both in the forests of the study area as well as in the small forests in the inland mountains to the north (Chapter 5). This distribution pattern suggest that the ranges of species ranges contracted from a once much wider distribution. Pterocelastrus rostratus, which has fleshy seeds in a fleshy capsule, has its eastern limit at the longitude running through George and is widespread to the west. Brachylaena glabra has wind-dispersed seeds, is common in the Tsitsikamma forest and again in Doringkloof and other forested gorges in the Baviaanskloof mountains to the north but nowhere else in the southern Cape region.

Recent colonization through long-distance dispersal cannot be ruled out, at least for some species. The forests are in an expanding phase after the climatic extremes of the Last Glacial Maximum and the Holocene (Scholtz 1986).

Prunus africana (Geldenhuys 1981) and Schefflera umbellifera are well-adapted to long-distance dispersal by birds and require disturbed sites for establishment and both occur in very confined areas. The question is, however, why S. umbellifera occurs abundant along the Elands river valley from the mountain to the coast but not east and west of the river in similarly suitable sites nearby. The range expansion of Strychnos decussata within the southern Cape forests was attributed to dispersal over some distance although its presence in Nature's Valley was been attributed to a cut-off from its eastern range by marine transgression (Geldenhuys 1986). Furthermore, the Rameron pigeon (Columba arquatrix) is a migrant frugivore along the coast which seasonally visit the forests in large numbers (Phillips 1927c; Koen 1987) and could contribute to long-distance dispersal (Oatley 1984).

From the reconstruction of the palaeofloras, Axelrod and Raven (1978) and Deacon (1983) discussed the distribution of vegetation types in southern Africa in relation to the climatic and landscape changes which have occurred in the area. Subtropical forest covered the largest part of southern Africa during the Late Cretaceous - Palaeocene (77 - 55 my BP) with extensive temperate forests at the southern tip. Subsequent northward drift of the continent (15-18°), epeirogenic uplift and particularly a climatic deterioration caused the narrowing of the temperate forest belt, its replacement by a similarly narrowing subtropical forest belt, and the expansion of savanna, thorn scrub, grassland, sclerophyllous vegetation (fynbos) and more arid environments by the Late Miocene - Early Pliocene (15 - 7 my BP). Pollen and macrofossils from Langebaanweg (Cape west coast) indicate an Early to Middle Miocene presence of lowland forest with palms which was replaced by open woodlands and grasslands during the Late Miocene - Pliocene (Hendey 1982). Pollen sequences from Noordhoek (Cape Peninsula) indicate a Miocene change from subtropical mixed montane forest to lowland forest in which palms were dominant, and a Late Miocene - Pliocene change to sclerophyllous vegetation (Coetzee 1986a). Miocene forests at the Cape fluctuated between palms and conifers as the climate oscillated between warmer and cooler phases associated with eustatically-induced marine transgressions and regressions respectively (Coetzee 1986b; Tyson 1986). Palynological evidence from the Knysna lignites (Thiergart et al. 1963; Thwaites and Jacobs 1987) indicated that the present forest in the area is a very impoverished relict of the ancient Miocene subtropical forest that existed at the Cape (Coetzee 1986a). The Late Miocene - Early Pliocene shift to a fynbos-grassland-forest mosaic in the southwestern Cape are attributed to a progressive cooling of the Atlantic Ocean and adjacent land, the development of the modern Benguela current and the increasing aridity of the environment (Tyson 1986). Evidence from the east coast however, suggest that conditions during the Pliocene were even warmer than during the Miocene (Maud 1986). The sequence of Pleistocene glaciations (the last 1,7 my) had large-scale effects on animal and plant distributions and community composition (Deacon 1983). Glacial (longer periods of cool and cold climate) and interglacial (short periods of warm climate) cycles occurred with a periodicity of some 100 000 years (Tyson 1986). During the last interglacial (about 125 000 years ago) conditions at Klasies River Mouth in the eastern part of the study area was warm and possibly moister than the present (Butzer 1978; Shackleton 1982). Maximum eustatic lowering of sea level at 85 m to 130 m below present sea level occurred at the last glacial maximum 18 000 years ago (Deacon 1983). Studies at Nelson Bay Cave near Plettenberg Bay (Klein 1972), at Groenvlei near Sedgefield (Martin 1968) and at Norga west of George (Scholtz 1986) indicated the vegetation changes within the study area between the last glacial maximum and the Holocene interglacial. From palynological and charcoal evidence Scholtz (1986) showed that during the periods 14 000 to 12 000 years ago, 4 000 to 2 500 years ago and since 1 800 years ago to the present, the climate favoured the spread of forest. However, the present period is not as favourable for forest spread as during the Holocene climatic optimum before 2 500 BP.

These environmental changes had two major effects on the forest flora. Firstly, the narrowing and fragmentation of the forest belt during the Late Miocene - Early Pliocene caused the isolation of forests, the extinction of taxa from particular areas and the selection of taxa with a tolerance of lower moisture, more extreme temperatures and fire disturbance. Secondly, an expansion and contraction of forest from refugia in mesic kloofs and sheltered sites along the mountains and coastal scarp during the glacial cycles of the Pleistocene caused the recombination of forest communities. This is reflected in the concentrations in different discrete localities in the study area of disjunct species and species with distribution limits which belong to different vegetation types outside the study area. It is also born out by the fact that no specific biological or habitat characteristics of the species are related to these disjunctions and distribution limits (Table 1). Individual species may, however, have specific habits and habitat requirements which restrict their distribution (e.g. Geldenhuys 1981, 1986). The species show at least three types of distribution patterns which can be related to the two types of environmental change.

CLIMATIC DETERIORATION AND FRAGMENTATION OF HIGH FORESTS SINCE THE PLIOCENE

I conceive that the last time when more or less continuous forests occurred to the west and east of the study area was during the Early Pliocene marine transgression to over 200 m (Dingle et al. 1983) with assumed increased temperature and rainfall (Hendey 1983). Since the general marine regression of the Late Pliocene, the coastal foreland have been exposed (Rogers 1986; Thwaites and Jacobs 1986). The wider coastal foreland with steeper rainfall gradient and the associated increased fire frequency to the east and west of the study area (Chapter 2) suggest that in these areas forests were much more fragmented than in the study area. I suggest that many of the disjunctions and distribution limits of species of the high forests date from the major forest retreat of the Late Pliocene (see also Chapter 5).

I have indicated that the majority of widespread and sporadic species of the southern Cape forests with distribution limits in the study area are concentrated in the George - Mossel Bay area. Several other widespread and sporadic species of the study area occur in small, disjunct populations west of the Gouritz river (Taylor 1955; McKenzie 1978; H C Taylor and P Masson, personal communication 1989). I relate the distribution pattern of this group of species to the fact that the southern Cape forests find their western limits in the George - Mossel Bay area. The coastal scarp and platform forests end around George and the mountain and foothill forests end north of Mossel Bay (Figure 1; Chapter 1). West of the Gouritz river the coastal scarp is poorly developed, is further away from the mountain range and has a much drier climate (Muir 1929). A prominent platform near the mountains is absent west of Great Brak river, the forests are very small and confined to valleys, ravines and rocky sites sheltered against ravaging fires from the south (Chapter 2) and have fewer component species (Muir 1929; Taylor 1955; McKenzie 1978).

Similarly, I relate the disjunctions of high forest species in the study area to the Late Pliocene isolation of the southern Cape mountain and coastal platform forests from the mountain forests of the eastern Cape. The wide, open Sundays river valley east of Port Elizabeth stretches from the coast to the escarpment remnants near Graaff Reinet through mostly semi-arid to arid parts of the Karoo. According to information supplied by Partridge and Maud (1987), this barrier became well established during the Late Pliocene (see Chapter 4).

I furthermore suggest that those species have survived in parts of the forest with a low disturbance history. Most of the disjunct species in high forest, both in the Knysna and Tsitsikamma forests, occur in infrequently burnt high forests in bergwind fire shadow areas (Chapter 2), or on the edges of those forests. Bond et al. (1988) suggested that fynbos islands in the forests north of Knysna formed as a result of recent forest expansion which implies former more widespread fynbos areas with more extreme fire regimes.

Disjunct populations to the west and populations of southern Cape disjunct species to the east occur at various distances from the study area (e.g. Von Breitenbach 1986). Island biogeography theory (McArthur and Wilson 1967; Bond et al. 1988) predicts that the decreasing size and increasing isolation of the forests west and east of the study area must have increased the rate of extinction of species in those areas. Long isolation may result in distinct ecological species within a taxonomic species, or the vicariant development of new species (Nelson and Rosen 1981). For example, I. ellipticus has a multi-stemmed shrubby growth form in its southern Cape disjunct locality, which is different from its typical single-stemmed, small-tree growth form in the Amatole forests and other eastern Cape forests. Its dry seed dispersed by a ballistic mechanism rules out a possible long-distance dispersal. The hypotheses of evolution of species in isolation relate to longer time scales. Although recent colonization through long distance dispersal cannot be ruled out for some species, the climatic and disturbance regimes east and west of the study area make the expansion of existing forests and the recolonization of forest very unlikely (Scholtz 1986; Chapter 2). I suggest that the opposing questions of vicariant speciation versus recent colonization could be resolved by means of studies of (i) species-area relationships of the forests, and (ii) the population structure and (iii) genetic relationships of species in sites of disjunct and continuous occurrence.

Of the species with an eastern distribution limit in the area, only the tree Platylophus trifoliatus is a relict of the temperate austral forests of the early Tertiary. It is much more restricted in its distribution than the closely related Cunonia capensis. Both belong to the austral Cunoniaceae which have a much wider distribution in the temperate forests around the southern Pacific (Morat et al. 1986). Most of the other species of this western group are forest margin and forest gap species and some occur in the understorey of cool, moist forests. I suggest that these species have speciated in the area due to climatic fluctuations and disturbance pressures and the isolation of the cool mountain forests during the Pleistocene and are restricted due to the same reasons.

COASTAL FOREST SPREAD DURING LATE PLEISTOCENE - HOLOCENE

Conditions during the Late Pleistocene still allowed scrub forest to persist along the present southern Cape coast (Avery 1986). Van Zinderen Bakker (1978) postulated that scrub forest (bush) replaced forest during the Early Glacial which was replaced by grassland during the coldest periods of the

Pleniglacial. During the climatic fluctuations of the Holocene widespread karroid vegetation replaced retreating forest during warmer, drier periods. Low karroid scrub and scrub forest still persist in the drier valleys east and west of the study area. Cowling (1983, 1984, 1986) and Everard (1987) studied this karroid vegetation (subtropical transitional thicket) in the eastern Cape. Most of the southern Cape disjunct scrub forest species occur more widespread in the eastern Cape subtropical transitional thicket. Similarly, most of the disjunct species of coastal forest occur more widespread along the eastern Cape coast. For example, S. nicolai and Syzygium cordatum occur widespread along the coast as far south as East London and Strychnos decussata as far as Port Elizabeth (Von Bretienbach 1986).

I suggest that coastal forest along dunes bordered by subtropical transitional thicket in the valleys covered large areas south of the present coastline during the warmer, drier periods of the Late Pleistocene - Early Holocene. With the marine transgression reaching the present coastline at about 9 000 years before present (BP), and with expansion of the high forest with climatic amelioration, these communities and populations were cut off and isolated from the communities to the east. The Bitou river valley, which joins the Keurbooms river estuary east of Plettenberg Bay, is a wide open valley with relatively low rainfall of 600 mm to 700 mm (Chapter 1). Similarly, the Klein Brak River valley is a relatively dry open valley with more or less direct links with the Gouritz river karroid scrub. These sites have allowed elements of the eastern Cape subtropical thicket to persist in scrub forest together with southern Cape dry forest species. Previously I have suggested long-distance dispersal as an alternative hypothesis to marine transgression to explain the disjunct population of Strychnos decussata in Nature's Valley (Geldenhuys 1986). However, the common distribution pattern of the Nature's Valley - Bitou river - Klein Brak river disjunct species with a common association with eastern Cape thicket - coastal forest vegetation suggest that their isolation through marine transgression is more probable.

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Appendix

LIST OF DISJUNCT SPECIES AND SPECIES WITH DISTRIBUTION LIMITS IN THE SOUTHERN CAPE FORESTS

For more details of each species see the annotated species list for the southern Cape forests (Chapter 3). The nomenclature follows Schelpe and Anthony (1986) for the ferns and Gibbs Russell et al. (1985, 1987) for the other species. The symbols used in the list below have the following meaning:

Forest type: H = high forest; S = scrub forest; G = forest gap; M = forest margin.

Distribution limit: MB = Mossel Bay; G = George; S = Sedgefield; K = Knysna; PB = Plettenberg Bay; GR = Groot river; ER = Elands river; KR = Kromme river; U = Unknown limits in study area.

Distribution type: => : western distribution limit; <= : eastern distribution limit; 0=> : disjunct locality as western limit; 0=0=> : two or more disjunct localities as western limit; <=0=> : disjunct localities in area but widespread outside both to east and west; 0 : endemic in area or disjunct in area and distribution outside study area unknown.

Species	Forest type	Distribution Limit and Type	Special localities
TREES			
Allophylus decipiens	S	MB =>	
Gonioma kamassi	H	MB =>	
Maytenus nemorosa	H	MB =>	
Canthium pauciflorum	H	G 0=>	Witfontein platform forest
Ficus sur	H	G =>	
Maytenus peduncularis	H	G =>	
Ochna arborea	H	G =>	
Pterocelastrus rostratus	H	G <=0=>	Outeniqua pass westwards
Scolopia zeyheri	H	G =>	
Trimeria grandifolia	H	G =>	
Virgilia divaricata	M	G =>	
Virgilia oroboides subsp. ferrugineus	M	G 0	Mosselbaai-George
Faurea macnaughtonii	H	K 0=>	Lily Vlei forest
Rothmannia globosa	H	K 0=>	Diepwalle forest
Zanthoxylum davyi	H	K =>	Goudveld forest
Schotia afra var. afra	S	PB <=0=0=>	Gouritz and Klein Brak rivers, Bitou river valley
Schotia latifolia	S	PB 0=>	Keurbooms river
Hippobromus pauciflorus	S	GR 0=0=>	Nature's Valley, Kromme river
Maytenus undata	H	GR 0=>	Nature's Valley
Prunus africana	H	GR 0=>	Bloukrans Gorge
Strelitzia alba	G, M	GR 0	endemic Knysna-Bloukrans Gorge
Strychnos decussata	H	GR 0=0=>	Biervlei, Brackenhill and

			Nature's Valley forests
Syzygium cordatum	S	GR 0=>	Nature's Valley
Brachylaena glabra	H	ER <=0=>	Lottering to Witelsbos
Chionanthus peglerae	H	ER 0=>	Koomansbos and Witelsbos
Erythrina caffra	H	ER =>	Blueliliesbush eastwards
Dovyalis lucida	H	ER 0=>	Koomansbos
Schefflera umbellifera	H	ER 0=>	Elands river: mountain to coast
Canthium spinosum	H	KR =>	Rozenhof forest
Clerodendron glabrum	S	KR =>	Driefontein coastal forest
Cussonia spicata	S	KR <=0=0=>	Kromme river valley, northern Outeniqua slopes and Gouritz river
Dovyalis rotundifolia	H	KR =>	Driefontein coastal forest
Loxostylis alata	S	KR =>	Kromme river valley
Platylophus trifoliatus	H	KR <=	Kromrivier mountain forests
SHRUBS			
Acokanthera oblongifolia	S	MB 0=0=>	Klein Brak River and Knysna coastal scrub forest
Euphorbia kraussiana	S	MB =>	
Ficus burtt-davyi	H	MB =>	
Passerina falcifolia	M	MB =>	
Rhus longispina	S	MB =>	
Andrachne ovalis	G	G =>	
Desmodium repandum	H	G =>	
Dovyalis rhamnoides	H	G =>	
Excoecaria simii	S	G =>	
Hibiscus pedunculatus	S	G =>	
Maerua racemulosa	H	G =>	
Diospyros pallens	S	S 0=0=>	Wilderness and Sedgefield
Argyrolobium tomentosum	S	K =>	
Hibiscus diversifolius	G, M	K 0=0=>	Knysna, Bitou river valley and Nature's Valley
Ochna serrulata	H	K =>	Kaffirkop forest eastwards
Psychotria capensis	H	K 0=>	Lily Vlei forest
Trichocladus ellipticus	H	K 0=>	Goudveld-Gouna forests
Calpurnia aurea subsp. sylvatica	S	PB 0=>	Bitou river valley
Plumbago auriculata	S	PB 0=>	Bitou and Keurbooms river valleys
Rhus refracta	S	PB 0=>	Bitou river valley
Rhus rehmanniana	M	PB 0=>	Bitou river valley
Sutera aethiopica	M	GR <=	
Canthium ciliatum	H	ER 0=>	Lottering forest
Osmitopsis osmitoides	G, M	ER <=	
Cassine parvifolia	M	KR <=	Kromrivier mountain forests
Diospyros glabra	G, M	KR <=	Kromrivier mountain forests
Gardenia thunbergii	H	KR =>	Rozenhof and Clarkson forests
Gnidia denudata	G	KR <=	
Tapinanthus sp.	H	U 0	

LIANES AND VINES

Ceratiosicyos laevis	H	MB =>	
Cissampelos torulosa	H	MB =>	
Ctenomaria capensis	H	MB =>	
Cynanchum ellipticum	S	MB =>	
Dioscorea mundtii	H	MB =>	
Senecio angulatus	S	MB =>	
Tylophora cordata	H	MB =>	
Astephanus marginatus	S	G =>	
Cineraria lobata	G	G 0=>	Herolds Bay
Cyphia heterophylla	S	G 0	Wilderness
Rhynchosia caribaea	S	G =>	
Tragia sp.	G	G 0=>	Saasveld
Vernonia mespilifolia	H	G =>	
Cissampelos capensis	S	S <=	
Cynanchum natalitium	G	S 0=>	Sedgefield dunes
Cynanchum obtusifolium var. pilosum	S	S =>	Sedgefield dunes
Cyphia digitata	G	S <=	
Thunbergia dregeana	H	S 0=>	Biervlei forest
Dumasia villosa	H	K =>	
Lagenaria sphaerica	S	K =>	Coastal forest
Mikania natalensis	S	K =>	
Dioscorea sylvatica	S	PB =>	Keurbooms river coast
Jasminum angulare	S	PB 0=>	Bitou river valley
Astephanus triflorus	S	GR <=	Nature's Valley
Cynanchum tetrapterum	S	GR =>	Nature's Valley
Kedrostis foetidissima subsp. obtusiloba	G	GR 0=>	Nature's Valley
Myrsiphyllum volubile	S	GR <=0=0=>	Klein Brak river, Wilderness, Robberg and Nature's Valley
Vernonia anisochaetoides	H	GR =>	Nature's Valley
Cyphostemma hypoleucum	S	KR =>	Driefontein coastal forest
Myrsiphyllum scandens	H	KR <=	Kromrivier mountain forests
Solanum geniculatum	S	U =>	

FERNS

Asplenium protensum	H	MB =>	
Blotiella glabra	H	MB =>	
Blotiella natalensis	H	MB =>	
Cheilanthes bergiana	H	MB =>	
Cheilanthes concolor	H	MB =>	
Cheilanthes hirta	S	MB =>	
Cheilanthes viridus var. macrophylla	H	MB =>	
Marattia fraxinea	H	MB =>	
Asplenium lunulatum	H	G =>	
Megalastrum lanuginosa	H	G =>	
Thelypteris knysnaensis	H	G 0=0	Groenkop forest, Keurboomsrivier
Thelypteris gueinziana	H	K =>	
Asplenium lobatum	H	GR =>	Nature's Valley

Osmunda regalis	M	KR <=0=>	eastern Tsitsikamma
Thelypteris interrupta	H	KR <=0=0=>	Bitou river valley, Rozenhof
EPIPHYTES			
Asplenium theciferum	H	MB =>	
Cyrtorchis arcuata	H	MB =>	
Mystacidium capense	H	MB =>	
Tridactyle bicaudata	H	MB =>	
Angraecum conchiferum	S	G =>	
Asplenium simii	H	G =>	
Hymenophyllum marlothii	H	K <=	
x Pleupodium simianum	H	K 0=>	Diepwalle forest
Angraecum pusillum	H	U 0	
GEOPHYTES			
Cyrtanthus purpureus	G	MB =>	
Disperis lindleyana	H	MB =>	
Haemanthus albiflos	H	MB =>	
Liparis capensis	S	MB =>	
Agapanthus praecox	S	G =>	
Calanthe sylvatica	H	G =>	
Scadoxus puniceus	H	G =>	
Liparis remota	S	G =>	
Disperis thorncroftii	H	K 0=>	Diepwalle forest
Gasteria acinacifolia	S	K =>	Harkerville coast eastwards
Tulbaghia violacea	S	K 0	Harkerville and Witelsbos coast
Melasphaerula ramosa	S	ER <=	
Monadenia bracteata	M	ER <=	
Gladiolus sempervirens	M	U 0	
Hypoxis sp.	H	U 0	
GRAMINOIDS			
Microstegium nudum	G	MB =>	
Ficinia fascicularis	G	G =>	
Sporobolus fourcadii	M	G =>	
Brachiaria chusqueoides	S	S 0=>	Sedgefield dunes
Stipa dregeana	S	S 0=>	Sedgefield dunes
Festuca africana	H	K 0	Kop se bos, Buffelsnek
Ficinia sp.	G	GR 0	Nature's Valley
Scleria natalensis	G	GR =>	Nature's Valley
Ehrharta erecta var. natalensis	H	ER =>	Witelsbos
Ehrharta rehmannii	H	ER <=	
Ehrharta subspicata	G	ER <=	
Epischoenus adnatus	M	ER <=	
Panicum subalbidum	G	ER =>	Witelsbos
Isolepis costata	G	U =>	
Schoenoxiphium altum	G	U 0	New species
FORBS			
Abutilon sonneratianum	G	MB =>	

Ceropegia africana	S	MB =>	
Crassula spathulatha	H	MB =>	
Dicliptera zeylanica	H	MB =>	
Gerbera cordata	H	MB =>	
Laportea peduncularis	H	MB =>	
Plectranthus verticillatus	S	MB =>	
Pupalia atropurpurea	S	MB =>	
Sida ternata	G	MB =>	
Crassula cordata	S	G =>	
Crassula sarmentosa	M	G =>	
Diclis reptans	S	G =>	
Drymaria cordata subsp. diandra	H	G =>	
Hypoestes forskaolei	H	G =>	
Isoglossa ciliata	H	G =>	
Isoglossa grantii	H	G =>	Wilderness
Knowltonia cordata	S	G =>	
Laportea grossa	H	G =>	
Lobelia patula	H	G =>	
Pavonia columella	G	G =>	
Sida dregei	G	G =>	Wilderness
Siphonoglossa leptantha	S	G =>	
Stachys graciliflora	G	G =>	Wilderness
Streptocarpus rexii	S	G =>	
Sutera cordata	S	G =>	
Knowltonia vesicatoria subsp. humilis	S	S 0	Sedgefield dunes
Pharnaceum thunbergii	S	S =>	Sedgefield dunes
Sutera hirsutior	S	S 0	Sedgefield dunes
Tetragonia glauca	S	S <=	Sedgefield dunes
Acalypha ecklonii	H	K =>	
Justicia anselliana	S	K =>	
Nemesia melissifolia	M	K =>	
Plectranthus ciliatus	G	K =>	
Siphonoglossa leptantha subsp. late-ovata	S	K =>	Harkerville coast
Stachys scabrida	G	K =>	
Stachys thunbergii	G	K <=	
Aptenia cordifolia	S	PB 0=>	Keurboomsrivier Nature Reserve
Isoglossa prolixa	H	PB =>	Keurboomsrivier Nature Reserve
Plectranthus madagascariensis	S	PB 0=>	Keurboomsrivier Nature Reserve
Hibiscus ludwigii	G	GR =>	
Isoglossa eckloniana	S	GR =>	Nature's Valley
Australina capensis	S	ER <=	
Felicia aculeata	M	ER <=	
Hippia frutescens	G	ER <=	
Isoglossa hypoestiflora	S	ER =>	Stormsrivier forest

Justicia protracta	S	ER =>	Witelsbos coast
Senecio amabilis	M	ER <=	
Nelsia quadrangula	H	KR =>	Rozenhof
Plectranthus laxiflorus	G	KR =>	Rozenhof
Crassula pellucida subsp. marginalis	S	U =>	
Cynoglossum lanceolatum	G	U =>	
Felicia westae	M	U 0	
Harveya stenosiphon	G	U <=	
Helichrysum petiolare	G	U =>	
Isoglossa sylvatica	H	U 0	
Knowltonia filia subsp. scaposa	H	U 0	
Lobelia cuneifolia	H	U 0	
Solanum aculeatissimum	G	U =>	

Chapter 7

PHYTOGEOGRAPHY OF THE SOUTHERN CAPE FOREST FLORA

CONTENTS

ABSTRACT

The hypothesis is tested that regional speciation of the floral elements of the tropical, subtropical and temperate regions of southern Africa has enriched the older Afromontane forest flora to make up the southern Cape forest flora. The distribution ranges in southern Africa of all 465 known species of the southern Cape forests were used to establish the generalized tracks of the flora. Five regional groups were formed. Log-linear analysis of contingency tables was used to determine the dependence between the biological and ecological characteristics of the species and their geographical categories. The results indicated that the ecological characteristics of the species of each geographical group reflected the environmental conditions and disturbance regimes which prevail in each source area. The results support the hypothesis. The southern Cape forest flora is made up of elements of a narrower, cool, humid Afromontane area; elements of a transition zone between the montane zone and the humid, warm subtropical coastal areas, with wide moisture tolerances in the southern Cape; elements which had to adapt to more frequent and extreme droughts and drier conditions of the eastern Cape lowlands; and western Cape elements which are associated with either cool, moist montane areas or with more frequently burnt forest margins.

INTRODUCTION

The mixed evergreen forests of southern Africa are generally considered as the southern extensions of the Afromontane and Indian Ocean Coastal forests of Africa (Moll and White 1978; White 1978, 1983). Their scattered nature, small size and distribution along the mountain ranges and coastline (Cooper 1985; Anonymous 1987) suggest that their composition must have been affected by the environmental conditions and disturbance regimes which prevailed in the different regions of southern Africa. The largest forest complex in southern Africa occurs in the southern Cape (Knysna Forest of Acocks 1953; Chapter 1) where the two forest zones mix, and where many species find their geographic limit (Chapter 6). This area had been subjected to climatic and sea level changes over geological time scales, and human impacts during historical times (Phillips 1963; Deacon et al. 1983; Scholtz 1986; Chapter 1). The Knysna forest is subjected to intensive management for timber and fern production, recreation and general conservation (Van Dijk 1987). Information is needed to determine the impacts of the management practices on the species diversity and ecological processes of the forests.

Cowling (1986) suggested that reconstruction of Quaternary environments is important for insights into the dynamics of contemporary vegetation and, therefore, has implications for their management and conservation. Biogeography links the distribution, composition and ecology of the contemporary vegetation with the historic evolution, phylogeny and geographic spread of the biota (White 1971; Ball 1975; Cowling 1983, 1986; Poynton 1983, 1986). The biogeographical approach (Cowling 1986; Poynton 1986) consists of an initial empirical descriptive phase in which generalized distribution patterns (tracks) are established. Ideally distributions should be analyzed from species ranges (Poynton 1986), i.e. independently of established biogeographic regions (habitats or districts) although Cowling (1983, 1986) found the latter approach useful if the tracks are coincident with established phytochoria. The generalized tracks are then correlated with contemporary geographic and ecological conditions. Patterns of endemism are established and their significance assessed. Phylogenetic analysis of track components give direction to the generalized tracks. In the analytical approach testable hypotheses are formulated on vegetation history and predictions based on the results. These are tested by using independently derived geomorphological, climatic, phylogenetic, palaeontological and palynological data. The narrative approach, which comprises a logical association of untestable statements (Ball 1975; Cowling 1986) have been used in studies of the South African flora but should be avoided for better progress (Poynton 1986).

The objective of this study is to determine the ecological characteristics of the species of the southern Cape forest flora as a basis for an improved floristic and structural classification of the forests. I test the hypothesis that regional speciation of the tropical-subtropical Afromontane (White 1978) and Tongaland-Pondoland (Moll and White 1978), and the temperate Cape (Goldblatt 1978) floral elements have enriched the historic Afromontane forest flora. This implies that evolutionary the environmental conditions and disturbance regimes which prevailed in each geographical region have moulded the growth form and tolerance limits of the forest species which have survived in each particular region. This would determine the forest type and geographic spread of those species in the southern Cape. I follow the biogeographic approach and use the ranges of the species to establish generalized tracks.

STUDY AREA

The study covers the forest flora in the area between the Gouritz River in the west and Kromme River in the east, and the Indian Ocean coastline in the south and crests of the east-west trending coastal Cape Folded Mountains in the north (Chapter 1). The mountains, up to 1600 m above mean sea level (a.s.l.) and between 10 and 37 km from the coast, separate the moist coastal region from the dry Little Karoo inland. To the south undulating foothills separate the mountains from the level coastal platform at 180 to 240 m a.s.l. The platform ends in a steep coastal scarp above the ocean. Many rivers run south from the mountains to form deep, narrow incisions through the coastal foreland. In several places, east-west tributaries form wider valleys along softer geological substrates of the coastal platform. Rocks of the Cape Supergroup (mainly supermature quartzitic sandstones with subordinate shales) underlie most of the area. Pre-Cape and Cretaceous rocks (granite, quartzites, shales and schists), and unconsolidated deposits of recent age occupy smaller areas (Toerien 1979). The soils are generally acid, leached, low in nutrients and shallow (G N Schafer personal communication 1988).

Mean annual rainfall, mainly orographic, ranges from 400 mm around Mossel Bay to about 1200 mm in several localities throughout the area. Rain falls all year with maxima in early and late summer. The mean daily maximum temperature ranges between 23,8°C for February to 18,2°C for August, and the mean daily minimum between 19,7°C and 8,9°C (Chapter 1). Frost is infrequent to absent. Bergwinds during winter and cold fronts during spring and autumn further contribute to a very equable climate.

Knysna Forest (Acocks 1953· Veld type 4), the subject of this study, covers a total area of 60 561 ha (Chapter 1). Based on species composition and structure, the forest occurs in three major zones (Phillips 1931; Laughton 1938; Von Breitenbach 1974; Geldenhuys 1987). The mountain forests consist of many small patches of mostly wet high-forest types with few tree but many fern species. The forests of the foothills and coastal platform are large and mostly moist to dry high forest with abundant species of all growth forms. The forests of the coastal scarp and the steep slopes of the river valleys cover large areas and are generally dry high and scrub forest with many species, particularly woody plants, vines, geophytes and forbs.

Acocks (1953) recognised several other vegetation types in the area. Fire-adapted sclerophyllous shrublands include large areas of Mountain Fynbos (Veld Type 70) along the mountains and coastal foreland, and smaller areas of Coastal Fynbos (Veld Type 47) and Coastal Renosterbos (Veld Type 46). Subtropical transitional thicket (Cowling 1984; Veld Type 23) cover small areas towards the western and eastern extremes of the area. McKenzie (1978) and Cowling (1983, 1984, 1986) studied the forest and other vegetation to the west and east of the study area.

METHODS

I compiled annotated species lists for high and scrub forest, forest gaps and forest edges of the study area (Chapter 3). In that study I qualitatively assigned biological and ecological characteristics (growth form, breeding and dispersal system, deciduosity, spinescence, moisture requirements, forest type, abundance and geographic spread in the study area) to each species in order to determine the dependence of the ecological characteristics of the species on their general distribution patterns. Typical habitat (forest type) assumes a gradient from optimal in mature high forest (highest rank) through scrub forest and disturbed forest (gaps) to the extreme of the forest edge (lowest rank). I assigned species to a specific habitat on the assumption that they may occur in habitats of lower rank, but not vice versa. I based the geographic range in southern Africa of each species on distribution maps and accounts of floras and taxa.

I categorized the geographic ranges on the basis of the distribution limits of each species to the west and to the east of the study area (Figure 1). I assumed that the current distribution of a species in southern Africa indicates its centre of origin and direction of spread, although this may not always be the case (White 1971). To the west the limits were based on whether a species reached its western limit between the Gouritz River and the longitude running through Caledon, or west of this longitude. Massive mountain ranges to the west of Caledon runs with a north-south orientation from the coast inland which may have posed a barrier to the western migration of species from the east. This area is also the boundary between the all-year rainfall area to the east and the winter rainfall area to the west. To the east several limits were used: the eastern Cape with the Kei River as eastern boundary; southern Natal with a line between Durban and Harrismith as eastern boundary; and three categories east of this latter boundary. Species with limits east of Durban and Harrismith were categorized as those which occur only along the Natal coast, those which occur only along the Drakensberg escarpment and foothills, and those which transgress the area between the coast and the escarpment.

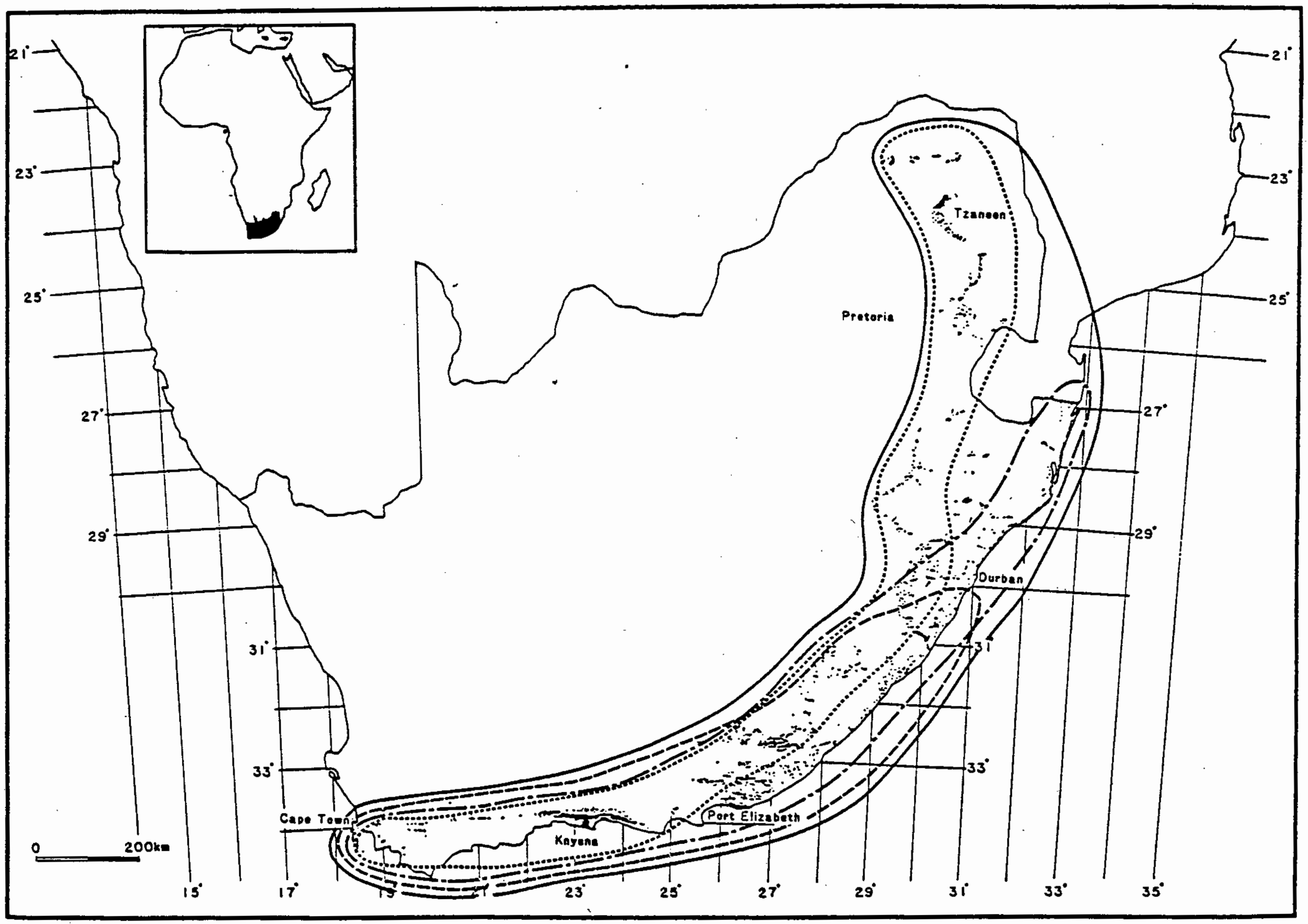

Figure 1 Distribution of mixed evergreen forest in southern Africa. The eastern and western distribution limits used in the delimitation of the species groups are indicated.

Dependence between variables were statistically analysed by means of Log-linear analysis of two or more dimensional contingency tables (Fienberg 1981; STSC 1986). The multinomial sampling model applies because of the fixed sample size. Zero values in the cross-tabulation were replaced by a small value (0,01). To overcome the problem of small expected frequencies, I pooled categories of certain variables in advance of the data analysis. The programme available required that the number of variables used in a single analysis had to be restricted to a maximum of three. The following hypotheses were tested:

* The geographic origin, growth form, moisture tolerance, forest type and geographic spread of a species are interdependent. For the log-linear analyses the variable categories were reduced to the following: growth form to trees, shrubs, climbers, ferns, epiphytes, geophytes, graminoids and forbs; moisture requirement to moist, moist to dry, and dry; forest type to high forest, scrub forest and disturbed forest; and geographic spread to widespread, sporadic and occasional.

* For trees, shrubs and climbers:
    + Geographic origin, geographic spread and abundance are interdependent. Abundance refers to the average density or cover of a plant over its distribution range in the study area and is categorized as common, scattered or rare.

    + Breeding system (dioecy, unisexual, bisexual) and propagule type (fleshy and dry; small and large fleshy; wind-dispersed, small and large dry) are dependent on both geographic origin and growth form. Growth form was used in six categories (canopy and subcanopy trees, woody and soft shrubs, lianes and vines) for most analyses, but was also used in two categories (woody and herbaceous) in some analyses with propagule type.

    + Propagule type is dependent on moisture requirement and forest type and determines the geographic spread and abundance of a species.

* The dependence of the variables spinescence, deciduosity and storage organs on geographic origin, forest type and moisture tolerance.

Finally, I reviewed the evidence from geomorphological, climatic, palynological and biogeographical studies conducted in the study area and further afield to give a causal historical explanation of the observed generalized tracks.

RESULTS

GENERALIZED TRACKS

The geographical distribution of the southern Cape forest species in southern Africa is summarized by means of the 18 categories which describe the western and eastern distribution limits of the species (Table 1). The categories were combined into five species groups which represent separate geographical regions. Allocation of some categories, or elements of some categories such as the southern Natal-western Cape category, to species groups was based on the frequency and/or abundance of species at their eastern/western distribution

TABLE 1 The geographical range of southern Cape forest species in southern Africa. Values between brackets indicate the five species groups which represent separate geographical regions: (1) western Cape with 69 species, (2) southern Cape with 18 species, (3) eastern Cape (and southern Natal) with 118 species, (4) afromontane with 99 species, and (4) transgressor with 161 species.

Eastern limit	Western limit			
	Southern Cape		Swellendam	Western Cape
	Number of species			
Southern Cape	16	(2)	2	(1)24
Eastern Cape	22		13	31
Southern Natal	24	(3)	3	11 | 14
Natal north coast	27		7	14
North-eastern Transvaal	28	(4)	14	57
Natal coast and Transvaal	57	(5)	30	74

limits. The contribution of species from the different groups to the total flora is as follows: western Cape 15%; southern Cape 4%; eastern Cape 25%; afromontane 21%; and transgressor group 35%. The southern Cape group was excluded from the log-linear analyses.

ECOLOGY OF THE GENERALIZED TRACKS

Dependence between geographic origin, growth form, moisture tolerance, forest type and geographic spread

All two-way interactions, except the interaction between geographic origin and spread, were significant (Table 2). The only significant three-factor interaction was between geographic origin, growth form and moisture tolerance (Likelihood ratio chi-square statistic or LRC of 64,9 with 42 df, P=0,0133). Table 3 gives the four-dimensional frequencies between geographic origin, growth form, moisture tolerance and forest type. The species included in each category are listed in the Appendix. The large, sparse multidimensional tables contained many cell values of 0 and 1 of which very few contributed significantly to the significant LRC value and which are difficult to interpret in the log-linear analysis (Fienberg 1981). Separate two-way tables were constructed to determine which categories contributed most to the significant relationships.

TABLE 2 Statistical significance in a log-linear analysis of the dependence between the variables geographic origin of a species in southern Africa, and its growth form, moisture requirements, forest type and geographic spread in the southern Cape. The values of the likelihood ratio chi-square statistic for the two-way interactions are indicated in the upper triangle and the degrees of freedom in the lower triangle. The symbol * indicates a significance level of P<0,0001 and ns a level of P>0,05.

Variables	Geographic origin	Growth form	Moisture tolerance	Forest type	Geographic spread
Geographic origin	-	129,8 *	29,4 *	59,6 *	7,5 ns
Growth form	21	-	97,7 *	111,3 *	84,5 *
Moisture tolerance	6	14	-	180,1 *	46,5 *
Forest type	6	14	4	-	38,3 *
Geographic spread	6	14	4	4	-

TABLE 3 Relationship between the geographic origin of a species in southern Africa, and its growth form, moisture tolerance and forest type in the southern Cape forests.

Growth form	Forest type*	Geographic origin and moisture tolerance+															Total
		W Cape			S Cape			E Cape			Afro-montane			Trans-gressor			
		+M	MD	D	M	MD	D	M	MD	D	M	MD	D	M	MD	D	
Tree	Hf	3	1	-	-	-	-	-	6	5	1	10	-	2	17	11	56
	Sf	-	1	1	-	-	-	-	-	5	-	-	2	-	-	14	23
	Fg	-	-	-	-	1	-	-	-	-	-	2	-	-	-	1	4
	Fm	-	-	-	-	1	-	-	1	-	1	-	-	-	-	-	3
Shrub	Hf	-	-	-	-	1	-	1	2	3	1	3	-	1	3	2	17
	Sf	-	-	3	-	-	-	-	-	8	-	-	4	-	-	7	22
	Fg	2	3	1	1	-	-	1	-	-	-	3	1	-	4	2	18
	Fm	1	3	4	-	-	-	-	4	2	1	2	-	1	2	5	25
Climber	Hf	1	1	-	-	-	-	-	5	1	-	-	-	2	8	5	23
	Sf	-	-	5	-	-	1	-	-	10	-	-	-	-	1	9	26
	Fg	-	-	1	-	-	-	-	-	3	-	1	-	1	-	2	8
	Fm	-	-	1	-	-	-	-	1	-	-	-	2	-	-	-	4
Fern	Hf	1	-	1	1	-	-	2	-	-	23	8	-	1	2	5	44
	Sf	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	3
	Fg	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
	Fm	-	-	-	-	-	-	-	-	-	2	-	-	1	1	-	4
Epiphyte	Hf	4	-	-	-	1	-	-	-	-	2	9	1	2	6	-	25
	Sf	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Fm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Geophyte	Hf	-	1	-	-	-	-	1	1	-	-	1	-	2	3	1	10
	Sf	-	-	3	-	-	1	-	-	7	-	-	1	-	-	1	13
	Fg	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	2
	Fm	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	3
Graminoid	Hf	3	-	-	1	-	-	1	-	1	1	4	-	5	1	2	19
	Sf	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	2
	Fg	-	1	1	-	1	-	2	2	-	2	-	-	-	-	-	9
	Fm	-	-	1	-	-	-	-	1	1	-	-	-	-	-	-	3
Forb	Hf	-	2	-	-	2	1	6	4	3	1	3	1	2	5	1	31
	Sf	1	-	5	-	-	2	-	-	16	-	-	-	1	2	9	36
	FG	3	3	-	1	-	-	-	1	3	-	-	4	-	-	-	15
	Fm	-	3	1	1	-	-	2	2	1	-	-	-	-	3	3	16
Total		19	20	30	6	7	5	17	30	71	36	46	17	21	58	82	465

* Hf = high forest; Sf = scrub forest; Fg = forest gap; Fm = forest margin.
\+ M = moist; MD = moist to dry; D = dry.

The geographic groups differed in their contributions of species of different growth forms, of different moisture tolerances and of different forest types. The transgressor group contributed many more and the western Cape fewer trees than expected. The eastern Cape group contributed very few ferns but many more forbs than expected. The afromontane group contributed very few climbers and forbs but most of the ferns. The eastern Cape group contributed many more dry species and the transgressor group much fewer moist species than expected, whereas the afromontane group contributed more moist species and fewer dry species. The western Cape group contributed very few high forest species but many more disturbed forest species than expected, whereas the transgressor group contributed very few disturbed forest species. The eastern Cape group contributed many more scrub forest species and fewer high forest species, whereas the afromontane group contributed many more high forest and much fewer scrub forest species.

The growth forms differ in their tolerance of moisture and disturbance and hence in their ability to spread. Fewer trees, shrubs and climbers but more ferns and graminoids which are confined to moist sites occur than expected. Conversely, more climbers and fewer ferns are tolerant of dry sites. Tree species richness is higher in high forest and very low in disturbed forest whereas shrub species richness is very low in high forest and very high in disturbed forest. More climber species than expected occur in scrub forest. More fern species than expected grow in high forest and fewer in scrub forest and disturbed forest. Forb species are fewer in high forest and are more prominent in scrub forest and disturbed forest. More than expected trees occur widespread and fewer occur sporadic or occasional. Very few ferns occur occasional. More than expected graminoids occur widespread. Forbs characteristically occur sporadic and fewer than expected occur widespread.

A very similar pattern is present in the relationships between forest type, moisture tolerance and geographic spread. More moist and moist-dry species than expected grow in high forest and fewer such species grow in scrub forest. The converse applies to species of dry sites which are prominent in scrub forest and deficient in high forest. More than expected high-forest species occur widespread and fewer occur occasional whereas the converse applies to scrub forest with fewer widespread and more occasional species. Moist-dry species generally occur widespread and dry species generally occur occasional.

Geographic spread and abundance of woody plants and vines

The significant relationship between geographic spread and abundance (LRC=35,5 with 4 df and P=0,00004) is shown in the frequency distribution (Table 4). Most of the species occur widespread with their plants scattered throughout. A minority of the widespread species are common in the average site. The common widespread species are the moist, high forest tree *Cunonia capensis*, the moist-dry high forest trees *Apodytes dimidiata*, *Gonioma kamassi*, *Olea capensis* subsp *macrocarpa*, *Podocarpus latifolius* and *Pterocelastrus tricuspidatus*, the dry high forest tree *Cassine peraqua*, the dry scrub forest tree *Sideroxylon inerme*, the forest margin tree *Virgilia divaricata*, the shrubs *Trichocladus crinitus* of moist-dry high forest, *Brachylaena neriifolia* of wet forest margins near streams and *Rhus crenata* of dune scrub forest margins, and the climbers *Pyrenacantha scandens* of moist-dry high forest and *Rhoicissus digitata* of dry scrub forest. The common occasional species are *Faurea macnaughtonii*, *Hippobromus pauciflorus*, *Psychotria capensis*, *Pterocelastrus rostratus*, *Schefflera umbellifera*, *Strelitzia alba* and *Virgilia oroboides* subsp. *ferruginea*. The majority of the occasional or disjunct species are rare.

TABLE 4 Relationship between the geographic spread and abundance of trees, shrubs and climbers in the southern Cape forests. Species which are confined to the southern Cape are excluded.

Geographic spread	Abundance		
	Common	Scattered	Rare
Widepsread	16	87	23
Sporadic	1	30	24
Occasional	4	14	25

Dependence of breeding system and propagule type on growth form and geographic origin of woody plants and vines

The breeding system of trees, shrubs and climbers interact significantly only with growth form (LRC = 28,2 with 10 df and P=0,002). Dioecy is confined to trees, woody shrubs and vines.

In the different analyses propagule type was never significantly dependent on geographic origin, but always significantly depended on growth form (P<0,0001). This is shown by comparing the percentage of fleshy propagules for trees, shrubs and climbers, and for trees alone (figure between brackets): transgressor 67% (89%), afromontane 61% (79%), eastern Cape 58% (67%) and western Cape 41% (50%).

Dependence between propagule type, forest type, moisture tolerance and geographic spread of woody plants and vines

Propagule type of a species is significantly dependent on its typical forest type (LRC=22,556 with 8 df and P=0,004) and determine its geographical spread (LRC=19,677 with 8 df and P=0,0116), but is not dependent on its moisture requirement. Forest type and moisture requirement of a species is however, significantly interdependent (LRC=102,871 with 4 df and P=0,0000), as is forest type and spread (LRC=17,752 with 4 df and P=0,0014), and moisture requirement and spread (LRC=24,878 with 4 df and P=0,0001). Table 5 shows the frequency distribution of trees, shrubs and climbers over propagule type, forest type and geographic spread.

The significant relationship between propagule type and forest type is attributed to the large number of fleshy propagules in high forest, especially large fleshy propagules, and their decrease in disturbed forest in favour of the dry propagule, especially the small dry propagule. The fleshy propagule is most important in high forest (72%), but decreases in importance in scrub forest (52%) and disturbed forest (39%). The fleshy propagule is also the most important propagule type in all categories of geographic spread although the majority of such species occur widespread. The significant relationship between propagule

TABLE 5 Relationship between propagule type, forest type and geographic spread in the southern Cape for trees, shrubs and climbers of the forest flora.

Growth form and Propagul type	Geographic spread and forest type[1]									
	Widespread			Sporadic			Occasional			
	Hf	Sf	Df	Hf	Sf	Df	Hf	Sf	Df	TOTAL
TREES										
Fleshy large	13	4	-	-	-	-	3	2	-	22
Fleshy small	23	5	2	1	5	-	7	3	-	46
Dry large	3	-	2	-	-	-	2	2	2	11
Dry small	3	1	-	-	-	-	-	1	-	5
Wind-blown	-	1	-	1	-	-	-	-	-	2
Total	42	11	4	2	5	-	12	8	2	86
SHRUBS										
Fleshy large	1	1	2	2	-	-	1	2	-	9
Fleshy small	4	3	7	1	4	6	3	1	3	32
Dry large	1	2	2	-	-	2	1	1	-	9
Dry small	1	3	9	2	3	7	-	2	2	29
Wind-blown	-	-	2	-	-	1	-	-	-	3
Total	7	9	22	5	7	16	5	6	5	82
CLIMBERS										
Fleshy large	2	-	-	-	-	-	-	-	-	2
Fleshy small	7	6	2	1	2	2	-	4	-	24
Dry large	-	-	-	-	-	-	-	-	-	-
Dry small	3	-	1	3	3	3	-	1	-	14
Wind-blown	6	3	2	1	5	1	-	2	1	21
Total	18	9	5	5	10	6	-	7	1	61
TOTAL	67	29	31	12	22	22	17	21	8	229

[1] Hf = High forest, Sf = Scrub forest, Df = Forest gap or margin.

type and geographic spread is attributed to the small number of large fleshy propagules and the large number of small dry propagules in species which occur occasionally.

<u>Spinescence, deciduosity and storage organs</u>

Several species other than geophytes and ferns have conspicuous adaptations to adverse conditions. Spines or prickles on the branches and bole or stem occur in 16 species of high forest, seven species of scrub forest, and four species of disturbed forest. The majority of these species occur in the dry high or scrub forest and belong in almost equal proportions to the transgressor, afromontane and eastern Cape groups.

The majority of deciduous species occur in drier forest, with some occurring in moister high forest. The majority (78%) are transgressors and eastern Cape species.

Water and/or food storage organs are conspicuous in certain families. All these plants are more conspicuous in the dry scrub forest, although several occur widespread in moist high forest and the majority are western and eastern Cape species.

DISCUSSION

The four identified geographical areas external to the study area differ widely in their contribution of species to different growth forms, forest types and moisture tolerances in the southern Cape forest flora (Table 1 and 3). However, several families and genera are shared between the recognized geographical groups. The ecological characteristics of the species of each geographical region support the hypothesis that they reflect the environmental conditions and disturbance regimes prevailing in those source areas.

ORIGIN OF THE SOUTHERN CAPE FOREST FLORA

Most species of the southern Cape forest flora have an Afromontane origin *sensu* White (1978, 1983) or are connected with the Afromontane Region. Cowling (1983) supported White (1978) in including the Knysna Forest enclave as the southernmost extension of the Afromontane archipelago and not with Coastal Tropical Forest Types (Acocks 1953) or separated as a Cape "Temperate Forest" (Axelrod and Raven 1978). I, however, suggest that the Afromontane Region includes different sub-zones as reflected in this study.

* A narrower afromontane zone occur in the cool, humid uplands and montane areas of Natal and eastern Transvaal and which experience frequent grassland fires (Killick 1963; Edwards 1967; Van der Schijff and Schoonraad 1971; Scheepers 1978). True afromontane species require relatively cool, moist conditions in the southern Cape forests as a possible latitudinal compensation for the low temperatures of tropical high altitudes.

* A transition zone occur between the montane zone and the humid, warm tropical-subtropical coastal areas with a drier sub-zone in the Transvaal lowveld, Natal and Transkei midlands, Ciskei and eastern Cape. This transition zone generally has a lower, more seasonal and less reliable rainfall than either the montane or the coastal areas (Zucchini and Adamson 1984). Droughts occur more frequently and thickets predominate (Edwards 1967; Gibbs Russell and Robinson 1981; Zucchini and Adamson 1984; Everard 1987). This zone is also present further north in Africa (Chapman and White 1970; White 1983). The generally small and scattered forests and larger areas of subtropical transitional thicket in this transition zone link elements of the forest floras of the Tongaland-Pondoland Regional Mosaic (Moll and White 1978) with those of the Afromontane Region (White 1978, 1983).

+ Species of the transgressor group bridge this drier zone between the escarpment and the coast over most of southern Africa. They have the widest moisture tolerances in the southern Cape. I suggest that they evolved to survive the varied climate (rainfall and temperature) and seasonal droughts of the this drier transition zone.

+ Eastern Cape species had to adapt to more frequent and extreme droughts and drier conditions (Gibbs Russell and Robinson 1981; Zucchini and Adamson 1984; Everard 1987). Those species are almost confined to dry high forest and scrub forest in the southern Cape. They are however, restricted in their geographic spread in the southern Cape possibly due to a shorter presence in the southern Cape during the Pleistocene (Chapter 6).

* Western Cape species are associated with either cool, moist montane areas or with more frequently disturbed forest margins due to the fynbos fires. The tree species are mostly remnants of the southern temperate forests which covered the southern tip of Africa during the early Tertiary (Deacon 1983). To the west of the southern Cape the forests are small, occur isolated and are almost confined to the mountain slopes and foothills. The area receives predominantly winter rain, experiences a relatively dry summer and fires are frequent in the fynbos shrublands surrounding the forests (Campbell and Moll 1977; McKenzie et al. 1977; McKenzie 1978; Van Wilgen 1987).

EVOLUTION OF THE SOUTHERN CAPE FOREST FLORA

I propose the following scenario to explain the evolution of the southern Cape forest flora.

* Axelrod and Raven (1978) and Deacon (1983) postulated that towards the end of the Late Cretaceous - Palaeocene, when Africa was 15° south of its present location, widespread temperate forest covered southern Africa. With the subsequent northward shift of the continent these forests were replaced by subtropical forest. Typical species of the southern temperate forests are the Cunoniaceae, Cunonia capensis and Platylophus trifoliatus. This family has a wider distribution with many more species in the temperate forests around the southern Pacific (Morat et al. 1986).

* I assume that at the time when subtropical forest replaced temperate forest, conditions favoured a more continuous distribution of forest along the eastern parts of southern Africa, both from north to south and from the coast towards the mountains. Species would have been arranged along the latitudinal and altitudinal climatic gradients. The true afromontane species of this study would have occupied the cooler end of the gradients, species of the Indian Ocean Coastal Region the warmer end and transgressor species the middle parts. As such many of the widespread species of Africa became established in the southern Cape area.

* Subsequent to the northward shift of the continent, epeirogenic uplift, sea level changes and climatic deterioration towards increasing aridity caused a narrowing of the subtropical forest belt (Deacon 1983; Hendey 1983). I suggest that during this period the Afromontane and the Indian Ocean Coastal Regions became established as floristic regions. The Afromontane archipelago became established as disjunct forests of the present eastern escarpment. A drier zone developed between the mountains and the ocean. Many forest species have survived this contraction of the subtropical forest belt.

+ River valleys and scarps in the drier lowlands and midlands provided refugia for forest species of both the present Afromontane and Indian Ocean Coastal Regions (Edwards 1967) and represent the transgressors of White (1983).

+ The widespread species were also present in the southern Cape and represent the species which are shared between the forests to the east as far as Natal, Transvaal and even east Africa (Chapters 3 and 4). These are the afromontane and transgressor species of this study and are essentially the generalists of the forest. The microclimate of the closed forest in the different geographical regions of southern Africa remains essentially more similar than the varied regimes of the macroclimate of those areas. I have shown elsewhere (Chapter 5) that long distance dispersal is a very unlikely event to maintain gene flow between the isolated forests. Most afromontane and transgressor species of closed high forest seem to have a broad genetic base and adaptable to the diverse climatic and/or edaphic conditions and/or disturbance pressures. They probably persist in the isolated areas as different ecological species, i.e. with different provenances, such as has been observed for <u>Podocarpus falcatus</u> (unpublished data).

+ Specialized and less adaptable species would be eliminated from the areas of high risk, or prevented to cross those areas. This could explain the attenuation of the species from the tropical, moister or less disturbed areas to the temperate, drier or frequently disturbed areas (Tinley 1985; Chapter 6).

* Increasing aridity and drought stress in areas with unreliable rainfall such as the Natal and eastern Cape midlands and lowlands (Zucchini and Adamson 1984) pressured taxa to evolve a lower stature, shorter life cycle, drier and smaller propagules, spinescence, deciduousness and storage organs to enable them to persist under the stress. Such species would only be able to persist in drier scrub forest or disturbed forest. The eastern Cape has been identified as a tension zone with a diverse mosaic of vegetation types (Gibbs Russel and Robinson 1981; Everard 1987). The subtropical transitional thicket of the eastern Cape (Cowling 1984; Everard 1987) and similar types in Natal (Edwards 1967) contain several of the more widespread forest tree species which have adopted a stunted growth form as well as species which are specific to this broader thicket vegetation. These species became incorporated in the southern Cape forest flora during the more arid periods with low sea levels of the Pleistocene and early Holocene (Chapter 6).

* Fires have contributed to the fragmentation of the forests. Hendey (1982) indicated the presence of fire during the Mio-Pliocene. Since then the fire regime have intensified with the onset of the wet winters and dry summers of the western Cape and the radiation of the fynbos vegetation (Deacon 1983). Species of disturbed forest are present in all the geographical groups. Some disturbed forest species have a wide geographic range in southern Africa such as <u>Clutia</u> <u>pulchella</u> and <u>Widdringtonia</u> <u>cupressoides</u>. However, most of the disturbed forest species, particularly forest margin species, are prominent in the western Cape group and have a limited geographic range. This suggest that they have evolved locally and relatively recently.

* The location of the forests in the southern Cape landscape has safeguarded their persistence during the many different environmental and landscape changes which have affected the area. Their altitudinal range would have allowed the species to cope with climatic changes and marine transgressions (Chapter 4). The specific combination of mountains and valleys provided areas where fires

driven by the hot, desiccating bergwinds are not likely to destroy the forests (Chapter 2). The area includes a range of sites from high to low rainfall (Chapter 1). This combination of environmental features allowed forest species of very different evolutionary and geographical histories to persist in different forest communities.

ECOLOGY OF THE GEOGRAPHICAL GROUPS

The ecological characteristics of the plant species reflect the environmental stresses and disturbances which prevailed in the regions from which they come. The majority of trees are transgressors (52%) which tolerate wide moisture ranges or drier conditions and which occur widespread in the southern Cape. These are the important species of the coastal platform forests (Geldenhuys 1980; Geldenhuys and Van Laar 1980). Trees of moist to wet forests are mainly western Cape and afromontane species, whereas the drier high and scrub forest species (Phillips 1931; Von Breitenbach 1974) are mainly transgressor and eastern Cape species. Very few gap and edge tree species are present. The frequency of fires on the forest edge would suggest that the tree growth form cannot persist except for the endemic widespread Virgilia spp. and that shrubs and forbs would occupy that niche. Many of the western Cape and afromontane shrubs and forbs prefer moister sites, occur widespread and are gap or edge species. The majority of dry shrubs are transgressor and eastern Cape species which occur sporadic and under the forest canopy. Many are shared with the subtropical transitional thicket of the eastern Cape (Cowling 1984; Everard 1987). Climbers are mostly dry species and the majority are transgressor and eastern Cape species, whereas ferns and epiphytes are mostly moist afromontane species, except for the mostly moist-dry epiphytic transgressor orchids. Geophytes and forbs are generally drier species with very few afromontane species. The prominent and widespread graminoids are afromontane and transgressor species of closed forest and forest gaps. The majority of deciduous species are transgressor and eastern Cape species of drier habitats. Spinescence is equally important in transgressor, afromontane and eastern Cape species. The majority of species with storage organs are Cape species of drier habitats.

Dioecy and unisexuality is confined to trees, woody shrubs and vines, and to particular families and genera and show no relationship with geographic origin, geographic range or abundance of the species. Propagule type vary significantly with growth form. Fleshy propagules are important in woody plants, whereas dry propagules predominate in herbaceous plants. The decrease in proportion of fleshy propagules in trees, shrubs and climbers from transgressors and afromontane species to the Cape species and the high proportion of dry propagules in shrubs suggest that drier conditions (eastern Cape) and more frequent disturbance (western Cape) select for the dry propagule type. Fleshy propagules are almost absent in the fynbos shrubs (Siegried 1983).

CONCLUSION

The use of all the species of the forest flora in determining the generalized tracks has provided a robust but logical ecological differentiation of the elements of the flora. The general approach has focused on the essential characteristics of the species which were contributed to the southern Cape forest flora through migration from the different geographical areas during different climates. It is possible that some species may have been wrongly interpreted. More detailed mapping of taxa of particular genera and families, also those belonging to other vegetation types in the tension areas, in combination with phylogenetic studies, would be a means of testing the ideas put forward in this study.

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<u>Appendix</u> **THE GEOGRAPHIC ORIGIN, FOREST TYPE AND MOISTURE TOLERANCE OF THE SPECIES OF THE SOUTHERN CAPE FORESTS**

Trees

Western Cape
<u>High forest</u>
MOIST Cunonia capensis, Platylophus trifoliatus, Pterocelastrus rostratus
MOIST-DRY Olinia ventosa
<u>Scrub forest</u>
MOIST-DRY Hartogiella schinoides
DRY Euclea racemosa

Southern Cape
<u>Forest gap</u>
MOIST-DRY Strelitzia alba
<u>Forest margin</u>
MOIST-DRY Virgilia oroboides subsp ferrugineus

Eastern Cape
<u>High forest</u>
MOIST-DRY Brachylaena glabra, Chionanthus peglerae, Maytenus nemorosa, Olea capensis subsp capensis, Pterocelastrus tricuspidatus, Strychnos decussata
DRY Canthium spinosum, Cassine peraqua, Dovyalis rotundifolia, Erythrina caffra, Lachnostylis hirta
<u>Scrub forest</u>
DRY Chionanthus foveolata subsp tomentellus, Diospyros dichrophylla, Euclea schimperi, Loxostylis alata, Schotia afra var afra
<u>Forest margin</u>
MOIST-DRY Virgilia divaricata

Afromontane
<u>High forest</u>
MOIST Ocotea bullata
MOIST-DRY Canthium mundianum, Cassine eucleiformis, Curtisia dentata, Diospyros whyteana, Gonioma kamassi, Kiggelaria africana, Nuxia floribunda, Prunus africana, Rothmannia capensis, Zanthoxylum davyi
<u>Scrub forest</u>
DRY Euclea crispa, Schotia latifolia
<u>Forest gap</u>
MOIST-DRY Rhamnus prinoides, Rhus lucida
<u>Forest margin</u>
MOIST Widdringtonia cupressoides

Transgressor
<u>High forest</u>
MOIST Halleria lucida, Ilex mitis
MOIST-DRY Apodytes dimidiata, Burchellia bubalina, Canthium inerme, Cassine papillosa, Ekebergia capensis, Faurea macnaughtonii, Ficus sur, Maytenus peduncularis, Ochna arborea, Olea capensis subsp macrocarpa, Podocarpus falcatus, Podocarpus latifolius, Psydrax

	obovatum, Rapanea melanophloeos, Rothmannia globosa, Schefflera umbellifera, Trimeria grandifolia
DRY	Calodendrum capense, Canthium pauciflorum, Celtis africana, Chionanthus foveolata subsp foveolata, Dovyalis lucida, Maytenus undata, Pittosporum viridiflorum, Rhus chirindensis, Scolopia mundii, Scolopia zeyheri, Vepris lanceolata
Scrub forest	
DRY	Allophylus decipiens, Cassine aethiopica, Clausena anisata, Clerodendron glabrum, Cussonia spicata, Euclea undulata, Hippobromus pauciflorus, Maytenus heterophylla, Maytenus acuminata, Olea europaea subsp africana, Sideroxylon inerme, Syzygium cordatum, Tarchonanthus camphoratus, Zanthoxylum capense
Forest gap	
DRY	Buddleja saligna

Shrubs

Western Cape

Scrub forest	
DRY	Olea exasperata, Rhus glauca, Zygophyllum morgsana
Forest gap	
MOIST	Brachylaena neriifolia, Osmitopsis osmitoides
MOIST-DRY	Clutia alaternoides, Diospyros glabra, Polygala myrtifolia
DRY	Rhyticarpus difformis
Forest margin	
MOIST	Myrica quercifolia
MOIST-DRY	Cassine parvifolia, Laurophyllus capensis, Pelargonium papilionaceum
DRY	Cassine maritimum, Ortholobium fruticans, Rhus crenata, Sutera aethiopica

Southern Cape

High forest	
MOIST-DRY	Tapinanthus sp
Forest gap	
MOIST	Gnidia denudata

Eastern Cape

High forest	
MOIST	Sparrmannia africana
MOIST-DRY	Ficus burtt-davyi, Trichocladus crinitus
DRY	Dovyalis rhamnoides, Gardenia thunbergii, Maerua racemulosa
Scrub forest	
DRY	Acokanthera oblongifolia, Calpurnia aurea subsp sylvatica, Cotyledon orbiculata, Diospyros pallens, Excoecaria simii, Maytenus procumbens, Rhus longispina, Rhus refracta
Forest gap	
MOIST	Hibiscus diversifolius
Forest margin	
MOIST-DRY	Passerina falcifolia, Pelargonium cordifolium, Pelargonium zonale, Phytolacca americana
DRY	Polygala fruticosa, Teedia lucida

Afromontane
<u>High forest</u>
MOIST Piper capense
MOIST-DRY Myrsine africana, Cassinopsis ilicifolia, Trichocladus ellipticus
<u>Scrub forest</u>
DRY Aloe arborescens, Argyrolobium tomentosum, Hibiscus pedunculatus, Plumbago auriculata
<u>Forest gap</u>
MOIST-DRY Andrachne ovalis, Clutia affinis, Clutia pulchella
DRY Buddleja salviifolia
<u>Forest margin</u>
MOIST Clutia laxa
MOIST-DRY Phytolacca octandra, Viscum obscurum

Transgressor
<u>High forest</u>
MOIST Plectranthus fruticosus
MOIST-DRY Carissa bispinosa subsp acuminata, Desmodium repandum, Psychotria capensis
DRY Canthium ciliatum, Ochna serrulata
<u>Scrub forest</u>
DRY Acokanthera oppositifolia, Crotalaria capensis, Euphorbia kraussiana, Heteromorpha trifoliata, Protasparagus macowanii, Putterlickia pyracantha, Viscum rotundifolium
<u>Forest gap</u>
MOIST-DRY Chrysanthemoides monilifera, Solanum aculeastrum, Solanum giganteum, Solanum hermannii
DRY Azima tetracantha, Peucedanum capense
<u>Forest margin</u>
MOIST Psoralea pinnata
MOIST-DRY Colpoon compressum, Myrica serrata
DRY Dodonaea angustifolia, Euclea polyandra, Leonotis leonurus, Rhus rehmanniana, Rhus undulata

Climbers

Western Cape
<u>High forest</u>
MOIST Myrsiphyllum scandens
MOIST-DRY Oncinema lineare
<u>Scrub forest</u>
DRY Astephanus triflorus, Cissampelos capensis, Convolvulus capensis var bowieanus, Myrsiphyllum volubile, Protasparagus aethiopicus
<u>Forest gap</u>
DRY Cyphia digitata
<u>Forest margin</u>
DRY Dipogon lignosus

Southern Cape
<u>Scrub forest</u>
DRY Cyphia heterophylla

Eastern Cape
High forest
MOIST-DRY Capparis sepiaria var citrifolia, Dioscorea mundtii, Pyrenacantha scandens, Thunbergia dregeana, Tylophora cordata
DRY Vernonia anisochaetoides
Scrub forest
DRY Astephanus marginatus, Cynanchum obtusifolium var obtusifolium, Cynanchum obtusifolium var pilosum, Cyphostemma hypoleucum, Cussonia thyrsiflora, Jasminum angulare, Kedrostis nana, Lagenaria sphaerica, Rhoicissus digitata, Senecio angulatus
Forest gap
DRY Cynanchum natalitium, Kedrostis foetidissima subsp obtusiloba, Tragia sp
Forest margin
MOIST-DRY Cuscuta africana

Afromontane
Forest gap
MOIST-DRY Rubus pinnatus
Forest margin
DRY Cassytha ciliolata, Rumex sagittatus

Transgressor
High forest
MOIST Ctenomaria capensis, Dumasia villosa
MOIST-DRY Cissampelos torulosa, Clematis brachiata, Myrsiphyllum asparagoides, Protasparagus setaceus, Rhoicissus tomentosa, Secamone alpinii, Senecio quinquelobus, Zehneria scabra
DRY Adenocline acuta, Cassine tetragona, Ceratiosicyos laevis, Rhoicissus tridentata, Vernonia mespilifolia
Scrub forest
MOIST-DRY Scutia myrtina
DRY Cynanchum ellipticum, Cynanchum tetrapterum, Dioscorea sylvatica, Grewia occidentalis, Mikania natalensis, Rhynchosia caribaea, Sarcostemma viminale, Senecio mikanioides, Solanum geniculatum
Forest gap
MOIST Convolvulus farinosus
DRY Cineraria lobata, Senecio deltoideus

Ferns

Western Cape
High forest
MOIST Adiantum aethiopicum
DRY Cheilanthes capensis

Southern Cape
High forest
MOIST Thelypteris knysnaensis

Eastern Cape
High forest
MOIST Asplenium adiantum-nigrum, Blotiella natalensis

Afromontane
High forest
MOIST Asplenium erectum, Asplenium gemmiferum, Asplenium lobatum, Asplenium protensum, Asplenium xflexuosum, Blechnum capense, Blechnum tabulare, Blotiella glabra, Cyathea capensis, Dryopteris inaequalis, Histiopteris incisa, Lycopodium clavatum, Marattia fraxinea, Ctenitis lanuginosa, Pteris buchananii, Pteris cretica, Pteris dentata, Selaginella kraussiana, Thelypteris bergiana, Thelypteris confluens, Thelypteris gueinziana, Thelypteris pozoi, Todea barbara
MOIST-DRY Asplenium aethiopicum, Asplenium lunulatum, Asplenium monanthes, Asplenium platyneuron, Blechnum australe, Blechnum giganteum, Polystichum pungens, Rumohra adiantiformis
Scrub forest
DRY Ceterach cordatum
Forest gap
MOIST Hypolepis sparsisora
Forest margin
MOIST Gleichenia polypodioides, Osmunda regalis

Transgressor
High forest
MOIST Adiantum capillus-veneris
MOIST-DRY Blechnum punctulatum, Cheilanthes bergiana
DRY Asplenium rutifolium, Cheilanthes concolor, Cheilanthes viridus, Cheilanthes viridus var macrophyllus, Thelypteris interrupta
Scrub forest
DRY Cheilanthes hirta, Mohria caffrorum
Forest margin
MOIST Lycopodium cernuum
MOIST-DRY Pteridium aquilinum

Epiphytes

Western Cape
High forest
MOIST Elaphoglossum angustatum, Hymenophyllum marlothii, Hymenophyllum peltatum, Microsorium ensiforme

Southern Cape
High forest
MOIST-DRY Angraecum burchellii

Afromontane
High forest
MOIST x Pleupodium simianum, Pleopeltis schraderi
MOIST-DRY Angraecum pusillum, Angraecum sacciferum, Asplenium theciferum, Elaphoglossum acrostichoides, Hymenophyllum capense, Hymenophyllum

	tunbridgense, Lycopodium gnidioides, Peperomia retusa, Peperomia tetraphylla
DRY	Angraecum conchiferum

Transgressor
High forest

MOIST	Polystachya ottoniana, Trichomanes pyxidiferum
MOIST-DRY	Asplenium simii, Cyrtorchis arcuata, Mystacidium capense, Pleopeltis macrocarpa, Tridactyle bicaudata, Vittaria isoetifolia

Geophytes

Western Cape
High forest
MOIST-DRY Hypoxis sp
Scrub forest
DRY Melasphaerula ramosa, Trachyandra ciliata, Chasmanthe aethiopica
Forest margin
MOIST-DRY Monadenia bracteata
DRY Ornithogalum dubium, Satyrium ligulatum

Southern Cape
High forest
MOIST Gladiolus sempervirens
Scrub forest
DRY Tulbaghia violacea

Eastern Cape
High forest
MOIST Aristea ensifolia
MOIST-DRY Haemanthus albiflos
Scrub forest
DRY Bulbine latifolia, Ornithogalum longibracteatum, Gasteria acinacifolia, Agapanthus praecox, Liparis capensis, Liparis remota, Holothrix parvifolia
Forest gap
MOIST Cyrtanthus purpureus

Afromontane
High forest
MOIST-DRY Disperis lindleyana
Scrub forest
DRY Habenaria arenaria

Transgressor
High forest
MOIST Disperis thorncroftii, Zanthedeschia aethiopica
MOIST-DRY Scadoxus puniceus, Calanthe sylvatica, Dietes iridioides
DRY Chlorophytum comosum
Scrub forest
DRY Bonatea speciosa

Graminoids

Western Cape
<u>High forest</u>
MOIST Cyperus tenellus, Ehrharta rehmannii, Juncus capensis

<u>Forest gap</u>
MOIST-DRY Ehrharta subspicata
DRY Ficinia sp
<u>Forest margin</u>
DRY Epischoenus adnatus

Southern Cape
<u>High forest</u>
MOIST Festuca africana
<u>Forest gap</u>
MOIST-DRY Schoenoxiphium altum

Eastern Cape
<u>High forest</u>
MOIST Ehrharta calycina
DRY Ehrharta erecta var natalensis
<u>Scrub forest</u>
DRY Brachiaria chusqueoides, Stipa dregeana
<u>Forest gap</u>
MOIST Carpha glomerata, Isolepis costata
MOIST-DRY Ficinia fascicularis, Ficinia leiocarpa
<u>Forest margin</u>
MOIST-DRY Stenotaphrum secundatum
DRY Sporobolus fourcadii

Afromontane
<u>High forest</u>
MOIST Schoenoxiphium lanceum,
MOIST-DRY Brachypodium flexum, Carex aethiopica, Ehrharta erecta, Schoenoxiphium lehmannii
<u>Forest gap</u>
MOIST Microstegium nudum, Scleria natalensis

Transgressor
<u>High forest</u>
MOIST Agrostis lachnantha, Isolepis ludwigii, Isolepis prolifer, Juncus lomatophyllus, Panicum subalbidum
MOIST-DRY Oplismenus hirtellus
DRY Panicum deustum, Stipa dregeana var elongata

Forbs

Western Cape
<u>High forest</u>
MOIST-DRY Knowltonia vesicatoria subsp grossa, Oxalis purpurea
<u>Scrub forest</u>
MOIST Falkia repens

DRY Acalypha capensis, Australina capensis, Crassula subulata, Oxalis stellata var gracilior, Tetragonia glauca

Forest gap

MOIST Harveya capensis, Lobelia anceps, Oxalis incarnata

MOIST-DRY Alchemilla capensis, Hippia frutescens, Stachys thunbergii

Forest margin

MOIST-DRY Felicia aculeata, Lepidium ecklonii, Senecio amabilis

DRY Limonium scabrum

Southern Cape

High forest

MOIST-DRY Lobelia cuneifolia, Isoglossa sylvatica

DRY Knowltonia filia subsp scaposa

Scrub forest

DRY Knowltonia vesicatoria subsp humilis, Sutera hirsutior

Forest gap

MOIST Harveya stenosiphon

Forest margin

MOIST Felicia westae

Eastern Cape

High forest

MOIST Acalypha ecklonii, Crassula pellucida subsp alsinoides, Crassula spathulatha, Droguetia burchellii, Drymaria cordata subsp diandra, Polygonum salicifolium

MOIST-DRY Centella eriantha, Gerbera cordata, Isoglossa ciliata, Lobelia patula

DRY Isoglossa grantii, Isoglossa prolixa, Nelsia quadrangula

Scrub forest

DRY Ceropegia africana, Crassula cordata, Crassula lactea, Crassula orbicularis, Crassula pellucida subsp marginalis, Crassula perforata, Crassula rubricaulis, Isoglossa hypoestiflora, Justicia anselliana, Knowltonia cordata, Pharnaceum thunbergii, Pupalia atropurpurea, Siphonoglossa leptantha subsp leptantha, Siphonoglossa leptantha subsp late-ovata, Streptocarpus rexii, Sutera cordata

Forest gap

MOIST-DRY Helichrysum petiolare

DRY Hibiscus ludwigii, Stachys graciliflora, Stachys scabrida

Forest margin

MOIST Crassula sarmentosa, Nemesia melissifolia

MOIST-DRY Senecio crenatus, Senecio ilicifolius

DRY Silene undulata

Afromontane

High forest

MOIST Impatiens hochstetteri

MOIST-DRY Cardamine africana, Laportea grossa, Sanicula elata

DRY Leidesia procumbens

Forest gap

DRY Pavonia columella, Plectranthus ciliatus, Sida dregei, Sida ternata

Transgressor

<u>High forest</u>

MOIST	Epilobium hirsutum, Lauremburgia repens
MOIST-DRY	Dicliptera zeylanica, Galopina circaeoides, Hypoestes forskaolei, Laportea peduncularis, Ranunculus multifidus
DRY	Commelina africana

<u>Scrub forest</u>

MOIST	Dichondria repens
MOIST-DRY	Diclis reptans, Stachys aethiopica
DRY	Amaranthus thunbergii, Aptenia cordifolia, Hypoestes aristata, Isoglossa eckloniana, Justicia protracta, Plectranthus madagascariensis, Plectranthus verticillatus, Rubia petiolaris, Silene bellidioides

<u>Forest margin</u>

MOIST-DRY	Asclepias fruticosa, Helichrysum cymosum, Solanum aculeatissimum
DRY	Cynoglossum lanceolatum, Plectranthus laxiflorus, Abutilon sonneratianum

Chapter 8

ENVIRONMENTAL AND BIOGEOGRAPHIC INFLUENCES ON THE DISTRIBUTION AND COMPOSITION OF THE SOUTHERN CAPE FORESTS: A SYNTHESIS

INTRODUCTION

The mixed evergreen forests of the southern Cape form the only large complex in southern Africa which is intensively managed for the sustained utilization of some of its products for commercial purposes: furniture timber (Van Dijk 1987) and Rumohra fern for florists greenery (Geldenhuys and Van der Merwe 1988). The objective of sustained utilization of products is however secondary to the main objective of the maintenance of natural diversity and the protective, scientific and aesthetic value of the indigenous forests (Seydack et al. 1982). Products are scientifically selected according to the growth potential, size classes and species composition of trees (Geldenhuys 1980; Seydack et al. 1982; Van Dijk 1987) and carefully harvested from the forests in order to minimize the size of canopy gaps (Geldenhuys 1982; Geldenhuys and Maliepaard 1983), and soil disturbance and compaction (Van Dijk 1987).

Monitoring in order to achieve the primary management objective of maintaining natural diversity is actively pursued only on that 20% of the area which is managed for product utilization. Outside that area the primary objective is pursued by relatively passive management action. The major activity is the control of alien invader plants (Van Dijk 1987) although these plants are generally not aggressive invaders in closed forest but only on the forest margin and in disturbed areas (Geldenhuys et al. 1986). Another important activity is the re-establishment of open and disturbed areas along the forest margin to assist the recovery of the forest margin (Geldenhuys et al. 1986; Van Daalen 1988). Only general descriptions are made of the composition of the flora and fauna, and then only for nature reserves. There is therefore no basis other than ethical or aesthetical reasoning by which threats of forest destruction for economic development can be resisted or negotiated.

AIMS OF THIS STUDY

The aims of this study were therefore to determine

* the extent of the forest in the southern Cape and the factors controlling their distribution;
* the floristic composition of these forests and the factors which have contributed to their specific composition; and
* centers of floristic interest and importance

in order to

+ provide guidelines for the improved management of the forest environment under the diverse landuse management systems operating in the southern Cape;
+ improve our understanding of the biogeography of the forests which I consider to be one of the primary determinants of the composition and structure of the forest communities in the area.

RATIONALE

In this study I investigated the determinants of forest distribution and composition in the southern Cape at the landscape and regional level. The ecological community is a hierarchical structure in which the patterns and processes of the different levels occur and operate on different spatial and temporal scales (Ricklefs 1987; Urban et al. 1987; Smith and Urban 1988; Kolasa 1989). This multi-layered nature of the influences and interactions has interpretative value for the relationships between the levels because the mechnisms of a particular level operate within the context of higher levels. For example, the forest stand is a steady-state expression of gap dynamics under a given set of environmental conditions (Smith and Urban 1988). Ricklefs (1987) suggested that local diversity cannot be explained solely by local processes of competition between species, predation and disease, or patchworks of natural disturbances, and that processes on larger spatial and temporal scales within which the community occur must also be considered. At the landscape and regional scale, disturbances such as fires and droughts occur infrequently over large areas; demographic processes include species migration or dispersal, adaptation and speciation; and environmental variables include climatic and geomorphological changes over geological time scales (Ricklefs 1987; Urban et al. 1987).

At the landscape and regional scale resolution is not as high as at the scale of the forest gap, and only broad patterns can be discerned (Urban et al. 1987). The scale of measurement of particular patterns must be appropriate to the scale of the causal factors (Smith and Urban 1988). The scale of measurement which I have chosen is forest size in the landscape and species composition and richness of the forests. I deduced pattern from the variation in species richness and composition in forests of different size and location.

HYPOTHESES

I tested the hypothesis that the floristic and structural composition of the southern Cape forests is the product of the physical environment in which it occurs, the disturbance regime operating in the region and the evolutionary history of the taxa. This hypothesis is tested by means of the following sub-hypotheses:

* The physical limit to forest in the southern Cape is rainfall below 525 mm and that forest size increases with increasing rainfall where altitude is used as index of annual rainfall.
* Forests in private ownership are smaller than forests in public ownership.
* Environmental factors of total annual rainfall, geology and soils determine the potential limits of forest distribution, but the bergwind-driven fire pattern determines the actual location pattern of forest in the southern Cape landscape.
* Size of forests and their distances from source areas determine their species richness.
* Species richness increases with increasing habitat diversity of a forest.

* Dispersal corridors and barriers are important determinants of species richness.
* Geomorphological history of an area determine the species composition of its forests.
* Regional speciation of the floral elements of the tropical, subtropical and temperate regions of southern Africa have enriched the older Afromontane flora to produce the present southern Cape forest flora.

RESULTS OF THE STUDY

Forest distribution

The tests of hypotheses which relate to the determinants of forest distribution and location pattern are discussed in chapters 2 and 3. I used existing information on the size and ownership of the 908 forest patches of size range between 0,3 ha and 25 706 ha, which cover a total area of 60 561 ha in the study area (Chapter 1). To test the hypothesis on the physical limits of forest in the southern Cape, I searched for forests in the marginal rainfall areas. A regrowth forest was found growing under extreme conditions near Great Brak River with annual rainfall of 506 mm. The forest grows on conglomerates on a steep southerly, upper slope (i.e. a well-drained site) on the lower end of a dense Pinus radiata stand (i.e. restricted availability of surface and seepage water). The rainfall data for this site give 45,2% winter half-year rainfall and 3,8 Summer Aridity Index (SAI) for the months of December to March. This point falls below the SAI limit for forests as was suggested by Rutherford and Westfall (1986). Dense, low, thicket vegetation dominated by forest species occurs scattered west of Great Brak river in areas with rainfall down to 400 mm. Scriba (1984) found that none of the climatic, geological, topographic and human factors which he investigated excluded forest, and only extreme conditions impede forest development. He indicated that forest occurred on all the geological formations.

Forest size does not increase with increasing annual rainfall above 500 mm (Chapter 1). However, forest size closely relates to the landscape types. The largest forests in the area occur on the coastal platform at the foot of the mountains, in the river valleys and on the steep coastal scarp. Forests in the mountains, with high rainfall, are small and scattered. Forest shape on homogeneous terrain was analyzed in relation to the surrounding terrain physiography, in an area with known limited, historical utilization of the forests. Data on rainfall and soils, both inside and outside the forests, were used. The results showed that the forests persisted in topographic shadow areas of the hot, dry northwesterly föhnlike bergwinds. This pattern is determined by the interaction between prevailing winds during dry periods and terrain physiography since prehistorical times.

I concluded that prehistorical natural (lightning) and anthropogenic fires (for hunting and grazing) are the main determinants of the present distribution and location pattern of the forests in the southern Cape. This pattern of small forests in the mountains and few large forests on the coastal foreland in specific localities and of particular shape has been established long before the arrival of the European settlers by 1750. Forest exploitation and clearing, grazing and the indiscriminate use of fire since their arrival and settlement have reduced the forest area (Phillips 1963), but to a much lesser degree than is generally believed, and mainly in areas of concentrated settlement (Scriba 1984). I suggest that most of the farming, forestry and township developments since then occurred in areas which were naturally devoid of forest.

Forest composition and biogeography

Tests of hypotheses which relate to determinants of composition of the southern Cape forests are discussed in chapters 3 to 7. A list was compiled of all the species which have been collected in sites which indicate their association with forest communities. The list was annotated with information on the growth form, breeding system, propagule type, forest type, moisture tolerance, abundance and spread in the study area, and the distribution range in southern Africa, of each species.

The annotated species list was used as the basis for various analyses.

* It was analysed to indicate the important statistics of the southern Cape forest flora, such as the number of families, genera and species, the important families and genera, the growth form spectrum for different forest types, and spectra of breeding systems and propagule types for different growth forms (Chapter 3). The forest flora consists of 465 species, 86 of which are trees, 82 are woody and soft shrubs, 61 are lianes and vines, 52 are terrestrial ferns, 25 are epiphytes, 28 are geophytes, 33 are graminoids and 98 are forbs. The results show that the species/family ratios are very low when compared to other forests in Africa and to the surrounding fynbos shrublands. Fleshy propagules predominate in woody plants and dry propagules in herbaceous plants. Several species have conspicuous adaptations to adverse conditions. Very few endemics are entirely confined to the area. The statistics suggest that speciation occurred outside the forest in shrubby and herbaceous growth forms.

* Its species richness and composition, and floristic similarity and relationships were compared with the floras of 13 other forests representing particular geographic regions in southern Africa (Chapter 4). The high similarity between the southern Cape forest flora and those forests along the escarpment of the eastern Cape, Transkei, southern Natal and Transvaal, as well as the increasing loss of species in a southerly direction, suggest that the forests were once continuous along a continuous escarpment. I concluded that the present patterns of composition, interrelationships and high species similarities of the different forests may have been established before the major fragmentation of the forests. Today the forests are poorly linked by broken mountain ranges which are separated by dry wide open valleys and extensive lowlands. One particularly prominant gap in forest distribution is formed by the Sundays river valley east of Port Elizabeth. It stretches in a northwesterly direction towards remnants of the escarpment of the African Surface in the vicinity of Graaff Reinet in the arid interior. East of this valley a massive uplift occurred during late Pliocene (ca 2,5 million years ago) along the Ciskei-Swaziland axis, whereas west of the valley the uplift was of lesser magnitude. This resulted in significant rejuvenation along the major inland drainage lines

which are evident in the high accumulation rates of sediment at the mouths of major rivers along the southeastern coast (Partridge and Maud 1987). I suggested that the forests in the southern Cape have become isolated from the forests along the escarpment to the east of the Sundays river valley by the late Pliocene. The only connections of the southern Cape forests with those to the east would have been along the coast and by means of the subtropical transitional thicket.

* Its species composition was compared with the composition of 23 small, isolated forests in the inland mountains north of the coastal mountains in the study area (Chapter 5). Patterns of species richness and composition of forests in the inland mountain complexes were studied in relation to the two rivers which link the coastal forests with the inland mountains: the Gouritz river in the west and the Gamtoos river in the east. The observed patterns, in combination with information on the geomorphological history of the river systems and information on climatic change, provided relative dates for the presence along the coastal areas of temperate forests (Late Cretaceous - Palaeocene), subtropical forests (Miocene to Pliocene), and subtropical transitional thicket (Late Pleistocene to early Holocene).

* The list contains 206 species which reach their distribution limits within the southern Cape forests, or have disjunct distributions within this area and wider distributions outside (Chapter 6). They were found to be mostly concentrated in a few localities. Biological variables such as growth form and dispersal type, and habitat variables such as forest type and moisture tolerance of the species were not significantly correlated with their drop-out, but their spread and abundance in the study area and their geographic origin were. The grouping of species in specific localities was related to two major periods of forest decline. Species which were concentrated in the western limit of the forests, and in other isolated localities in high forests on the coastal platform, were related to the major forest decline with the onset of the Late Pliocene marine regression. Species tolerant of drier conditions are concentrated in high forest and scrub forest in various disjunct localities along the coast. Their pattern is attributed to the elimination of coastal dune forest and subtropical transitional thicket on the Agulhas Bank during the marine

transgression after the Last Glacial Maximum, i.e. Late Pleistocene to early Holocene.

* It was used to test the last hypothesis that regional speciation of tropical, subtropical and temperate floral elements enriched the historic Afromontane forest flora (Chapter 7). The distribution range in southern Africa of each of the 465 species was used to establish generalized tracts of the flora. Five regional groups were formed. Log-linear analyses of three-way contingency tables indicated significant dependence between the biological and ecological characteristics of the species and their geographical categories. The results therefore supported the hypothesis. It indicates that the species of each geographical group carry biological and ecological characteristics which relate to the environmental conditions and disturbance regimes which prevail in the particular source areas. The species therefore occupy specific sites in the southern Cape. The southern Cape forest flora therefore consists of species with varied origin but which occupy sites which relate to the conditions to which they became adapted to in their source area. Four floral elements contributed to the southern Cape forest flora: elements of a narrower, cool, humid Afromontane area; elements of a transition zone between the montane zone and the humid, warm subtropical coast, with wide moisture tolerances in the southern Cape; elements which had to adapt to more frequent and extreme droughts and drier conditions of the eastern Cape lowlands which currently form the bulk of the drier scrub forest; and western Cape elements which are associated with either cool, moist montane areas or with frequently burnt forest margins.

<u>Determinants of species richness and composition</u>

Species-area and species-distance relationships did not feature as significant determinants of species richness of forests. These hypotheses were tested in the study of the 14 forests of southern Africa (Chapter 4) and in the study of the forests of the inland mountains of the southern Cape (Chapter 5). Significant linear species-area relationships were obtained for both woody and herbaceous plant species richness in the southern African forests, but explained respectively only 30% and 38% of the observed variation. In a multiple regression model the significant variables were the number of dispersal corridors, the proximity to other forests and mean altitude and explained 81% of the variation in the number of woody species in the southern African forests. The number of landscape types and the number of dispersal corridors explained 75% of the variation in number of herbaceous species in these forests. In the southern Cape inland mountains the number of woody species and vines was significantly correlated with altitude and forest area which explained 86% of the observed variation in a multiple regression analysis, but altitude alone explained 74% of the variation in a linear regression analysis. The number of herbaceous species was significantly correlated with forest area only, but explained only 18% of the observed variation.

The relationship with altitude on both areas was negative and related to a climatic gradient. The growth form spectra of the 14 southern African forests showed specific patterns which relate to the altitudinal or climatic gradients such as an abundance of ferns in montane forests, and of woody plants and vines in coastal forests (Chapter 4). The same pattern was observed in the southern Cape forests (single forest complex) and Natal forests (several forests from escarpment to coast) (Geldenhuys and MacDevette 1989). This confirmation of the pattern together with the observation that some of the small southern African forests (Chapter 4) with wide altitudinal range have high species richness, suggest that richness of a forest flora increases with increasing altitudinal range in the forest. This factor together with the importance of the number of landscape types contributed to the large forest flora of the southern Cape perhaps more than the large size of this forest complex. Several southern Cape forests cover almost the entire gradient from mountain to coast, and most of the landscape types (Chapter 1).

The other important determinants of species richness are the number of dispersal corridors and the proximity to other forests (Chapter 4). I have indicated that, although long-distance dispersal may be important in some species to enable them to cross ecological barriers, this factor is generally unimportant (Chapter 5). The Gouritz and Gamtoos rivers were important dispersal corridors which contributed to the species richness and composition of the southern Cape inland mountain forests. I suggest that the importance of the number of dispersal corridors in determining the richness of the southern African forests (Chapter 4) is partly a relictual feature, particularly for the inland forests to the east and for the southern Cape forests. The important corridors are mountain ranges, escarpments and rivers. A dispersal corridor provides environments which are similar to the two source areas on either end of it, or it is a broad band of similar habitat (Brown and Gibson 1983). In the study of the 14 southern African forests they link forests into larger complexes on either side of dry open valleys and lowlands (Chapter 4). They also protect the forests against frequent fires, extreme droughts and extreme temparatures.

I suggest that with the increasing aridity since the Pliocene (Deacon 1983), forests became increasingly fragmented. Forests survived in areas which I have considered to be dispersal corridors. Increasing pressures from droughts and fires caused the elimination of species with narrower tolerances from many areas of their ranges, whereas other species of smaller growth form evolved. This view is supported by two findings of this study. Firstly, forests in closer proximity share more species than forests further apart. Secondly, most of the large families, and many of the other important families and genera are shared between the forest and the other vegetation types (Chapters 3 and 4). Their species-family ratios are small in the forests compared to the large ratios outside the forest. They have few but widespread species in the forest, and many but relatively localized species in the surrounding vegetation types. Their taller, longer-living growth forms occur in the forests whereas the smaller and often herbaceous growth forms occur in the vegetation types which are exposed to more extreme environmental conditions.

I therefore conclude that the results from this study support the general hypothesis that the floristic and structural composition of the southern Cape forests is the product of the physical environment in which it occurs, the disturbance regime operating in the region and the evolutionary history of the taxa.

IMPLICATIONS FOR INDIGENOUS FOREST MANAGEMENT

The results have several implications for the management and conservation of indigenous forests.

* Forests persist and function in a regime of a low frequency of disturbance events, particularly fire and drought. On that scale they can recover, and many of the species in the southern Cape forests have the ability to do so. Several species are adapted to develop optimally in particular seral stages and require those seral stages for persistence. It is therefore a challenge to reserve managers to maintain a balance between areas of early, middle and late forest seral stages in order to maintain the existing species richness of the forests (Geldenhuys and MacDevette 1989).

* Many of the areas surrounding forests are suitable sites for forest establishment if fires, in particular, could be limited or prevented. Fast-growing alien trees planted in forest gaps and in plantations along forest margins protect forest margins against frequent fires, aid the rehabilitation of the forests and provide for timber, fibre and firewood needs. They allow forest succession to proceed in a similar way to that of the indigenous pioneer trees. The initial pure stand of the indigenous or alien pioneer tree is gradually colonized by the shade-tolerant species of middle to late seral stages (Geldenhuys et al. 1986; Knight et al. 1987). This process could be utilized to establish and grow useful indigenous species for commercial purposes. Furthermore, alien invader plants could be used to advantage to nurse the establishment and growth of indigenous forest species as a permanent solution to weed problems in selected areas (Geldenhuys et al. 1986).

* Species richness of the forests increase with the number of landscape types, the number of dispersal corridors and the altitudinal range, i.e. the habitat diversity in an area. Options for the establishment of nature reserves should therefore firstly include as many of these variables as possible, and then consider size of an area.

* Many of the areas where species reach their distribution limits, or where species have a disjunct presence, are in the western and eastern extremes of the southern Cape, or along the coast, and are privately owned. Similarly, the forests in the inland mountains are small and mostly ignored in the management of those areas. Yet those forests contain species which carry ecological information of historical importance. Special measures should be considered for maintaining the natural condition of those areas to ensure the survival of those species.

OPPORTUNITIES FOR FUTURE RESEARCH

In almost every chapter points have been raised which need further study. Some of these are listed below.

* Results from the bergwind fire study suggest that a gradient exists of high fire frequency (and probably lower intensity) along the ridges and northern slopes, with a low frequency (and probable high intensity) in the valleys, and that the fynbos plants and other biota may be ordered along these gradients according to their adaptation to different fire frequencies and intensities. I have raised the possibility that the current practice of trying to achieve a uniform burn throughout the catchment with a single block burn may break down the natural gradients of species diversity.

* Several statistics suggest that pressures of greater aridity and low soil fertility, and disturbance by fire caused forest families to speciate outside the forest in shrubby and herbaceous growth forms. I suggest that the effect of increasing aridity and disturbance pressure on the radiation of species outside the forests in forest-shared families should be considered in studies of the phylogenies of many of the groups, such as Rhus, Asteraceae, Liliaceae, Orchidaceae, Proteaceae and Rosaceae.

* Studies of the phylogenetic relationships of species and genera such as Lachnostylis, and Virgilia, and of provenances of several other species, such

as Ilex mitis, the Podocarpus species and several other of the disjunct species and species with distribution limits in the southern Cape, may clarify their status and history in the area. Such information may also be of importance in the selection of suitable material for the propagation of some useful species. The opposing questions of vicariant speciation versus recent colonization could be resolved by means of studies of (i) species-area relationships of the forests in relatively uniform areas, and (ii) the population structure and (iii) genetic relationships of species in sites of disjunct and continuous occurrence.

* In the consideration of dispersal distances, assumptions had to be made from few observations on dispersal distances by wind of the small, dry seeds of Cunonia capensis and Nuxia floribunda, important forest species in the isolated forests. Furthermore, information is required on the flight patterns of frugivorous birds between the coastal and inland forests, and between forests along the coast, as well as their feeding behaviour.

* The Sundays river valley is considered an important gap in the distribution of forests along the escarpment, and I have speculated that it existed by the late Pliocene. This has implications for the genetic isolation and stability of the forest taxa and may be an important time in the speciation of many other taxa. The dating of this gap would be useful in studies of the eastern Cape flora.

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