WEST COAST STRANDVELD:

ITS UTILIZATION AND MANAGEMENT

A dissertation submitted for the degree of

Master of Science

at the University of Cape Town

by

Christine   Anne   Liengme

Department of Botany
University of Cape Town
October 1987

_ABSTRACT

West Coast Strandveld is a mediterranean-type shrubland occurring in the drier parts of the Cape's mediterranean climate zone. It occurs on alkaline to neutral soils, extending on acidic soils in drier areas. There is rainfall gradient from south to north along the west coast which is reflected in structural and floristic changes in the vegetation. Evergreen, sclerophyllous shrubs dominate in the south, with drought-deciduous shrubs and succulents becoming more important to the north. Strandveld comprises three successionally related communities: Pioneer Littoral Vegetation, Successional Littoral Dune Vegetation and Dune Scrub. Strandveld contains elements of Capensis and Karoo-Namib floras, as well as Tongaland-Pondoland and Afromontane elements. Existing conserved areas in Strandveld are small and inadequate. Several priority areas for conservation are discussed.

Strandveld has been, and still is, primarily a stock-farming area. The vegetation contains many palatable species and provides adequate natural pasture. It has undoubtedly suffered as a result of stock-grazing. Experiments at Nortier Experimental Farm, Lambert's Bay, show that judicious use of the veld can result in the maintenance of good natural pasture with a high cover of grasses and other palatable species. Incorrect use of the veld and overstocking lead to decreased cover and increased succulence.

Strandveld is a highly seasonal vegetation, with a growth peak in the wet months from autumn to spring, although some shrubs grow at other times of the year. Flowering is concentrated in spring and early summer, and fruiting is in spring and summer. Leaf fall occurs from summer into autumn. Most of the growth forms in Strandveld have similar phenophases. Moisture availability is the major factor controlling the initiation of growth. Leaf fall is related to low moisture availability in summer. Flowering appears to be temperature or photoperiod dependant. Strandveld

phenology is similar to that of analogous shrublands elsewhere in the world.

The effects of fire on the subsequent regeneration of the vegetation are mainly structural. In the first years after a fire, annuals, geophytes and hemicryptophytes are important. Most shrubs species of the canopy resprout soon after the fire. _Eriocephalus africanus_ resprouts quickly and vigourously after fire and dominates three to four year-old vegetation. Within 10 to 12 years thicket species regain their dominance. Most mediterranean-type shrublands have a high proportion of resprouting shrubs and therefore have the ability to regenerate well after fire.

As a result of the highly seasonal nature of the vegetation, predicted fire behaviour in Strandveld differs markedly from wet to dry season. Fires in winter are likely to be small and of low intensity, and relatively unaffected by increases in wind speed. In summer, on the other hand, the amount of fuel is greater and fires are likely to spread faster, be bigger and more intense. Increases in wind speed will affect all aspects of the fire. Fires in Strandveld are predicted as being smaller and less intense than fires in fynbos due to differences in the nature of the vegetation and the fuel load. Fynbos will also burn in any season, unlike Strandveld.

West Coast Strandveld shares many features with other analogous mediterranean-type shrublands; physiognomy, phenology and the regeneration after fire are all broadly similar in these shrublands. However, differences also occur, as a result of the particular set of environmental conditions occurring along the Cape west coast.

There is a need for physiological and autecological research in Strandveld to lead to a better understanding of its functioning and dynamics.

ACKNOWLEDGEMENTS

CONTENTS

1.GENERAL INTRODUCTION

Mediterranean-type shrublands have been the subject of considerable ecological, physiological and systematic research over the past few decades. Much of this work is well summarised in Di Castri, Goodall & Specht's (1981) definitive volume. A broad research programme was initiated in the 1970's in the winter-rainfall region of the Cape, and is still ongoing. However, it has been almost exclusively concerned with fynbos vegetation types, which are heathlands (Moll & Jarman, 1984). It is generally recognised that the Cape's non-heath shrublands are the true mediterranean shrublands of that region; including Mountain and Coastal Renosterveld and Strandveld (Boucher & Moll, 1981; Moll, Hilton-Taylor & Jarman, 1984). It is these shrublands that should be studied and compared with other mediterranean-type shrublands elsewhere. South Africa's mediterranean-type shrublands make up the smallest proportion of these shrublands in the world (Di Castri, 1981), and Strandveld covers only a relatively small area; 2072 km² remain (Bossi, 1984). Little co-ordinated research has been carried out in Strandveld or in Renosterveld.

Strandveld can be differentiated into South Coast and West Coast forms (Moll et al., 1984). It is the latter which is the focus of this thesis, the aim of which is to review what is known about West Coast Strandveld. This thesis, however, restricts itself to West Coast Strandveld that occurs within those climatic types generally considered to be mediterranean. For this reason, the narrow, northern extension of Strandveld shown on Acocks' (1953) map has not been included in the discussions that follow. The limits of the study area are therefore Table Bay in the south, the Olifants River in the north and

Acocks's (1953) interior boundary for Strandveld.

I would like to look specifically at the exploitation and management of West Coast Strandveld as a natural pasture resource. The definition and description of this vegetation type, its utilization, its patterns of seasonality and its response to fire, as well as the behaviour of fires will all be discussed. Wherever pertinent, comparisons with mediterranean-type shrublands elsewhere in the world will be given. To this end a brief summary of the characteristics of mediterranean-type ecosystems is given by way of introduction.

1.1 MEDITERRANEAN-TYPE ECOSYSTEMS

Mediterranean-type climates and their associated plant formations occur on five continents across the globe. They occur between 40° and 30° of latitude, south and north, in the Mediterranean Basin, on the west coasts of South America (Chile) and North America (California), on the southwestern coast of South Africa and the south and west coasts of Australia.

The mediterranean climate is transitional between temperate and dry tropical climates (Di Castri, 1981), with rain falling mostly in the cooler winter months and a summer drought. There is a high degree of variability in the year-to-year rainfall. Summers are warm to hot and winters cool to cold. Fog is frequent on the west coasts in summer and humidity is high.

There are two systems currently used to classify the sub-types of mediterranean climates. The Köppen classification distinguishes two climatic types; Csa, with a hot summer and Csb, with a mild summer. The

pronounced summer drought extends into the more arid climatic type BSk, which can be also be considered a mediterranean-type climate (Specht, 1981). This system is used in South Africa, Australia and California (Di Castri, 1981). In the countries of the Mediterranean Basin and Chile another system has been used, originally defined by Emberger and modified by Di Castri (1981). The mediterranean climate is divided into six types, based on the length of the summer drought; perhumid (1-2 months), humid (3-4 months), subhumid (5-6 months), semi-arid (7-8 months), arid (9-10 months) and per-arid (11-12 months).

Orshan (1983) states that mediterranean areas are characterized by climax plant communities dominated by evergreen sclerophyllous trees or shrubs. Mediterranean-type shrublands are generally scrub formations, found mainly at the drier end of mediterranean-type climates. The main ecological factor controlling the distribution of these shrublands is the summer drought. The plants of mediterranean-type shrublands have evolved two forms of adaptation to seasonal water-stress; sclerophylly and seasonal dimorphism (most plants usually referred to as drought-deciduous are probably dimorphic) (Margaris, 1981). The evergreen sclerophyllous shrublands occur primarily in the semi-arid and arid mediterranean climates, and the drought-deciduous vegetation is found in the arid climates. The formations are dominated by an upper storey of woody, broad-leaved, evergreen plants. An understorey of annuals and herbaceous perennials is usually present, although not necessarily (as in chaparral) (Di Castri, 1981).

Typical types of mediterranean-type shrublands include; Mediterranean maquis (Quezel, 1981; Tomaselli, 1981), Chilean matorral (Rundel,

1981), Californian chamise chaparral (Hanes, 1981), South African renosterveld (Boucher & Moll, 1981) and Australian mallee open scrub (Specht, 1981). At the drier end of the climatic gradient the vegetation is lower and more open, more drought-deciduous and succulent. Examples are: the phrygana and garrigue of Europe (Tomaselli, 1981), coastal matorral in Chile (Rundel, 1981) and coastal sage scrub in California (Hanes, 1981; Westman, 1982). Man has played an important role in increasing the extent of the drier shrubland types through over-grazing and erosion.

In European Mediterranean areas, three physiognomic types of shrublands are distinguished; low matorral (phrygana/batha), middle matorral (garrigue) and high matorral (maquis). Each is further sub-divided on the basis of the density of the vegetation; dense, discontinuous, scattered (Tomaselli, 1981).

Biogeographically, mediterranean shrublands are described as 'open' formations that have received and incorporated elements from a variety of very different origins. Mediterranean-type ecosystems have a high degree of spatial, temporal and perceptional heterogeneity, all of which contribute to their relatively high species diversity (Di Castri, 1981). This heterogeneity is very important in the maintenance of the ecosystems, which Godron et al., (1981) have described as 'elastic'.

The vegetation is usually fire-prone, and has evolved a number of adaptions to survive fire, mainly, the ability to resprout from stumps, root-crowns or lignotubers and epicormic buds (Gill, 1977). Many of the long-lived woody species in mediterranean-type shrublands have lignotubers (Specht, 1982). Margaris (1981) distinguishes two types of

resprouters in mediterranean-type shrublands; obligate resprouters that regenerate immediately after a fire (common in evergreen sclerophyllous shrublands) and facultative resprouters whose regeneration is delayed until the first rains (common in the more drought-deciduous shrublands). These two will undoubtedly be differently affected by season of burn and fire intensity. In general, the vegetation of mediterranean shrublands regenerates rapidly after fire, regaining its previous structure and composition in about ten years. Chilean matorral appears to be the exception, since when burnt, it tends to become steppe or thorny scrub (Trabaud, 1981). Matorral is thought to be less prone and therefore less well adapted to fire (Di Castri, 1981).

Agricultural exploitation of mediterranean-type shrublands has resulted in large areas being destroyed as a result of cultivation (Di Castri, 1981). Much of the vegetation that remains, primarily in the semi-arid and arid climate areas, has been altered as a result of burning and grazing. Le Houerou (1981) recognises fire and grazing as the principal enemies of mediterranean shrublands. Around the Mediterranean, high stocking rates of sheep and goats and little rational exploitation of pastures have lead to a reduced pastoral value of the vegetation. The combination of fire and grazing have reduced some shrublands to grasslands. Chile, too, has suffered from considerable grazing pressure and much of the vegetation of the matorral is maintained in a disturbed state (Rundel, 1981), especially in the arid parts where little cultivated or improved pasture occurs (Canas et al., 1982).

The mediterranean-climate regions can be grouped according to their similarities and differences. Australia, South Africa and Chile are similar in that they have more oceanic climates and old phylogenetic

5

links, while California, Chile and the Mediterranean Basin are similar in having virtually no summer rain and physiographic similarities. California and the Mediterranean Basin have phylogenetic similarities. The greatest similarities occur between California and Chile, and between South Africa and Australia (Di Castri, 1981).

The mediterranean-climate zones of South Africa and Australia differ from the others in that they receive a definite, if unpredictable summer rainfall. They also differ in having milder temperatures and smaller temperature amplitudes. Geological and soil features also distinguish these two areas from others, in that their basement complexes are more ancient and more stable, and their soils tend to be lower in nitrogen and phosphorus (Di Castri, 1981). The nutrient status of soils is a major factor controlling the development of plant formations in these two areas. Both heathlands and mediterranean-type shrublands occur, the former being restricted to soils of low nutrient status. However, the heathlands are not climatically defined and extend beyond the mediterranean-climate zone, and only the shrublands on the more fertile soils are considered analogous to the sclerophyllous shrublands of California, Chile and the Mediterranean Basin.

The mediterranean areas of Australia and South Africa also have in common the absence of a pole-ward temperate region, being at the southern edges of continents. The vegetation is mostly derived from common tropical ancestors (Di Castri, 1981).

The South African mediterranean-climate region differs from that of Australia in that the topography is more diverse and the region is more compressed between desertic and moist climates. Furthermore, winds are

stronger and more frequent in South Africa (Di Castri, 1981) and there is a virtual absence of a tree growth form.

There is a striking similarity in the structure of the vegetation of the various mediterranean regions, and in the growth forms that occur, despite major floristic differences. Comparisons between California and Chile have shown that there is a remarkable degree of convergence in structure (Parsons, 1976), as have comparisons of two different shrubland types of Israel and California (Schmida & Barbour, 1982). However, distinctive differences also occur, arising from small differences in climatic patterns. For example, certain growth forms are found only in one of a matched pair of sites: spiny, drought-deciduous, green-stemmed shrubs occur in matorral, but not chaparral (Parsons, 1976).

A comparison of community structure along a climatic gradient in South Africa's mediterranean zone and analogous gradients in Chile and California, showed little convergence of the former to the latter two (Cowling and Campbell, 1980). The non-convergence of the foothill and montane sites can be explained by the fact that heathlands in South Africa were compared with mediterranean shrublands in the other two regions.

A further broad similarity between the various regions, occurs in the phenological patterns of the vegetation. Since summer drought is the most important factor of mediterranean-climate regions this is to be expected. The most detailed phenological work has been done in California and Chile, where numerous analogous sites in the two areas have been compared (Mooney & Kummerow, 1981). A general trend in the seasonal growth cycle of these shrublands can be observed. After the start of the

7

rains in autumn, annuals and shallow-rooted perennials of the understorey start growing, followed later, usually in spring, by the deeper-rooted, evergreen shrubs of the overstorey (Mooney and Kummerow, 1981; Montenegro et al., 1982; Specht, 1982; Specht et al., 1983). In the drier shrublands growth of drought-deciduous shrubs occurs in winter and/or spring (Montenegro et al., 1982). The patterns of rainfall are an important factor regulating the timing of vegetative growth in mediterranean shrublands. Flowering is spread-out, from early spring to late summer, and there is a broad range of flowering periods for the various species in each zone. The seasonality of leaf fall is very marked, being closely tied to moisture availability (Kummerow, 1983). Although the general phenological patterns are similar for all mediterranean shrublands, each region, however, has unique environmental aspects, so that both similarities and differences occur.

1.2 REFERENCES

ACOCKS JPH 1953. Veld-types of South Africa. Memoirs of the Botanical Survey of South Africa No. 28.

BOSSI L 1984. Mapping Cape Fynbos vegetation with the aid of LANDSAT imagery. Veld & Flora 70(1): 31-33.

BOUCHER C & MOLL EJ 1981. South African mediterranean shrublands. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 233-248.

CANAS R, ANGUILAR C, PALADINES,O & MUNOZ G 1982. Biomass production and utilization of natural pastures in the Chilean mediterranean ecosystems. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 34-41.

COWLING RM & CAMPBELL BM 1980. Convergence in vegetation structure in the mediterranean communities of California, Chile and South Africa. Vegetatio 43: 191-197.

DI CASTRI F 1981. Mediterranean-type shrublands of the world. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 1-52.

DI CASTRI F, GOODALL DW & SPECHT RL (eds) 1981. Ecosystems of the world 11. Mediterranean-type shrublands. Amsterdam - Oxford - New York: Elsevier.

GILL AM 1977. Plant traits adaptive to fires in mediterranean land ecosystems. IN: Proceedings of the symposium on the environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report WO-3, United States Department of Agriculture. pp 17-26.

GODRON M, GUILLERM JL, POISSONET J, POISSONET P, THIAULT M & TRABAUD L 1981. Dynamics and management of vegetation. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 317-344.

HANES TL 1981. Californian chaparral. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 139-174.

KUMMEROW J 1983. Comparitive phenology of mediterranean-type plant communities. IN: Mediterranean-type ecosystems: the role of nutrients, eds FJ Kruger, DT Mitchell & JUM Jarvis. New York: Springer. pp 300 - 317.

MOLL EJ, CAMPBELL BM, COWLING RM, BOSSI L, JARMAN ML & BOUCHER C 1984. A description of major vegetation categories in and adjacent to the Fynbos Biome. South African National Scientific Programmes Report No. 83, Pretoria: CSIR.

MOLL EJ & JARMAN ML 1984. Clarification of the term fynbos. South African Journal of Science 80: 351-352.

LE HOUEROU HN 1981. Impact of man and his animals on mediterranean vegetation. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 479-522.

MARGARIS NS 1981. Adaptive strategies in plants dominating mediterranean-type ecosystems. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 309-316.

MOLL EJ, HILTON-TAYLOR C & JARMAN ML 1984. Where are the Cape's mediterranean shrublands? Proceedings of the 4th International Conference on Mediterranean Ecosystems, University of Western Australia. p 115.

MONTENEGRO G, ALJARO ME, WALKOWIAK A & SAENGER R 1982. Seasonality, growth and net productivity of herbs and shrubs of the Chilean Matorral. IN: Proceedings of the symposium on dynamics and management of

mediterranean-type ecosystems.   General Technical Report PSW-58, United
States Department of Agriculture. pp 135 - 141.

MOONEY HA & KUMMEROW J 1981.   Phenological development of plants in
mediterranean-climate regions.   IN: Ecosystems of the world 11.
Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht.
Amsterdam - Oxford - New York: Elsevier. pp 303-308.

ORSHAN G 1983.   Approaches to the definition of mediterranean growth
forms.   IN: Mediterranean-type ecosystems: the role of nutrients, eds
FJ Kruger, DT Mitchell & JUM Jarvis. Ecological Studies 43. New York:
Springer.

PARSONS DJ 1976.   Vegetation structure in the mediterranean scrub
communities of California and Chile. Journal of Ecology 64: 435-447.

QUEZEL P 1981.   Floristic composition and phytosociological structure of
sclerophyllous matorral around the mediterranean.   IN: Ecosystems of the
world 11.   Mediterranean-type shrublands, eds F di Castri, DW Goodall &
RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 107-122.

RUNDEL PW 1981. The matorral zone of Chile. IN: Ecosystems of the world
11.   Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL
Specht. Amsterdam - Oxford - New York: Elsevier. pp 175-202.

SCHMIDA A & BARBOUR M 1982.   A comparison of two types of
mediterranean scrub in Israel and California.   IN: Proceedings of the
symposium on dynamics and management of mediterranean-type ecosystems.
General Technical Report PSW-58, United States Department of Agriculture.
pp100 - 106.

SPECHT RL 1981. Mallee ecosystems in southern Australia. IN: Ecosystems
of the world 11.   Mediterranean-type shrublands, eds F di Castri, DW
Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 203-
232.

SPECHT RL 1982.   General characteristics of mediterranean-type
ecosystems. IN: Proceedings of the symposium on dynamics and management
of mediterranean-type ecosystems. General Technical Report PSW-58,
United States Department of Agriculture. pp 13-19.

SPECHT RL & MOLL EJ 1983.   Mediterranean-type heathlands and
sclerophyllous shrublands of the world: an overview. IN: Mediterranean-
type Ecosystems. The role of nutrients, eds FJ Kruger, DT Mitchell &
JUM Jarvis New York: Springer-Verlag.

SPECHT RL, MOLL EJ, PRESSINGER F & SOMMERVILLE J 1983. Moisture regime
and nutrient control of seasonal growth in mediterranean ecosystems. IN:
 Mediterranean-type ecosystems: the role of nutrients, eds FJ Kruger, DT
Mitchell & JUM Jarvis. New York: Springer. pp 120 - 132.

TOMASELLI R 1981. Main physiognomic types and geographic distribution of
shrub systems related to mediterranean climates.   IN: Ecosystems of the
world 11.   Mediterranean-type shrublands, eds F di Castri, DW Goodall &
RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 95-106.

TRABAUD L 1981. Man and fire: impacts on mediterranean vegetation. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 523-538.

TRABAUD L 1982. Effects of past and present fire on the vegetation of the French Mediterranean Region. IN: Proceedings of the symposium on Dynamics and management of Mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 450-457.

WESTMAN WE 1982. Coastal sage scrub succession. IN: Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 450-457.

2. WEST COAST STRANDVELD

ITS DESCRIPTION, DEFINITION AND DISTRIBUTION

2.1 INTRODUCTION

Strandveld is a true mediterranean shrubland of the winter rainfall region of southern Africa. It is a "non-heath" shrubland (sensu Boucher & Moll, 1981) occurring, together with other "non-heath" shrublands (ie. renosterveld) on more fertile soils than those supporting heathland (fynbos) communities. The distinction between the three categories of "non-heath" shrubland is primarily floristic, and secondarily physiognomic. The major factors determining their distribution are soils and climate.

Taylor (1978) points out that the term Strandveld has been used to mean slightly different things by different authors, some of whom included communities which fall within the scope of Coastal Fynbos. He suggests restricting the term to the chiefly broad-sclerophyll woody scrub of the dunes near the coast. Acocks (1953) restricts the use of the term Strandveld to the woody scrub of the west coast.

2.2 DESCRIPTION AND DISTRIBUTION OF STRANDVELD

The most recent classification of the vegetation types of the south-western Cape is that of Moll et al. (1984), in which two forms of Strandveld are recognised; a South Coast and a West Coast form (see Figure 2.1). Strandveld is described broadly as a mid-dense to closed, broad-leaved shrubland occurring along the southern and western Cape coasts.

11

VEGETATION TYPES

Key

▓	Mesic
	Mountain Fynbos
░	Dry
▒	Sand Plain Fynbos
▒	West Coast Renosterveld
▥	West Coast
	Strandveld
▨	South Coast
░	Karroid shrublands
▥	Mosaic West Coast Strandveld & Sand Plain Fynbos
▨	Mosaic Karroid shrublands & Dry Mountain Fynbos
☐	Cultivated land, alien vegetation etc

Olifant's River
Lambert's Bay
Eland's Bay
St Helena Bay
Berg River
Langebaan
Geelb...
Yzerfontein
Melkbos
Table Bay
False Bay

10 5 0   10   20   30   40 km

18°

FIGURE 2.1   Veld types of the Cape west coast (redrawn from Moll & Bossi, 1984; 1:1000 000 map 'Vegetation of the Fynbos Biome')

West Coast Strandveld stretches from Table Bay to just south of the Orange River (Acocks, 1953). It tends to have more drought-deciduous shrubs and succulents of Karoo affinity than does South Coast Strandveld.

The occurrence of non-heath Cape vegetation was probably first recognised by Marloth, who described a hard-leaved vegetation within the Cape fynbos that contained succulents such as _Crassula_ and _Euphorbia_. Marloth was also aware that the sand dune vegetation of the west and south coasts differed (Boucher & Jarman, 1977).

Bews (1916) too recognised a coast succession in the south-western Cape that was distinct from fynbos, but gives no details. Pole Evans (1936) incorporated the vegetation of the west coast into Evergreen Sclerophyllous Bush, which he describes as bush or scrub with dominantly small hard leathery leaves. He saw this vegetation type as stretching from the Olifants River to Port Elizabeth, the whole extent of what is now called the Fynbos Biome (Moll _et al_., 1984). Pole Evans did, however state that the various habitats, eg. the coast, each had their own characteristic vegetation, but gave little detail.

Adamson (1938) described two vegetation types along the west coast, with different affinities (Fig. 2.2). The area up to the Berg River mouth he included into the Cape vegetational region and called Dry Sclerophyll Bush. He stated that this vegetation develops in lower rainfall areas and grades into Sclerophyll Bush such that "no sharp line of demarcation can be made between them " (Adamson, 1938 p 91). However at the dry extreme the vegetation is very different to the typical Sclerophyll Bush.

Dry Sclerophyll Bush is open and not distinctly layered. Shrubs have small dry flat leaves and ericoid-leaved shrubs are less common, while succulents, geophytes and annuals can be important. Along the low-lying coastal belt north of St. Helena Bay, Adamson described Coastal Succulent Bush - a vegetation showing many features in common with his Tall Succulent Bush of the interior. He recognised that there is a considerable range of rainfall within this coastal zone (50 - 250 mm) with a corresponding range of plant communities. Communities tend to be open with the larger plants less than a metre high and predominantly succulent.

Acocks (1953) also considered the vegetation of the west coast to have an affinity with karroid veld-types, and included West Coast Strandveld under his Karroid veld types. Acocks' Strandveld (Veldtype 34) more or less matches Adamson's Coastal Succulent Bush, but extends southwards as far as False Bay (Fig. 2.3), thereby including the western margin of Adamson's Dry Sclerophyll Bush. Acocks describes two variants of Strandveld; Dense Strandveld Scrub and Strandveld proper; but gives no details as to how they are related ecologically or geographically. The inland limits of Strandveld are not always clearly discernible, hence the use of broken lines on Acocks' map. The uncertainty of the boundaries is due in part to the impact of man and to ecotonal situations (Boucher & Moll, 1981). The West Coast Strandveld of Moll et al. (1984) more or less coincides with Acocks' Strandveld.

Taylor (1978) defined climax Strandveld vegetation as a broad-leaf sclerophyll woody scrub occurring along both the southern and western Cape coasts. He concedes that there are large differences between the extremes of the south and west coast Strandveld and that the dominant

14
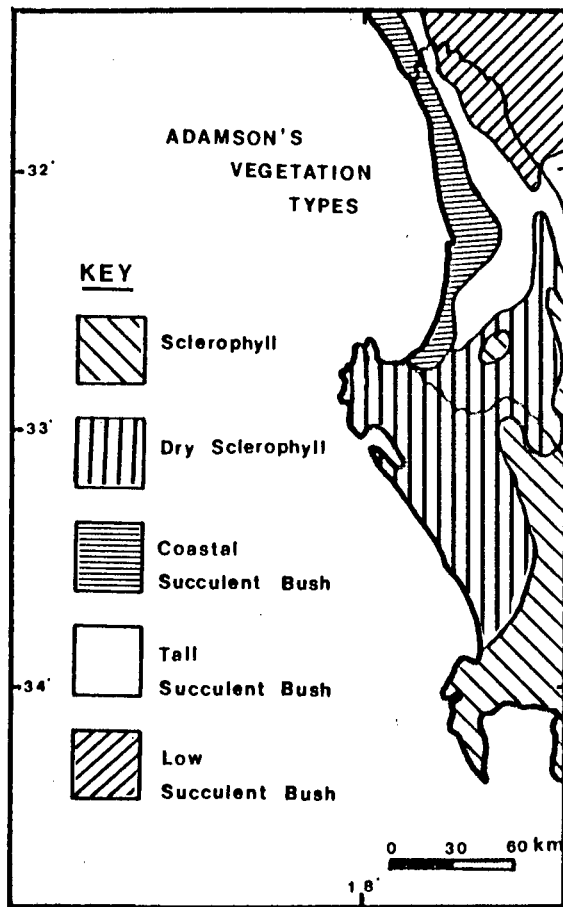
FIGURE 2.2 Adamson's vegetation types of the south-western Cape (redrawn from Adamson, 1938)
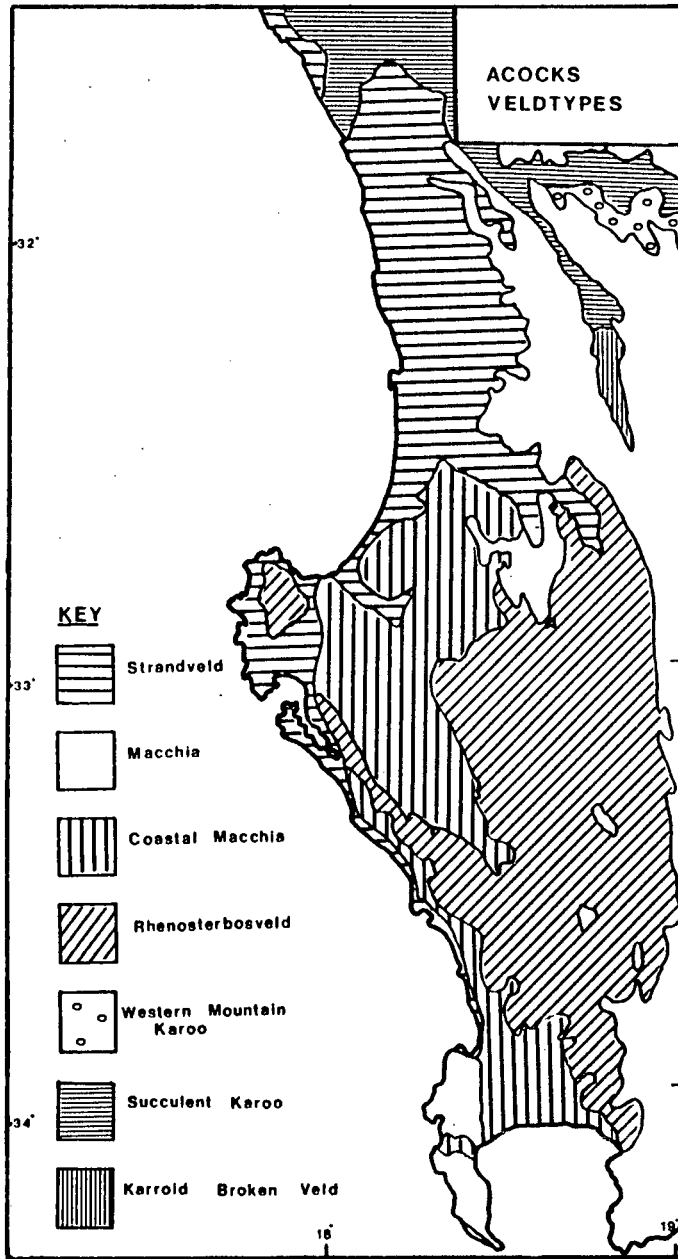
FIGURE 2.3 Acocks's veld types in the western Cape
(redrawn from Acocks, 1953; map 'Veld types of South
Africa')

species differ in the two areas, although several woody species are common to both (Table 2.1). West Coast Strandveld has fewer species, is shrubbier, shorter, thornier, more succulent and drought-resistant than that of the south coast, but is more widespread. It also contains more karroid and fewer heath and forest elements than does south coast Strandveld.

TABLE 2.1   IMPORTANT WOODY SPECIES OF STRANDVELD
(Taylor, 1978)

SOUTH COAST STRANDVELD	WEST COAST STRANDVELD
Sideroxylon inerme	Putterlickia pyrecantha
Carissa bispinosa	Zygophyllum morgsana
Diospyros dichrophylla	Lycium spp.
	Solanum guineense
	Diospyros glabra

SPECIES COMMON TO BOTH AREAS

Euclea racemosa
Maytenus heterophylla
Pterocelastrus tricuspidatus
Rhus glauca
Rhus laevigata

Although all of the various definitions and descriptions mentioned above have differed with regard to nomenclature and the extent of Strandveld vegetation, all of them have recognised that along the Cape west coast there is a distinct vegetation that is unlike fynbos. The more detailed nature of the plant communities of West Coast Strandveld will be discussed later.

2.3 ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION OF STRANDVELD

West Coast Strandveld appears to be influenced primarily by two factors; precipitation and soil nutrients. South of the Berg River the boundary between Strandveld and Sand Plain Fynbos appears to be closely correlated to soil nutrients, in particular phosphorus, and soil pH (Boucher, 1982b; Witkowski, Mitchell & Brown, 1984), while further north rainfall seems to be the predominant factor. Soil factors may also be involved here, since at Verlore Vlei there appears to be some correlation between soils and the different veld types (Grindley, Lane & Robertson, 1980). No detailed data are available. Even further north where Strandveld is restricted to a narrow belt along the coast the increase in effective precipitation as a result of the fogs may be an important factor in determining the boundary between Succulent Karoo and Strandveld.

2.3.1 CLIMATE

The Cape west coast falls within the winter rainfall region of southern Africa, receiving most (75%) of its rain between April and September and experiencing severe drought in the summer. According to the Köppen classification the west coast can be divided into two climatic zones (Schultz & Mcgee, 1978) (Fig. 2.4). A true mediterranean climate (Csa & Csb) occurs only in the area south of Saldahna Bay. From there northwards to Lambert's Bay the climate is classified as BSk - semi-arid with a mean annual temperature of less than 18°C, but still with a pronounced summer drought. It can be considered a mediterranean-type climate (Specht & Moll, 1983). West Coast Strandveld extends mainly across two Köppen climatic types; Csb and BSk.
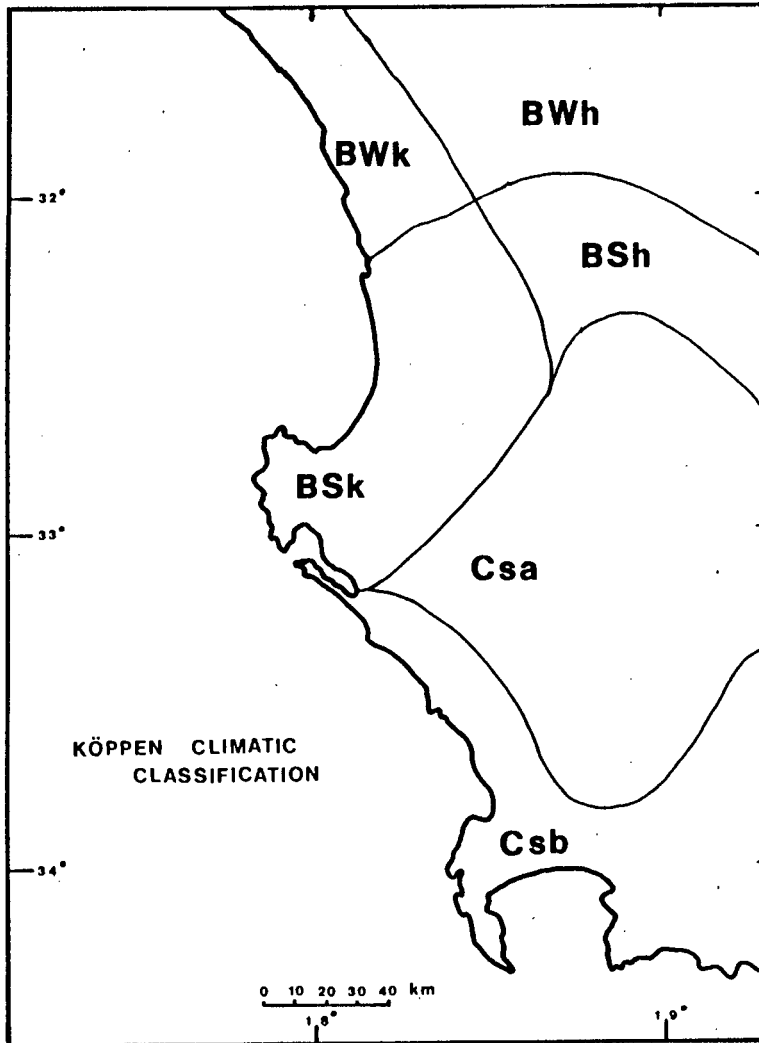
FIGURE 2.4   Köppen climatic zones of the south-western Cape
(redrawn from Schultz & Mcgee, 1978)
    Csa - Warm temperate climate - hot dry summer
    Csb - Warm temperate climate - warm dry summer
    BSk - Cool steppe climate
    BSh - Hot steppe climate
    BWk - Cool desert climate
    BWh - Hot desert climate

MOISTURE REGIONS

Key

2	Humid	20-40
3	Moist Sub-humid	0 - 20
4	Dry Sub-humid	-20 - 0
5	Semi - arid	-40 - -20
6	Arid	< -40

0 10 20 30 40 km
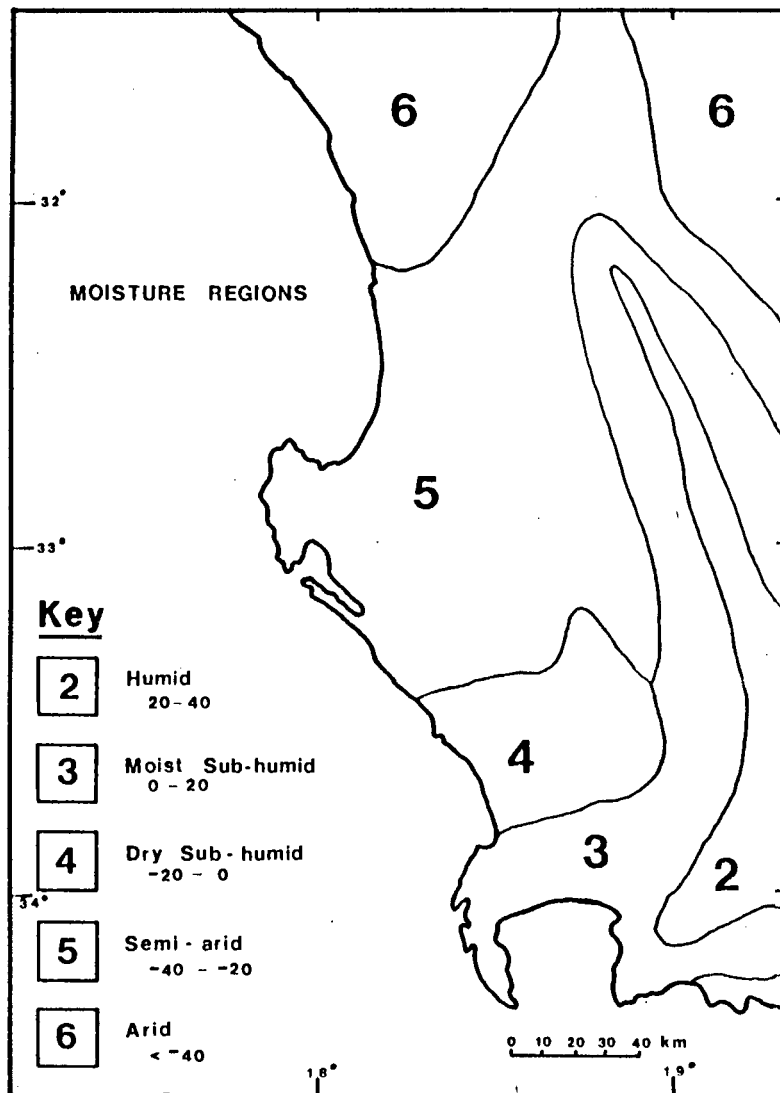
FIGURE 2.5 Moisture regions of the south-western Cape (redrawn from Schultz & McGee, 1978). Values in key refer to Thornthwaite's moisture index.

Another system of classifying climates that may have direct value in explaining the variation that occurs in Strandveld is that of Thornthwaite, which is based on an index of effective precipitation. Schultz & Mcgee (1978) show that the west coast can be divided into three moisture regions (Fig. 2.5) running from south to north: dry sub-humid, semi-arid, arid. According to Specht & Moll (1983) most of the mediterranean climate zone of South Africa is relatively dry and has an annual moisture index of <0.6, while Strandveld tends to occur in areas with a moisture index of <0.2.

2.3.1.1 Rainfall

Rainfall in the western Cape is mainly cyclonic, resulting from cold fronts coming in from the south Atlantic. Annual precipitation (Fig. 2.6 a) decreases rapidly northwards along the west coast, from about 360 mm at Melkbos to 125 mm at Lambert's Bay, and continues decreasing up the coast. The cold Benguela current inhibits rainfall development along the west coast, hence the arid conditions that prevail.

The number of rain days per month in winter and early spring is 12-15 for Cape Town but only six on average for Lambert's Bay, with a range of 1-15. The rainfall is therefore not only lower but also very much more erratic in the north. Hail is rare along the coast.

The amount and distribution of the rainfall (Figure 2.6 b) determines the length of the growing season, which is about seven months in the south and only about five months in the Lambert's Bay area (Fuggle & Ashton, 1979). This must have a direct influence on both vegetation cover and plant growth form.
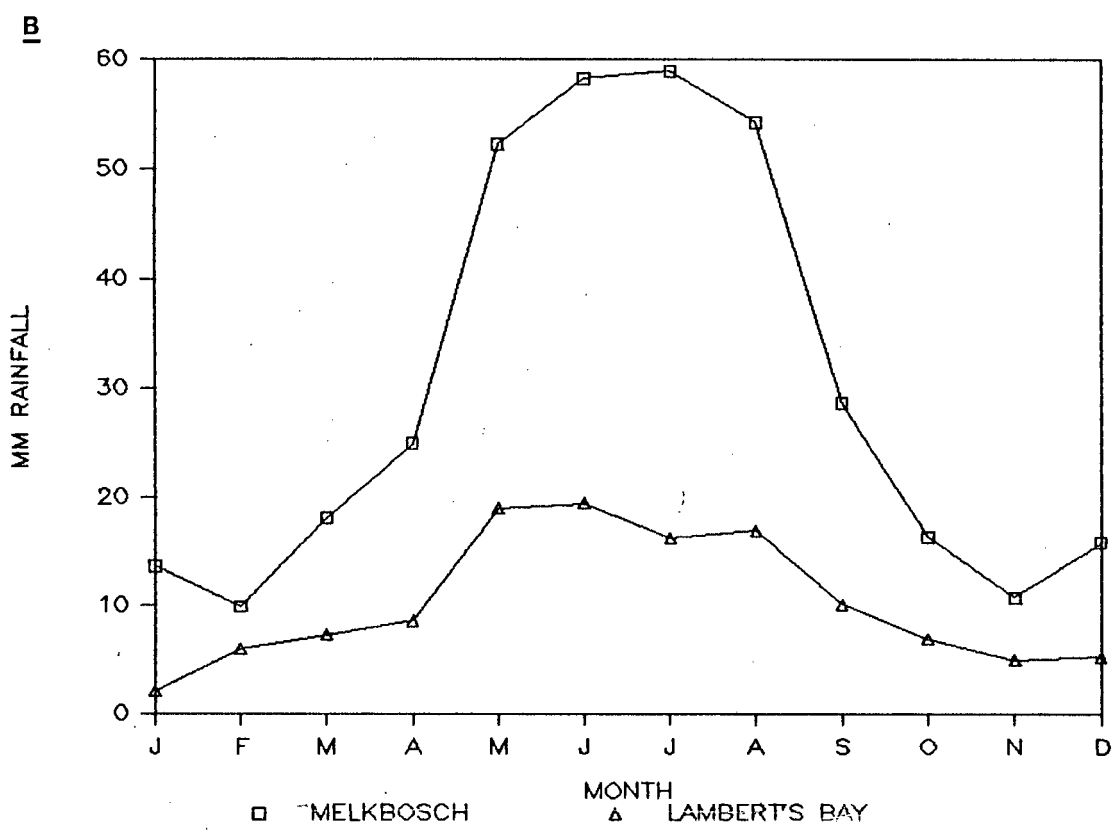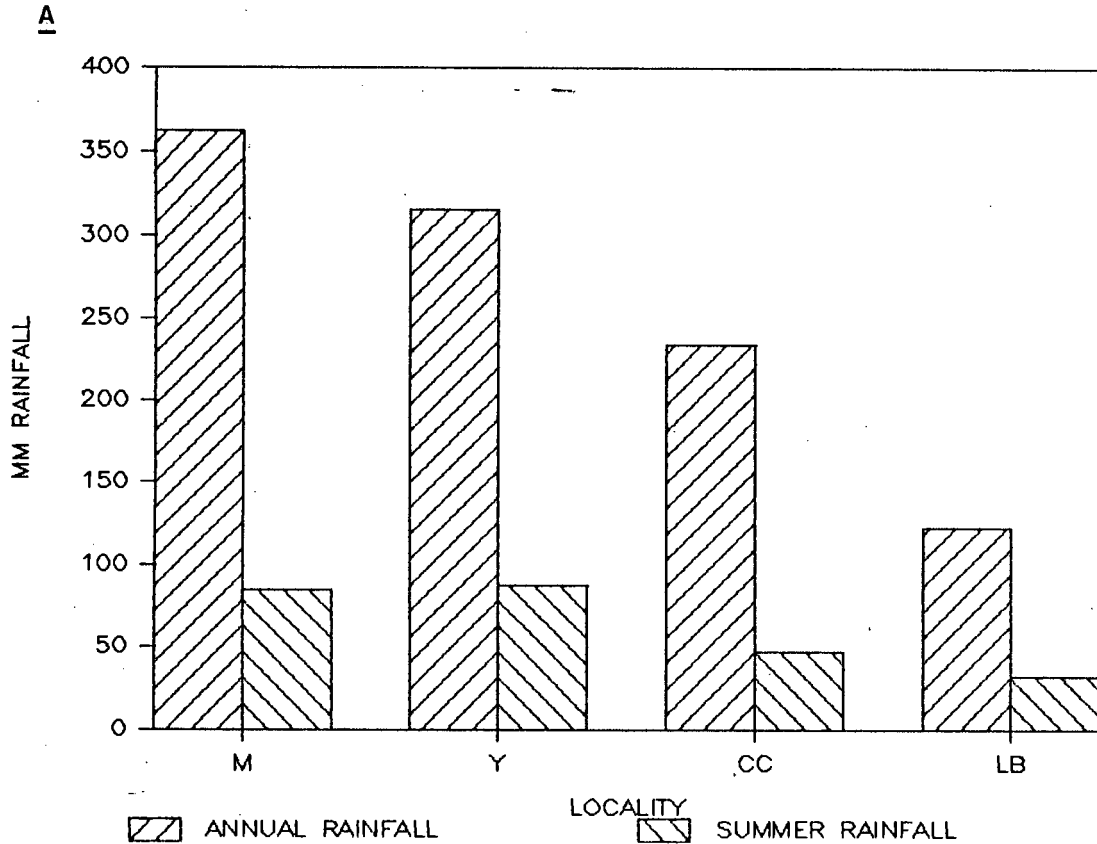
FIGURE 2.6 a) Annual and summer rainfall at four stations
along the Cape west coast; M Melkbosstrand (33° 44'S), Y
Yzerfontein (33° 20'S), CC Cape Columbine (32° 50'S), LB
Lambert's Bay (32° 05'S).   (Weather Bureau, pers. comm.)

b) Distribution of rainfall at Melkbos and Lambert's Bay

2.3.1.2 Evaporation

Annual evaporation from Class A pans in the western Cape is in the vicinity of about 2000mm per annum (Fuggle & Ashton, 1979) of which about 40% occurs in summer. Annual evaporation rates are lower along the southern portion of the west coast than in the north, although in summer the situation may be reversed (Table 2.2).

TABLE 2.2   EVAPORATION RATES
(from Boucher & le Roux, in press)

LOCATION	EVAPORATION		
	ANNUAL (mm)	JULY (mm)	JANUARY (mm)
Cape Town	2142	71	323
Alexander Bay	2464	130	297

2.3.1.3 Fog

Radiation and advection fogs occur all along the west coast of southern Africa. These fogs form at sea and drift inland and their influence is felt for about 3 km inland on average (Nagel, 1962). These fogs are most common in summer when south-easterly winds cause upwelling of cold water along the coast. The frequency of fog increases from south to north; 33 days of fog a year in Cape Town and 146 days in Port Nolloth (Boucher & le Roux, in press). These fogs, together with heavy dews compensate somewhat for the lack of summer rain. Their main effect is to increase effective precipitation along the coast which in turn influences plant growth. Taylor (1978) feels that it is these fogs that allow the growth of low coastal scrub containing elements of sub-tropical thicket along the west coast. A further effect of these fogs is to have a moderating effect on summer temperatures.

23

2.3.1.4 Temperature

The average daily maximum temperature for Cape Town is 28°C in midsummer and 17°C in winter. At Lambert's Bay these temperatures are about 25°C and 18°C respectively. The hottest period of the year in the western Cape is January - March. The probability of heat-waves of >30°C is 8% in January, 14% in February and March (Department of Agriculture & Fisheries, 1985a). Temperatures of over 40°C can occur during periods of easterly winds. Summer temperatures along the coast are tempered by the cold Atlantic water and the frequent summer fogs. Minimum temperatures in July average about 6°C for Cape Town and 7 - 8°C for Lamberts Bay and they seldom fall below zero. Frost is rare.

In general the temperatures experienced along the west coast are not limiting to plant growth.

2.3.1.5 Wind

Winds along the west coast can be very strong. In summer they tend to blow from the south/south-east and in winter the north-west. Wind plays an important role in determining the nature of the vegetation by virtue of its effect on evapotranspiration rates. The hot dry offshore south-easterly winds that occur in summer very quickly dessicate the vegetation once the rains have ended. Even in winter winds are strong and cause higher transpiration rates than those found for mediterranean type vegetation in Australia (Specht & Moll, 1983). Salt-laden on-shore winds constantly stunt new growth of shrub species along the coast, resulting in the commonly seen wind-pruning effect.

2.3.2 LANDSCAPE, GEOLOGY AND SOILS

The western coastal region lies between about 5 and 100m altitude and comprises mainly an undulating plain of varying width with low coastal cliffs, small estuaries and long beaches. Extensive dune plumes occur in a number of places (Boucher & le Roux, in press).

Geological substrates are predominantly Quaternary aeolian sands, sometimes of considerable depth, and Tertiary calcareous outcrops. The width of this sand cover is variable along the coast (Lambrechts, 1979), from a few kilometres to nearly 50 km in the Velddrif area. Outcrops of older granites, sandstones and shales also occur (Fig. 2.7).

The soils of the coastal areas are predominantly arenosols; aeolian sands with a low reserve of weatherable minerals and a low silt/clay ratio (Lambrechts, 1979). Arenosols of marine origin have high pH, while those of inland origin have a low pH (Table 2.3(a)). High rainfall results in increased acidity. Soil colour varies; in upland, well-drained sites soils are red, in level areas they are yellow and in bottomland sites or on the shore they are grey. These soils tend to have a low moisture-retention capacity, a low cation exchange capacity and some trace element deficiencies. The soils are highly calcareous at the coast (Table 2.3(a) and are commonly underlain by calcrete. Soil depth is variable, from shallow to very deep. They are very susceptible to wind erosion.

From the work of Schloms, Ellis & Lamprechts (1983) it would appear that within the area mapped by Moll et al. (1984) as Strandveld the following soil types occur: 1. south of the Berg river: calcareous aeolian sands with some red kaolinitic loams and clays in the granite areas 2. north of the Berg river: acid aeolian sands and podzols.
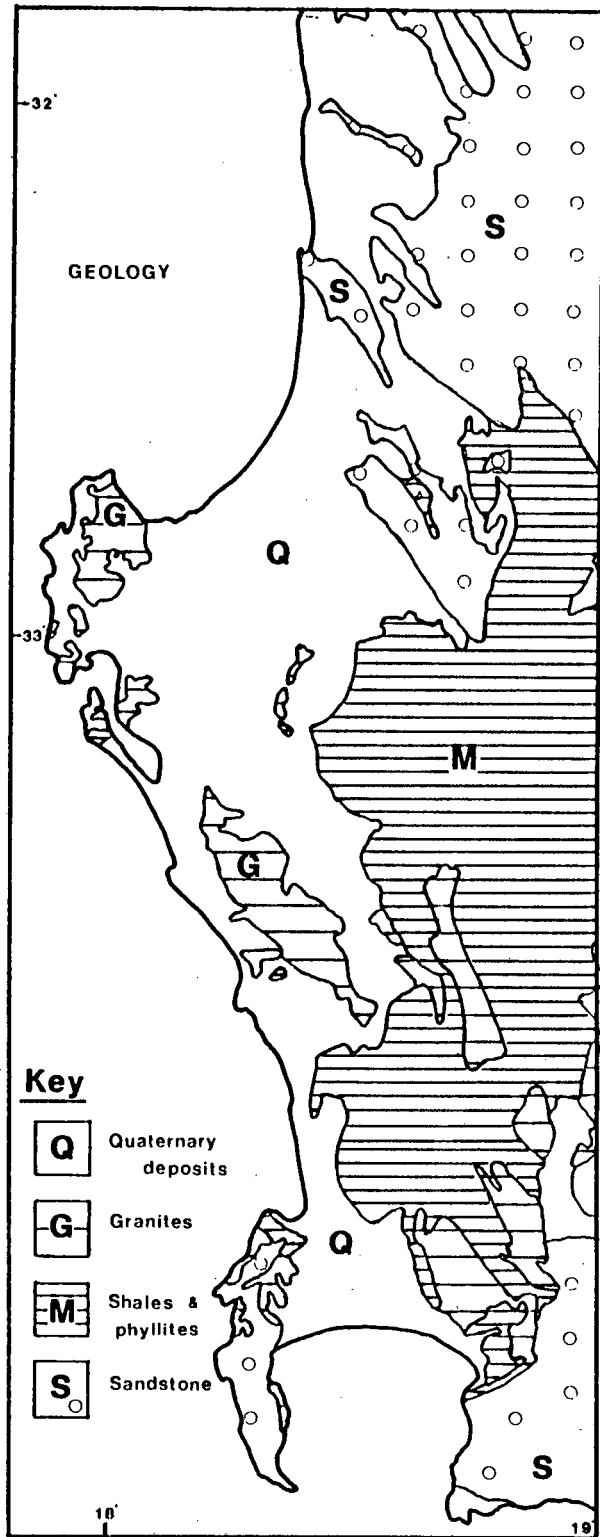
FIGURE 2.7 Major geological substrates of the Cape west coast (redrawn from Lambrechts, 1979)

TABLE 2.3 (a) Phosphorus content of Strandveld soils compared with soils
           from other lowland sites on the Cape west coast.

Vegetation type	Site	Total P (g P/g dry mass)	Bray	Resin	Organic P (% total)	
STRANDVELD	Melkbos	422	72	40	15	*
	Melkbos	285	23	56		#
	Geelbek	660	106	485		#
	Nortier	338	68	13	10	*
	Rondeberg	89.4	6	10.4		ə
SAND PLAIN FYNBOS	Melkbos	29	2.9	1.6	68	*
	Barhuis	127	5.6	1.4		#
RENOSTERVELD	Tygerberg	159	4	0.4	67	*
	De Grendel	207	3.5	4.4		#

* Witkowski et al., 1984
# data from Sommerville, unpublished
ə Glyphis & Puttick, 1980

TABLE 2.3 (b) Analysis of soils from four lowland sites.
              (unpublished data from J. Sommerville)

SITE VEGETATION	Melkbos Strandveld	Geelbek	Barhuis Fynbos	De Grendel Renosterveld
Oxid. C (%)	1.5	1.7	1.3	6
Total N	0.05	0.08	0.03	0.19
Exch. K	20	49	15	309
Ca	267	1140	115	145
Mg	65	91	15	204
Na	73	67	46	99
pH	7	7.75	4.35	5.3

Witkowski, Mitchell & Brown (1984) report that Strandveld soils contain the highest total and available phosphorus of any soils in the Fynbos Biome. The proportion of organic-P to total-P is low but the organic-P is similar to that in other soils (Table 2.3(b)). In soils close to the high-water mark the most important inorganic-P is Ca-bound. Further inland saloid- and Fe-bound inorganic-P become more important. At Melkbos the strandveld and coastal fynbos soils differ markedly in total phosphorus content as well as Bray No.2-P and resin-P, and in the form of inorganic-P.

There is no available detailed account of soils which has been accurately correlated with the heathland/shrubland division in the south-western Cape. However, Boucher (1981) defines Strandveld as occurring on these alkaline coastal soils extending onto arid granitic soils in drier areas. Inland and with increasing rainfall the soils become more leached and acidic and tend to support heathland.

Following the binomial system developed by MacVicar et al. (1977) the predominant soils of the Strandveld in the south belong to the Fernwood and Mispah series with Glenrosa, Glendale, Slangkop and Sandveld series associated with granite hills (Schloms, Ellis & Lambrechts, 1983). In the north red and yellow sands of the Hutton, Clovelly and Pinedene series occur (Department of Agriculture & Fisheries, 1985b). Boucher & Jarman (1977) found a variety of soils in the Langebaan area (Table 2.4).

TABLE 2.4 Soil Forms and Series occurring in Strandveld in the
Langebaan area (data from Boucher & Jarman, 1977)

	FORM	SERIES
Coastal platforms	Mispah	Muden
	Oakleaf	Levubu
	Hutton	Maitengwe
Limestone areas	Mispah	Muden
Granite areas	Cartref	Kusasa
		Grovedale
	Estcourt	Darling
		Balfour
	Hutton	Gaudam
	Fernwood	Fernwood
	Nomanci	Nomanci
Dunes	Mispah	Kalkbank
	Fernwood	Langebaan
	Clovelly	Sandspruit

Scattered across the lowlands of the west coast are "heuweltjies", earth
mounds. These "heuweltjies" are remarkably uniformly distributed and
have a distinct vegetation. They are most conspicuous on the inland
section of the coastal plains (Lovegrove & Siegfried, 1986), but also
occur, to a lesser degree, in West Coast Strandveld, where they seem to
be associated with shrubs such as Lycium spp.. The mounds appear to be
formed by the action of the harvester termite (Microhodotermes viator)
and mole rats (Cryptomys hottentotus). The base exchange capacity of the
soils of these heuweltjies is higher than that of surrounding soil
(Slabber, 1930). This must play a role in determining the composition of
the vegetation of these structures.

2.4 VEGETATION - COMPOSITION

Within Strandveld itself there are two major environmental gradients that influence the composition and structure of the plant communities. These occur more or less at right angles to each other. There is the larger-scale rainfall gradient from south to north and at a smaller scale there is the gradient of factors related to distance from the sea. These two together result in a set of three successionally related community types that change in composition and structure from south to north. Following Taylor's (1978) nomenclature these communities are:

1. Pioneer Littoral Vegetation

2. Successional Littoral Dune Vegetation

3. Coast Scrub

These communities have been described for various localities along the west coast. The only detailed survey of the vegetation of the west coast published to date is that for the Langebaan area (Boucher & Jarman, 1977). A survey of the lowland area south of St. Helena has been done by C. Boucher and should be published soon. The Strandveld communities occurring in the area to the north of Boucher's study area need to be assessed within the framework of Boucher's survey in order to assess where these more arid communities fit and whether or not ecological and phytosociological surveys are needed in order to more fully describe these communities.

Although not common on the west coast, there are in local, well-drained, wetter areas, such as at the foot of granite outcrops, patches of Scrub forest (sensu Taylor, 1978), characterised by the species _Maurocenia_ _frangularia,_ _Chionanthus_ _foveolata,_ _Maytenus_ _heterophylla,_ _Myrsine_

africana and Sideroxylon inerme.

There are also other communities occurring in specialised habitats. Limestone areas, salt marshes, vleis and seeps all have characteristic vegetation (Boucher & Jarman, 1977; Taylor, 1978). The species found in these habitats are not always restricted to Strandveld, but occur throughout the coastal lowlands. These are not dealt with here.

2.4.1 STRANDVELD COMMUNITIES

2.4.1.1. Pioneer Littoral Vegetation

This pioneer community, also called Strand vegetation (Tinley, 1985; Boucher & le Roux, in press), occurs on unconsolidated dune sand and is under constant maritime influence. Boucher & le Roux (in press) found that the primary feature of strand communities is that species confined to the littoral zone predominate over those of adjacent inland vegetation. Taylor (1978) describes this littoral community as comprising pioneer grasses and herbs: on the west coast these are chiefly Cladoraphis cyperoides, Arctotheca populifolia and Senecio elegans (Table 2.5).

In the Langebaan area Boucher & Jarman (1977) describe a littoral community they call Didelta-Psoralea littoral dune open grassland. The differential species are Didelta carnosa, Psoralea repens and Carpobrotus edulis, with Cladoraphis cyperoides and Senecio elegans occurring as dominants. The plants are generally prostrate spreading chamaephytes. Succulence and hairiness are common features.

TABLE 2.5   PIONEER COMMUNITIES DESCRIBED FOR WEST COAST STRANDVELD.
(Modified from Taylor, 1978; Dean, 1985; Tinley, 1985;
Boucher & Jarman, 1977; Boucher & le Roux, in press)

AUTHOR	NAME OF COMMUNITY	CHARACTERISTIC & DOMINANT SPECIES
Taylor	Pioneer littoral vegetation	Ehrharta villosa, Hebenstreitia cordata, Senecio elegans, Cladoraphis cyperoides, Arctotheca populifolia, Carpobrotus acinaciformis, Didelta carnosa
Dean	Seaward dune Strandveld	Didelta carnosa, Arctotheca populifolia, Hebenstreitia cordata, Cladoraphis cyperoides, Carpobrotus spp., Ehrharta villosa, Senecio maritimus, Tetragonia spp., Senecio elegans
Tinley	Strand community (Zone 1)	Cladoraphis cyperoides, Polygonum maritimum, Hebenstreitia cordata, Salsola kali, Pteronia onobromoides, Sporobolus virginicus, Arctotheca populifolia, Tetragonia decumbens, Chenopodium spp.
Boucher & le Roux	Strand vegetation common species	Protasparagus capensis, Ruschia sp., Didelta carnosa var. carnosa, Tetragonia decumbens, Drosanthemum sp., Tetragonia fruticosa, Lycium horridum, Zygophyllum morgsana, Othonna floribunda
	dune species	Didelta carnosa var. tomentosa, Hebenstreitia cordata, Arctotheca populifolia, Trachyandra divaricata, Cladoraphis cyperoides, Mesembryanthemum sp.
	characteristic species of Capensis coast	Chenolea capensis, Exomis microphylla, Helichrysum micropoides
	differential species of Capensis rocky coastal community	Frenia pallens, Euclea racemosa, Frankenia pulverulenta, Disphyma crassifolium, Puccinellia fasciculata, Crassula sp., Mesembryanthemum sp., Putterlickia pyracantha, Euphorbia mauritanica, Rhus glauca
	differential species of Capensis coastal dune community	Polygonum maritimum, Ehrharta villosa, Manulea tomentosa, Pentzia sabulosa
Boucher & Jarman	Didelta-Psoralea littoral dune open grassland	Didelta carnosa var. tomentosa, Senecio maritimus, Psoralea repens, Dischisma ciliatum, Carpobrotus edulis, Trachyandra divaricata, Cladoraphis cyperoides, Amellus asteroides, Senecio elegans, Scirpus trachyspermus, Artcotheca populifolia, Manulea tomentosa, Myrica cordifolia,

32

At Elands Bay the littoral community is characterized by low sprawling evergreen shrubs, grasses and annuals of the same species found at other localities (Dean, 1985).

Tinley (1985) describes a Strand community that occurs all around the coast of southern Africa in various forms. The littoral plant community changes continuously along the coast responding to such factors as rainfall and the adjacent vegetation. His west coast variant is characterised by Cladoraphis cyperoides, Hebenstreitia cordata and Pteronia onobromoides (Table 2.5).

Boucher & le Roux (in press) surveyed the west coast strand vegetation in more detail and found that different sectors of the coast are characterized by different species groups. Namaqualand strand vegetation differs phytosociologically from that along the Capensis coast, with boundary between the two being the Olifants river mouth. The vegetation is essentially dwarf shrubs <50cm high usually with succulent leaves or stems and grasses. The Capensis strand vegetation is distinguished by the presence of Chenolea diffusa, Exomis microphylla and Helichrysum micropoides. On rocky substrates there appear to be northern and southern communities, characterised by Prenia pallens and Euclea racemosa/Euphorbia mauritanica respectively, with the boundary zone St. Helena Bay (Table 2.5).

The above descriptions do not all refer strictly to the pioneer vegetation. Boucher & le Roux' (in press) Strand vegetation appears to incorporate both Pioneer Littoral and Successional Littoral Dune Vegetation (described later), as does Dean's (1985) description.

33

As a result of the variation in species composition along the coast the descriptions of the community emphasize different characteristic species depending on the locality under study. However, one species is common to all the descriptions - Cladoraphis cyperoides. This grass is typical of west coast littoral vegetation as well as areas of open sand further inland. In these latter sites vegetation very similar to that of the Strand habitat occurs and C. cyperoides is also the primary colonizer.

2.4.1.2. Successional Littoral Dune Vegetation

This is Taylor's (1978) second community inland, which Tinley (1985) calls the Zone II shrub community. This occurs on partly stabilised sand. The shrubs are usually precursors and subsequent canopy species of the climax scrub community. Typical species are Chrysanthemoides monilifera and Colpoon compressum (Table 2.6). Grasses can be important and common species are Cladoraphis cyperoides, Ehrharta villosa and Cynodon dactylon. Species diversity is a little higher than that for the pioneer community.

In the Langebaan area a number of communities have been identified that fall within this zone (Boucher & Jarman, 1977): Hermannia pinnata littoral dune dwarf succulent shrubland, Thamnochortus spicigerus dune dense tall restiod herbland and Metalasia-Myrica dune dense ericoid shrubland. This latter community is thought to be part of Sand Plain Fynbos rather than Strandveld. In the north pioneer species tend to be succulents such as Tetragonia fruticosa and Manochlamys albicans as well as Galenia africana on red sands.

TABLE 2.6. SUCCESSIONAL DUNE COMMUNITIES
(Modified from Taylor, 1978; Tinley, 1985;
Boucher & Jarman, 1977)

AUTHOR	NAME OF COMMUNITY	CHARACTERISTIC & DOMINANT SPECIES
Taylor	Successional littoral dune vegetation	Chrysanthemoides monilifera, Myrica cordifolia, Colpoon compressum, Chironia baccifera, Metalasia muricata, Passerina vulgaris
Tinley	Shrub community (Zone II)	Chrysanthemoides monilifera, Othonna floribunda, Ehrharta villosa, Pentzia suffruticosa, Protasparagus capensis, Salsola sp., Aster sp., Senecio elegans, Cynodon dactylon, Didelta carnosa, Tetragonia fruticosa, Lebeckia cinerea, Trachyandra divaricata, Lycium spp., Zygophyllum morgsana, Nylandtia spinosa, Mesembryanthemaceae
Boucher & Jarman	Hermannia pinnata littoral dune dwarf succulent shrubland	Hermannia pinnata, Ehrharta calycina, Grielum grandiflorum, Ruschia geminiflora, Nylandtia spinosa, Cladoraphis cyperoides, Limeum africanum, Trachyandra divaricata, Gazania pectinata, Amellus asteroides, Polycarena selaginoides, Cnidium suffruticosum, Ehrharta villosa, Manulea tomentosa, Limonium perigrinum
	Thamnochortus spicigerus dune dense tall restiod herbland	Thamnochortus spicigerus, Colpoon compressum, Limonium perigrinum, Kedrostis nana, Ehrharta calycina

2.4.1.3. Coast Scrub

This is the climax vegetation of Strandveld.   It occurs on stable dunes and further inland on older sands. A number of different names have been applied to this scrub: Littoral scrub, Dune Valley scrub, (Cited in Taylor, 1978), Dune scrub (Boucher, 1974) and Scrub Thicket (Tinley, 1985).   On the west coast this scrub is poorer in species composition than its equivalent on the south coast (Table 2.7), but is more extensive, occurring well inland in places.   The scrub is a dense, short, broad-sclerophyllous and thorny community, varying from 1 – 2.5 m depending on locality.   Important   species   are _Euclea_ _racemosa,_   _Pterocelastrus_ _tricuspidatus,_ _Olea_ _exasperata,_ _Putterlickia_ _pyracantha,_ _Rhus_ _glauca_ and _Zygophyllum_ _morgsana._   North of St. Helena Bay the arborescent succulent _Ruschia_ _frutescens,_ and the shrubs _Tetragonia_ and _Salvia_ increase in importance.   The Strandveld scrub here fits Acocks' (1953) description of Strandveld proper.

In the Langebaan area and to the south, climax dune scrub communities include the _Maytenus-Kedrostis_ dense evergreen shrubland and _Willdenowia_ dense evergreen restiod shrubland (Boucher & Jarman, 1977). These dense scrub communities are what Acocks (1953) called Dense Strandveld Scrub. Important species are _Maytenus_ _heterophylla,_ _Euphorbia_ _mauritanica,_ _Salvia_ _lanceolata,_ _Eriocephalus_ _africanus_ and _Willdenowia_ _incurvata,_ as well as those mentioned previously.   The dense shrubland is more or less confined to the dune cordon and dune fields and the seaward-facing slopes further inland.   The _Willdenowia_ dominated community occurs inland of the shrubland.   In it occur marginal fynbos shrubs such as _Aspalathus,_ _Nylandtia,_ _Diosma_ and _Passerina._   This community merges into Sand Plain

Fynbos with scattered clumps of dune-scrub species.

At Verlore vlei the scrub is very similar to that described by Boucher & Jarman (1977), only not as dense. Clumps of broad sclerophyll shrubs up to 2.5m tall are interspersed with grasses and _Willdenowia_ and smaller succulent and drought-deciduous shrubs. The same species are common. Dean (1985) describes two types of Strandveld scrub in the Verlore Vlei area: Shrubby Strandveld and Reedy Strandveld (Table 2.7). In the latter _Willdenowia incurvata_ dominates. Towards Lambert's Bay succulents become more abundant in the vegetation, particularly _Ruschia_ spp. Palatable grasses can become an important constituent of mature Strandveld in these parts if appropriate management techniques are applied (see Chapter 3). _Ehrharta calycina_ becomes the dominant species. Other grasses include _Ehrharta villosa_ spp. and _Chaetobromus dregeanus_. Dense _Euclea-Ruschia_ dune scrub tends to occur only where moisture availability is higher, such as on the dunes themselves and on west-facing slopes that benefit from the fogs.

Different Strandveld forms have been described on the different soils in the area north of Elands Bay (Department Agriculture & Fisheries, 1985). On white sands a number of plants are characteristic: _Zygophyllum_ spp., _Hermannia_ spp., _Chrysanthemoides monilifera_ and _Eriocephalus racemosus_ amongst others. On red sands _Didelta spinosa_ is common, and _Chrysanthemoides incana_ replaces _C. monilifera_ and _Chaetobromus dregeanus_ replaces _C. schraderi_. Yellow sands occur amongst the red

sand and are mainly covered with _Willdenowia incurvata_ and _Elegia_ spp. as well as some grasses. Downing & van der Merwe (ND.) have described several vegetation units for Nortier Experimental farm, of which some correlate to the three discussed above, ie. a _Willdenowia_ unit, a _Chrysanthemoides_ unit and a _Zygophyllum_ unit. They also describe several dune vegetation units.

TABLE 2.7   DUNE SCRUB COMMUNITIES
(Modified from Taylor, 1978; Tinley, 1985; Boucher, 1974; Boucher & Jarman, 1977; Dean, 1985; Dept. Agriculture & Fisheries, 1985)

AUTHOR	NAME OF COMMUNITY	CHARACTERISTIC & DOMINANT SPECIES
Taylor	Coast scrub	Pterocelastrus tricuspidatus, Solanum guineense, Euclea tomentosa, Diospyros glabra, Euclea racemosa, Maytenus heterophylla, Rhus glauca, Rhus laevigata, Putterlickia pyracantha, Lycium spp., Protasparagus spp., Tylecodon paniculata, Euphorbia spp., Zygophyllum morgsana
Boucher	Dune scrub	Zygophyllum morgsana, Rhus glauca, Euclea racemosa, Pterocelastrus tricuspidatus, Putterlickia pyracantha, Euphorbia spp., Protasparagus spps.
Tinley	Scrub thicket	Euclea racemosa, Ruschia frutescens, Euphorbia mauritanica, Rhus glauca, Zygophyllum morgsana, Salvia aurea, Pterocelastrus tricuspidatus, Tetragonia fruticosa, Chrysanthemoides monilifera, Limonium perigrinum, Putterlickia pyracantha, Rhus laevigata, Tylecodon paniculata, Cotyledon orbiculata, Lycium spp.
Dean	Shrubby Strandveld	Rhus spp., Euclea racemosa, Diospyros sp., Colpoon compressum, Maytenus heterophylla, Putterlickia pyracantha, Lebeckia sp., Lycium spp., Protasparagus spp., Zygophyllum sp., Salvia sp., Eriocephalus sp., Euphorbia mauritanica, Kedrostis sp., Cysticapnos sp., Mesembryanthemaceae, Pteronia sp., Senecio sp., Ehrharta spp.,
	Reedy Strandveld	Willdenowia incurvata dominates. (Other species as above.)
Dept. Agric. & Fish.	Strandveld on white sand	Zygophyllum morgsana, Hermannia scordifolia, Hermannia heterophylla, Chrysanthemoides monilifera, Eriocephalus racemosus, Euclea racemosa, Ehrharta calycina, Ehrharta villosa, Chaetobromus schraderi
	Strandveld on red sand	Didelta spinosa, Zygophyllum spp., Chrysanthemoides incana, Chaetobromus dregeanus, Monechma incana, Osteospermum oppositifolium
	Strandveld on yellow sand	Willdenowia incurvata, Elegia spp., Ehrharta villosa, Stipagrostis ciliata
Boucher & Jarman	Maytenus-Kedrotis consolidated-dune dense evergreen shrubland	Maytenus heterophylla, Kedrostis nana, Tylecodon paniculata, Cotyledon orbiculata, Euphorbia mauritanica, Salvia lanceolata, Clutia daphnoides, Putterlickia pyracantha, Zygophyllum morgsana, Ehrharta villosa, Limonium perigrinum, Euclea racemosa, Senecio floribunda, Pentzia pilulifera, Ehrharta calycina, Zygophyllum flexuosum, Tetragonia fruticosa
	Willdenowia striata consolidated-dune dense evergreen restioid shrubland	Willdenowia incurvata, Eriocephalus africanus, Helichrysum hebelepis, Salvia lanceolata, Putterlickia pyracantha, Zygophyllum morgsana, Euclea racemosa, Ehrharta racemosa

2.5 VEGETATION - STRUCTURE

Strandveld communities vary from open to dense and short to >2m and are characterised by a diversity of growth forms (Table 2.8). In the pioneer communities typical growth forms appear to be tufted graminoids (*Cladoraphis cyperoides*), rhizomatous graminoids (*Ehrharta villosa*) and sprawling semi-succulent herbs (*Arctotheca populifolia*) and dwarf shrubs (*Hermannia* spp.). Dense Strandveld scrub is usually dominated by broad-leaved sclerophyllous phanerophytes 1 to 2.5m tall, with sclerophyllous chamaephytes in the lower stratum (Table 2.9). The shrubs are predominantly resprouters. Hemicryptophytes up to 1m tall can also be quite common. Drought-deciduous succulent-leaved shrubs are usually present (eg. *Zygophyllum* spp.) and become more abundant northwards (Figure 2.8). There is a substantially higher degree of both stem and leaf succulence in Strandveld than in either of the other two lowland vegetation types - shrubs, dwarf shrubs and even annuals can be succulent. Seasonal geophytes are common and annuals are an important feature, particularily in disturbed areas.

There are a number of trends in the structure of Strandveld vegetation related to the south - north environmental gradient. There is a general decrease northwards in the height of the vegetation and of the shrubs in particular, as well as a decrease in shrub cover, evergreenness and leaf size. There are concommitant increases in drought-deciduousness, spinescence and succulence.

TABLE 2.8   TYPICAL GROWTH FORMS IN STRANDVELD VEGETATION

GROWTH FORM	EXAMPLES
Broad-sclerophyllous evergreen shrubs	Rhus glauca Euclea racemosa Pterocelastrus tricuspidatus
Narrow-sclerophyllous evergreen dwarf shrubs	Diosma aspalathoides
Drought-deciduous shrubs	Zygophyllum spp.
Spinescent shrubs & sub-shrubs	Putterlickia pyracantha Protasparagus capensis
Leaf-succulents	Crassula orbiculata Ruschia spp.
Stem-succulents	Euphorbia spp.
Climbers	Cissampelos capensis Myrsiphyllum spp. Cynanchum africanum
graminoid herbs	Ehrharta spp. Chaetobromus spp.
Restioid herbs	Willdenowia incurvata Thamnochortus spicigerus
Geophytes	Babiana spp. Gladiolus spp. Antholyza plicata
annual dicotyledonous herbs	Dimorphotheca pluvialis Zaluzianskya villosa Sutera tristis

TABLE 2.9 LIFE FORMS IN WEST COAST LOWLAND VEGETATION.
       (Boucher, 1982)

	geophytes	hemicrypt.	succulents	sprouting shrubs	seeding shrubs
Strandveld	15	10	25	29	21
Renosterveld	22	13	7	27	31
Fynbos	5	18	3	45	29

A

2m
1m

B

2m
1m

KEY

Evergreen
shrub

Evergreen
stem-
succulent

Restionaceae

Deciduous
dwarf shrub

Annual
grass

Geophyte

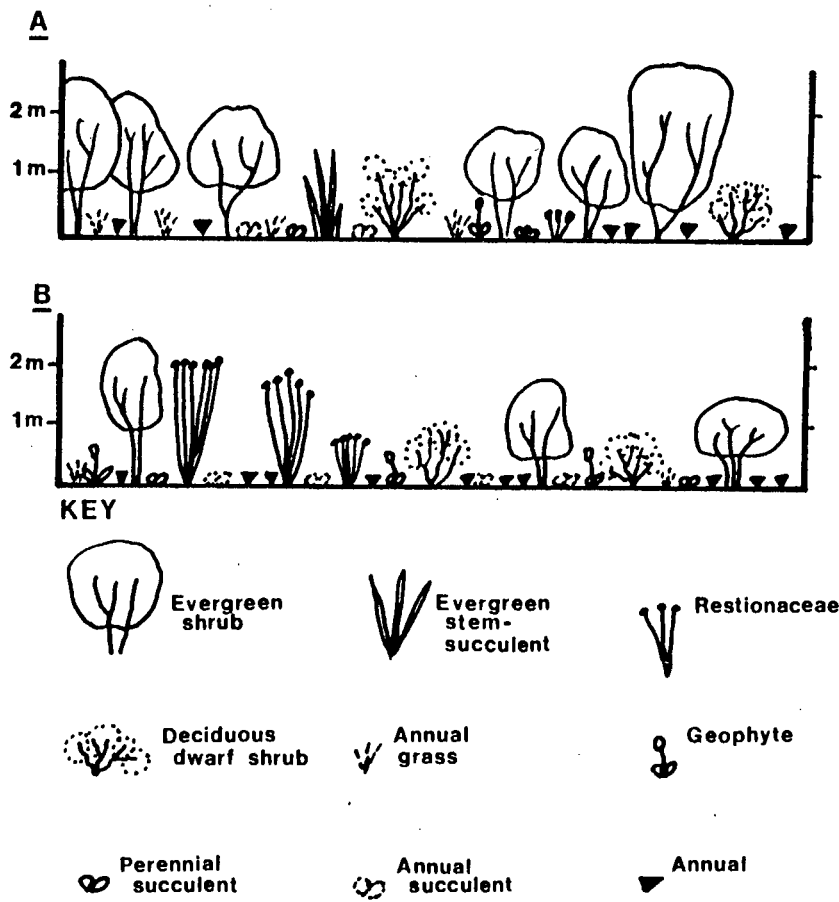Perennial
succulent

Annual
succulent

Annual

FIGURE 2.8 Typical structure of Strandveld shrublands,
a) mesic b) drier (redrawn from Specht & Moll, 1983)

Canopy cover in Strandveld varies considerably, depending on a variety of factors such as soil, grazing pressure, season, rainfall. Cover values as low as 30% have been recorded (Boucher & Jarman, 1977; Grindley, Lane & Robertson, 1980). In relatively undisturbed vegetation in winter canopy cover values can exceed 80%. The difference between wet and dry seasons can be quite high as shown by Nortier surveys (Table 2.10). This is as a result of the high degree of drought-deciduousness of the vegetation in this area. To the south seasonal differences are not so exaggerated.

TABLE 2.10 Seasonal differences in cover at Nortier, Lambert's Bay.

Species	% Cover	
	Nov 1982	Apr 1983
Ehrharta calycina	50.3	15.3
Hermannia scordifolia	8.2	6.2
Chaetobromus schraderi	9.6	4.8
Zygophyllum morgsana	5.0	6.0
Tetragonia fruticosa	1.7	0.9
Ruschia caroli	2.5	2.5
Eriocephalus racemosus	1.5	1.5
Ehrharta villosa	1.7	1.7
Lycium afrum	2.5	0.2
Ballota africana	0.4	0.5
Pteronia divaricata	0.6	0.4
Protasparagus sp.	0.2	0.5
Salvia lanceolata	0.8	0.4
Euclea racemosa	0.1	0.4
Lycium horridum	0.2	2.3
Cassine crocea	0.3	0.2
Protasparagus capensis	0.2	0.2
Ruschia sp.	0.1	0.1
BARE GROUND	25.4	57.7
OVERALL PLANT COVER	74.6	42.3

2.6 PHYTOGEOGRAPHY

The vegetation of the Cape west coast forms part of two phytogeographic regions; the Capensis and Karoo-Namib Regions. There have been differences of opinion as to what comprises Capensis, with regard to both geographical extent and the component vegetation types. Werger (1978) provides a well summarised account of southern African phytogeography.

As early as 1886 Bolus placed part of the Cape west coast into the South-Western Region and part into the Karoo Region. In the early 1900's a separate west coast region was recognised by both Bolus (Western Coastal Region) and Marloth (West Coast littoral) as distinct from the Kalahari and Karoo (Werger, 1978). Pole Evans (1936) recognised a Cape Region more or less equivalent to what is today termed the Fynbos Biome. Weimarck (1941) recognised the Olifants River mouth as the west coast boundary of the Cape Flora. He identified two centres in the Cape Flora on the west coast (Fig.2.9); 1. The south-western centre, which occurs as far north as the Berg River. The centre includes the western lowlands, which have a predominantly Cape element and few endems. 2. The north-western centre whose boundaries in the west are the Berg River in the south and Olifants River in the north. The vegetation is poorer in Cape species and has fewer endems than the south-western centre. The lower rainfall favours the Karoo element, while the winter rain allows the Cape element.

These two areas are also recognised by Werger (1978) but he sees them as belonging to two different Regions rather than both being in the Cape Region (Fig. 2.10). Werger followed Monod, Troupin and White (cited in
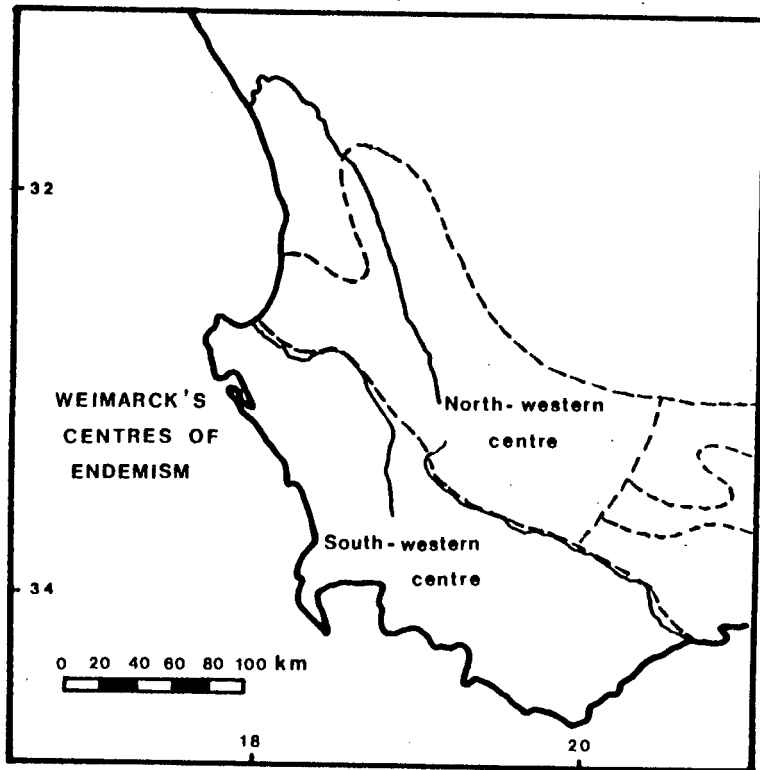
FIGURE 2.9 Weimarck's centres of endemsim on the Cape
west coast (redrawn from Weimarck, 1941)
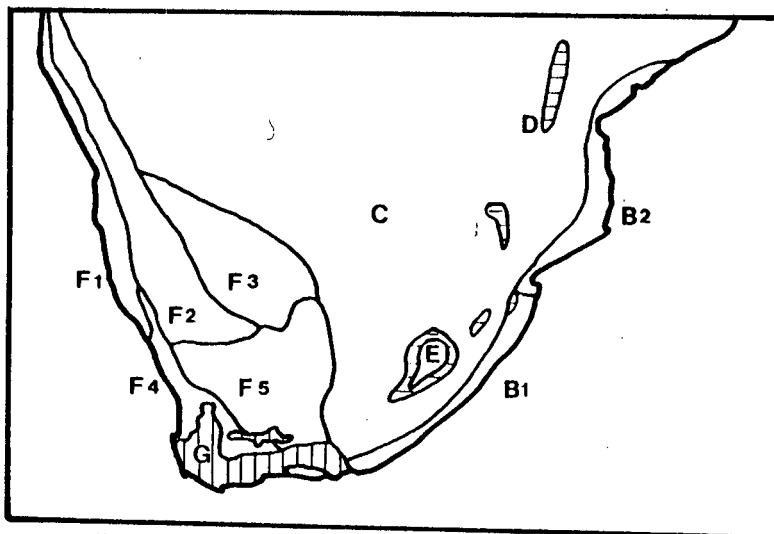
FIGURE 2.10 Werger's phytogeographical regions of southern
Africa (redrawn from Werger, 1978).

B1	Tongaland-Pondoland Regional Mosaic	F	Karoo-Namib Region
B2	Zanzibar-Inhambane Regional Mosaic	F1	Namib Domain
C	Sudano-Zambezian Region	F2	Namaqualand Domain
D	Afromontane Region	F3	Southern Kalahari Subdomain
E	Afro-alpine Region	F4	Western Cape Domain
		F5	Karoo Domain
		G	Capensis Region

Werger, 1978) who all recognised that part of the west coast fell within the Cape Region and part within a domain of the Karoo-Namib Region. He states that the boundary is not always clear in the lowlands because of the mixing of floras in the Strandveld and Renosterveld, although on his map that area of the west coast north of St. Helena Bay (Berg River) falls within the Western Cape Domain of the Karoo-Namib Region and that part south of St. Helena Bay into the Capensis Region.

Boucher & le Roux (in press) have defined two regions of the west coast based on Strand vegetation, as described previously. The boundary between these two, the Namaqualand and the Capensis coasts, is the Olifants River.

It would appear therefore that West Coast Strandveld stretches across two phytogeographic regions.

Whether or not it is part of the Fynbos Biome is also a matter of contention. Kruger's definition of the Fynbos Biome (Moll, Hilton-Taylor & Jarman, 1984a) corresponds geographically to Capensis of Werger (1941) and includes Strandveld, however Goldblatt (1978) excluded Strandveld from his concept of 'fynbos' vegetation types.

Moll et al. (1984) are of the opinion that the Cape Floristic Kingdom has three distinct components of different age: 1. Fynbos 2. A component with affinity to both Cape and Palaeotropic Kingdoms 3. A component with strong Palaeotropic affinity, which has a strong winter-rainfall bias and Karoo-Namib affinity, but does include Cape endemic genera (this would include the Strandveld of the west coast). They propose that Strandveld is part of the Cape-Palaeotropical Floral Kingdom Transition, since it comprises both Cape and non-Cape elements. Their main reason

for placing it in Cape Transitional shrublands is the widespread occurrence of Restionaceae. In the south-eastern Cape, Dune Thicket has been described as a Subtropical Transitional thicket because of the dominance of species of Tongaland-Pondoland origin (Cowling, 1983). On the west coast some of these elements persist, such as _Olea_ _exasperata,_ _Euclea_ _racemosa_ and _Rhus_ spp. Cape elements such as Restionaceae and _Ehrharta,_ and Karoo-Namib elements, such as _Zygophyllum,_ _Pteronia,_ _Nylandtia,_ _Lycium,_ _Tylecodon_ and many of the geophytes, are more prominent (Tinley, 1985; Moll, Hilton-Taylor & Jarman, 1984b). A few Afromontane elements also occur, for example _Myrsine_ _africana_ and _Pterocelastrus_ _tricuspidatus_ (Taylor, 1979). Endemic west coast species include _Cladoraphis_ _cyperoides,_ _Didelta_ _carnosa_ _subsp._ _tomentosa_ and _Manulea_ _tomentosa,_ all of which have their southern limit in False Bay (Boucher & le Roux, in press). Strandveld also contains genera common in Capensis but with their maximum concentrations in Namaqualand; _Babiana,_ _Osteospermum,_ _Carpobrotus,_ _Erepsia,_ _Zygophyllum_ and _Crassula._

Acocks (1953) had previously defined Strandveld as a Karroid veld-type, intermediate between Coastal Fynbos and Succulent Karoo. He considered Strandveld to be Karroid due to the succulent nature of the vegetation and the number of species of Karroid affinity. Strandveld shares many species with Succulent Karoo, which in the north is immediately adjacent to it. Taylor (1978) felt that West Coast Strandveld had a close similarity to Sundays River Scrub. This is presumably as a result of the many Karroid species in both of these two vegetation types. In similar vegetation at low altitudes in the Gamtoos valley succulents of the genera _Euphorbia,_ _Crassula,_ _Senecio_ and _Zygophyllum_ occur (Cowling & Campbell, 1983), all of which are associated with West Coast Strandveld.

It is difficult to place boundaries differentiating the various parts of what is essentially a continuum. It is suggested here that south of the Olifants River mouth West Coast Strandveld can probably be divided into two sections on the basis of species composition, growth-forms and phytogeographic affinity. North of the Olifants River Strandveld is restricted to a very narrow belt along the coast, and could be considered as a third form of West Coast Strandveld. Several species common along the coast further south do not extend into this area, for example, Chrysanthemoides monilifera (Neser & Morris,1984). Similar north-south gradations, from evergreen sclerophyllous shrublands in semi-arid mediterranean climates to drought-deciduous shrublands in arid mediterranean climates, occur in the coastal shrublands of Chile (Rundel, 1981) and California (Westman, 1983). In these regions different plant formations are recognised.

2.7 CONSERVATION STATUS

In a 1974 survey of the conservation of various vegetation types it was found that only between 1 and 5% of Strandveld was conserved (Edwards, 1974). Of the four conservation areas existing at the time for this veld type, only Rocher Pan was believed to be guaranteed permanence, being administered by the Province (Boucher & Jarman, 1977). Recent statistics (Jarman, 1986) show that about 192 000 ha of Strandveld remain on the West coast, of which protected areas (including dune areas administered by Forestry) comprise 12.5% (approximately 24 000 ha) (Table 2.11). Some areas, however, consist of vegetation that is in poor condition.

47

TABLE 2.11 EXISTING PROTECTED AREAS ON THE WEST COAST
          (Modified from Jarman, 1986)

NAME	OWNER-SHIP	TOTAL AREA	AREA OF STRANDVELD			STATE OF VELD
			sand	granite	limestone	
Rocher Pan Nat.Res.	CPA	390	220			good
Sandveld For. Res.						
Elands Bay	DEA	392	392			poor
Ysterfontein	DEA	3037	3037			poor
Columbine Nat.Res.	LA	263	100			good
Postberg Nat.Res.	P	2701	400	1000	1100	fair
Langebaan Nat. area	NPB	22375	15700	1425		good

The soils of the Strandveld area are less suited to crop cultivation and
hence the vegetation is in better condition that areas inland, although
the influence of burning and grazing the veld is evident. Large areas of
the remaining natural vegetation are heavily grazed. Overgrazing and
trampling cause changes in the structure and composition of the
vegetation.   Grasses and palatable shrubs get grazed out and succulents,
annuals and unpalatable dwarf shrubs of take over.   Some of the effects
of overgrazing can be seen at Nortier Experimental Farm, Lambert's Bay.
The _Hermannia_ _pinnata_ community at Langebaan is suggested by Boucher &
Jarman (1977) to be the result of heavy grazing.   They also found that
plant cover was reduced from 95% to 30% by heavy grazing.

A recent compilation of the endangered plants (Hall & Veldhuis, 1985)
shows that in West Coast Strandveld there are on average 31 threatened
plant species and 1-6 endangered plant species (Table 2.12).   The major
threat to plants in Strandveld are agriculture and aliens in the south
and overgrazing in the drier north.

TABLE 2.12   RARE PLANTS OF WEST COAST STRANDVELD
      (Modified from Hall & Veldhuis, 1985)

SPECIES

rare	vulnerable	endangered	extinct
Agathosma thymifolia	Athanasia rugulosa	Agathosma corymbosa	Agathosma glabrata
Aloe distans	Calopsis impolitus	Chondropetalum acockii	
Echiostachys spicatus	Chondropetalum rectum	Hermannia procumbens	
Hessea leipoldtii	Diosma aspalathoides	subsp procumbens	
Ixia purpureorosea	Diosma dichotoma	Lachenalia purpurea-	
Leucadendron brunioides	Elegia verreauxii	caerula	
var flumenlupinum	Erica ferrea	Moraea loubseri	
Leucospermum arenarium	Euphorbia marlothiana	Relhania rotundifolia	
Moraea elsiae	Felicia elongata	Serruria aemula	
Nemesia strumosa	Galaxia alata		
Serruria trilopha	Geissorhiza mathewsii		
Thesium litoreum	Hessea chaplinii		
Tylecodon fragilis	Hessea mathewsii		
	Ischyrolepis duthiae		
	Ixia curta		
	Leucospermum tomentosum		
	Limonium acuminatum		
	Romulea saldanhensis		
	Serruria linearis		
	Stapelia nouhuysii		
	Steirodiscus speciosus		
	Stoebe gomphrenoides		

A habitat which is particularily vulnerable to grazing pressure is the
pioneer littoral community. This is usually palatable and nutritious and
often heavily grazed, leading to thinning of cover (Taylor, 1978).
Surface fresh water would be a major attraction to animals in the
relatively waterless environment of the west coast. Dune slacks often
provide temporary sources of fresh water. Trampling by animals makes

49

openings in the vegetation and effects subsequent dune dynamics. Many of the dune fields landwards of frontal dune systems were initiated by white farming in the last 100 years (Tinley, 1985) as a result of grazing and burning of the vegetation.

Another vulnerable habitat along the coast is the vlei/pan habitat, which is also threatened by grazing and trampling, as well as by cultivation. Wind erosion is a big problem where over-grazing has lead to reduction in cover.

Exotic woody species have invaded Strandveld to varying degrees in different areas. Australian _Acacia_ spp. are the predominant menace (Boucher, 1984). In the south infestations can be very dense, but in the drier north acacia infestation is scattered. Along most of the coast the threat from alien vegetation is associated with plantings of _Acacia cyclops_ to stabilize drift sands. Tinley (1985) suggests that dune fields need to be assessed and only stabilised if they present a direct threat to something. Ideally indigenous strand species should be used.

Exploitation pressures other than farming activities include roads, railways, holiday settlements, recreational pressure as well as commercial fishing and mining (in the north). Wood fuel gathering is also a problem and has in arid areas lead to the reduction of scrub species.

Concern over the conservation status of the lowlands lead to the decision by the Fynbos Biome Steering Committee of the CSIR's Foundation for Research Development to draw up plans to initiate conservation in this region. Numerous sites along the west coast lowlands were studied and

assessed with regard to such factors as size, shape, habitat diversity, species richness, abuse, threatened flora, exotic invasion, rarity of plants (Jarman, 1986). Of the 34 sites examined along the west coast only six are existing protected areas and only Rocher Pan scored high (>50) in the assessment. It seems that the conservation objective of preserving representative portions of ecosystems has not been achieved (Jarman, 1986). The two highest scoring sites in the region are Verlore Vlei coastal lake and the Langebaan-Hopefield area (Table 2.13). These have been recommended as high priority sites for conservation (Jarman, 1986). A Sandveld National Park has been proposed stretching from Bok Bay to Langebaan and inland as far as Hopefield. This would then conserve wetlands, coast, Strandveld, Coastal Fynbos and a dune plume.

TABLE 2.13   PRIORITY RANKING OF PROPOSED AND EXISTING
             CONSERVATION SITES.

Ranking   Site

 1   Langebaan-Hopefield Park
 2   Verloren Vlei
 3 * Rocher Pan
 4   Olifants River Estuary
 5   Wadrif Salt Pan
 6   Saldahna Navy Area
 7 * Postberg
 8 * Sandveld For. Res. Ysterfontein
 9   Lambert's Bay Common
10 * Columbine Nat. res.
11 * Sandveld For. Res. Elands Bay
12 * Lambert's Bay Nat. Res.

 * Existing protected sites.

Tinley (1985) has identified the same two areas as high priorities, but considers Verlore Vlei, Elands Bay dunes and Wadrifsoutpan to be a unit. He also recommends that the Dwarskersbos parallel dune ridges, the only parallel dune ridges on the west coast, be considered for conservation, together with the Berg River estuary.

It has been recommended by Jarman (1986) that all sites scoring >50 in the survey deserve priority consideration for conservation and that research is needed on many sociological, financial and legal aspects of encouraging conservation. The potential failure of conservation in the lowlands as a whole necessitates a re-assessment of future financial commitments by all conservation agencies.

2.8 CHAPTER SUMMARY

West Coast Strandveld is a mediterranean-type shrubland comprising both Cape and non-Cape floristic elements, and it is therefore regarded as a Cape Transitional Shrubland by Moll et al. (1984). It characteristically consists of fairly dense thickets of evergreen, sclerophyllous, broad-leaved shrubs in the south, and more open, drought-deciduous and succulent shrubland in the north. That the shrubland of the Cape west coast differed from other vegetation types in the south-western Cape was already recognised early in this century by Marloth (Boucher & Jarman, 1977). Subsequent descriptions have differed principally in the boundaries of this west coast shrubland.

The primary factors influencing the distribution of West Coast Strandveld are the pattern of rainfall and soil nutrients. In the north fog plays an important role.

There are two major environmental gradients in Strandveld: perpendicular to each other. These result in a set of successionally related communities that changes from south to north. Pioneer Littoral Vegetation occurs on unconsolidated sand immediately adjacent to the high water mark, and comprises principally pioneer herbs and grasses - notably *Eragrostis cyperoides*. Successional Littoral Dune Vegetation occurs inland to the pioneer community, on partly stabilised sand. It consists of both pioneer herbs and grasses, and shrubs that become canopy species of the climax scrub. Coast scrub is the climax vegetation of West Coast Strandveld, occurring on stable dunes and older sands. Broad-leaved, evergreen shrubs are dominant. Characteristic species are *Euclea racemosa* and *Pterocelastrus tricuspidatus*.

Plant communities change in composition and structure from south to north, along the gradient of diminishing rainfall. There is a general decrease in height and cover northwards, and an increase in spinescence, succulence and drought-deciduousness.

There is a large variety of growth forms in Strandveld.

There have been some differences of opinion regarding the phytogeographical affinities of Strandveld and the boundaries of phytogeographic regions along the west coast. The west coast is a zone of transition and the vegetation contains elements of several floras. Werger (1978) places the west coast up to St. Helena Bay into the Capensis region and that part of the coast north of St. Helena Bay into the Western Cape domain of the Karoo-Namib region. Others have considered the Olifants River mouth to be the boundary of the Capensis

vegetation. Strandveld has also been considered to be a karroid
vegetation type.

Only a small proportion of West Coast Strandveld has been conserved.
This vegetation has suffered less clearing for cultivation of crops than,
for example, Renosterveld has, but much of the vegetation is not in a
good state. There are relatively few rare and endangered species. The
most sensitive areas ecologically are the dunes. A number of sites have
been recommended as priorities for conservation, of which the two most
important are the Langebaan Lagoon - Hopefield and the Verlore Vlei
areas.

2.9 REFERENCES

ACOCKS JPH 1953. Veld-types of South Africa. Memoirs of the Botanical
Survey of South Africa No. 28.

ADAMSON RS 1938. The vegetation of South Africa. London: British
Empire Vegetation Committee.

BEWS JW 1916. An account of the chief types of vegetation in South
Africa, with notes on the plant succession. The Journal of Ecology 4:
129-159.

BOUCHER C 1974. Dune vegetation in the south-western Cape. Veld &
Flora 4(4): 67-69.

BOUCHER C 1981. Unpublished talk prepared for SABC.

BOUCHER C 1982a. Some thoughts about the West Coast Strandveld
vegetation. Veld & Flora 68(4): 108-109.

BOUCHER C 1982b. Floristic and structural features of the coastal
foreland vegetation south of the Berg River, western Cape province, South
Africa. IN: Proceedings of a symposium on coastal lowlands of the
Western Cape. ed. EJ Moll. University of the Western Cape.

BOUCHER C 1984. Patterns of invasion by larger woody alien species in
selected areas of the Fynbos Biome, South Africa. IN: Proceedings of
the 4th International Conference on Mediterranean Ecosystems. University
of Western Australia.

BOUCHER C & JARMAN ML 1977. The vegetation of the Langebaan area, South Africa. Transactions of the Royal Society of South Africa 42(3): 241-272.

BOUCHER C & LE ROUX A (in press). Dry Coastal Ecosysytems: South African West Coast Strand Vegetation.

BOUCHER C & MOLL EJ 1981. South African Mediterranean Shrublands. IN: Ecosystems of the world 11. Mediterranean-type Shrublands, eds Di Castri F, Goodall DW & Specht RL. Amsterdam: Elsevier. pp 233-248.

COWLING RM 1983. Diversity relations in Cape shrublands and other vegetation in the southeastern Cape, South Africa. Vegetatio 54:103-127.

COWLING RM & CAMPBELL BM 1983. A comparison of fynbos and non-fynbos coenclines in the lower Gamtoos River valley, southeastern Cape, South Africa. Vegetatio 53:161-178.

DEAN S 1985. Unpublished report on the vegetation of Verlore Vlei and its catchment area.

DEPARTMENT OF AGRICULTURE AND FISHERIES 1985(a). Agricultural Development Program: Swartland sub-region, Winter Rainfall Region. Elsenburg.

DEPARTMENT OF AGRICULTURE AND FISHERIES 1985(b). Agricultural Development Program: North-western Sub-region, Winter Rainfall Region. Elsenburg.

DOWNING BH & VAN DER MERWE P ND. Veld grazing studies at the Nortier experimental farm, including a vegetation map of the farm. Winter Rainfall Region Project Report W-NT 1,2.

EDWARDS D 1974. Survey to determine the adequacy of existing conserved areas in relation to vegetation types. A preliminary report. Koedoe 17: 2-37.

FUGGLE RF & ASHTON ER 1979. Climate. IN:Fynbos ecology: a preliminary synthesis, eds J Day, WR Siegfried, GN Louw & ML Jarman South African National Scientific Programmes Report No. 40, Pretoria: CSIR. pp. 7-15.

GOLDBLATT P 1978. An analysis of the flora of southern Africa; its characteristics, relationships and origins. Annals of the Missouri Botanic Garden 65: 369-436.

GRINDLEY JR, LANE SB & ROBERTSON HN 1980. The environment and ecology of Verlorevlei. IN: Verlore Vlei, a challenge to conservation. Cape Town: University of Cape Town.

HALL AV & VELDHUIS HA 1985. South African Red Data Book: Plants - Fynbos and Karoo Biomes. South African National Scientific Programmes Report No. 117, Pretoria: CSIR.

JARMAN ML (ed) 1986. Conservation priorities in lowland regions of the fynbos biome. South African National Scientific Programmes Report No. 87, Pretoria: CSIR.

LAMBRECHTS JJN 1979. Geology, geomorphology and soils. IN: Fynbos ecology: a preliminary synthesis, eds J Day, WR Siegfried, GN Louw & ML Jarman. South African National Scientific Programmes Report No. 40, Pretoria: CSIR. pp 16-26.

LOVEGROVE BG & SIEGFRIED WR 1986. Distribution and formation of mima-like earth mounds in the western Cape Province of South Africa. South African Journal of Science 82: 432-436.

MACVICAR CN, DE VILLIERS JM, LOXTON RF, VERSTER E, LAMBRECHTS JJN, MERRYWEATHER FR, LE ROUX J, VAN ROOYEN TH & VON HARMSE HJ 1977. Soil classification. A binomial system for South Africa. Pretoria: Department of Agricultural Technical Services.

MOLL E J, CAMPBELL B M, COWLING R M, BOSSI L, JARMAN M L & BOUCHER C 1984. A description of major vegetation categories in and adjacent to the Fynbos Biome. South African National Scientific Programmes Report No. 83, Pretoria: CSIR.

MOLL EJ, HILTON-TAYLOR C & JARMAN ML 1984a. Exactly what is the Cape Floristic Kingdom? IN: Proceedings of the 4th International Conference on Mediterrnaean Ecosystems, University of Western Australia. p 113.

MOLL EJ, HILTON-TAYLOR C & JARMAN ML 1984b. Where are the Cape's mediterranean shrublands? IN: Proceedings of the 4th International Conference on Mediterranean Ecosystems, University of Western Australia. p 115.

NAGEL JF 1962. Fog precipitation measurements on Africa's Southwest coast. Notos 11: 51-60.

NESER S & MORRIS MJ 1984. Preliminary observations on natural enemies of Chrysanthemoides monilifera in South Africa. IN: Bitou bush and Boneseed. Proceedings of a conference on Chrysanthemoides monilifera. eds A Love & R Dyason. National Parks and Wildlife Service/ Department of Agriculture New South Wales.

POLE EVANS IB 1936. A vegetation map of South Africa. Botanical Survey of South Africa Memoir No. 15. Pretoria: Department of Agriculture & Forestry.

PUTTICK G & GLYPHIS J 1980. Herbivory studies in a Strandveld community. Final Report, Fynbos Biome Project, CSIR. (unpublished).

RUNDEL PW 1981. The matorral zone of Chile. IN: Ecosystems od the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Elsevier: Amsterdam - Oxford - New York. pp 175-202.

SCHLOMS HA, ELLIS F & LAMBRECHTS JJN 1983. Soils of the Cape coastal platform. IN: Fynbos palaeoecology: a preliminary synthesis. eds HJ Deacon, QB Hendey & JJN Lambrechts. South African National Scientific Programmes Report No. 75, Pretoria: CSIR. pp 70-86.

SCHULTZ RE & MCGEE OS 1978. Climatic indices and classifications in relation to the biogeography of southern Africa. IN: Biogeography and Ecology of southern Africa, ed MJA Werger The Hague:Junk. pp 19-52.

SLABBER MH 1930. Die uitruilbare basisse in Malmesbury lei-gronde. South African Journal of Science 27: 270-299.

SPECHT RL & MOLL EJ 1983. Mediterranean-type heathlands and sclerophyllous shrublands of the world: and overview. IN: Mediterranean-type Ecosystems. The role of nutrients, eds FJ Kruger, DT Mitchell & JUM Jarvis New York:Springer-Verlag.

TAYLOR HC 1978. Capensis. IN: Biogeography and Ecology of southern Africa, ed MJA Werger The Hague:Junk. pp 171-229.

TAYLOR HC 1979. Phytogeography. IN: Fynbos ecology: a preliminary synthesis, eds J Day, WR Siegfried, GN Louw & ML Jarman. South African National Scientific Programmes Report No. 40, Pretoria: CSIR. pp 70-81.

TINLEY KL 1985. Coastal dunes of South Africa. South African National Scientific Programmes Report No. 109, Pretoria: CSIR.

WEIMARCK H 1941. Phytogeographical groups, centres and intervals within the Cape flora. Lunds Universiteits Arrskrift 2, 37(5):1-43.

WERGER MJA 1978. Biogeographical divisions of southern Africa. IN: Biogeography and Ecology of southern Africa, ed Werger MJA The Hague: Junk. pp 145-170.

WESTMAN WE 1983. Xeric mediterranean-type shrubland associations of Alta and Baja California and the community/continuum debate. Vegetatio 52: 3-19.

WITKOWSKI ETF, MITCHELL DT & BROWN G 1984. Variations in soil phosphorus in the fynbos biome, South Africa. IN: Proceedings of the 4th International Conference on Mediterrnaean Ecosystems, University of Western Australia. p 169-170.

3. WEST COAST STRANDVELD AS NATURAL PASTURE - ITS EXPLOITATION AND MANAGEMENT

3.1 INTRODUCTION

In order to better understand what Strandveld is today, we need to know something of its past and present exploitation. The western Cape lowlands have been subject to major human influences since prehistoric times.   Hunter-gatherers used the resources available to them with probably little long-term effect.   However, the arrival of cattle- and sheep-herding people in the area about 2000 years ago must have had dramatic effects on the vegetation.   Grazing and burning of the vegetation would have influenced both the composition and structure of the plant communities.

Both the Khoi and the European used Strandveld primarily for grazing domestic animals.   The vegetation has a high proportion of palatable species and has an adequate nutritional value for the most part, though a copper deficiency is a problem in some areas (Brock, 1959; Terblanche, 1966).

3.2 PREHISTORIC PASTORALIST USE OF STRANDVELD

Evidence from archaeological sites in the western and southern Cape points to the presence of sheep and cattle in these regions from about 2000 years ago.   It has been suggested that the arrival of sheep in the Cape preceded that of cattle (Deacon, 1983; Deacon, 1984; Deacon et al., 1978).   In the south-western Cape the earliest known remains of sheep are from deposits dated to about 1860 B.P. (Schweitzer, 1974).   Sheep remains have been found in more recent deposits at a number of sites in

the western Cape, including Diepkloof, Tortoise Cave and Elands Bay Cave
in the vicinity of Verlore Vlei (Deacon, 1984) and Kasteelberg, close to
present-day Vredenburg (AB Smith, pers. comm.). Positively identified
cattle remains are rare in sites, and most come from more recent
deposits, but at Kasteelberg cattle bones have been recovered from
deposits dated to 1860 ± 60 B.P. (Pta-3711), the earliest known
occurrence in the Cape (AB Smith, pers. comm.).

Early travellers to and settlers in the Cape described cattle-keeping
people in the coastal areas of the western Cape, sometimes with large
numbers of animals (Thom, 1952; Raven Hart, 1967). These people,
Khoikhoi, moved around with their stock from place to place as grazing in
one area was used up. Large numbers of stock would be concentrated in
limited areas for short periods leading to non-selective grazing. This
would have had the effect of reducing the potential for over-grazing of
the more palatable species (Deacon, 1984).

The patterns of Khoikhoi movements are not altogether clear from the
records, but would have been dictated by the need for food and water for
their animals. On the lowlands of the west coast they appear to have
moved in a transhumant cycle from the interior of the plains in summer to
the coast in winter. Smith (1984) suggests that the nutrient
deficiencies inherent in the vegetation of certain areas and water
availability were the driving factors behind this movement. It has also
been suggested that during the wet winter months the Khoikhoi dispersed
across the landscape with their cattle, but congregated in the dry summer
months along rivers and areas of permanent water (Elphick, 1985).
Historical evidence of seasonal transhumance is ambiguous, since there
must have been some change in movements after contact with the Europeans,

particularly after the setting up of the settlement at the Cape.

From early reports it appears that the Khoikhoi used fire as a pasture

management tool (Sparrman, 1785; Thunberg, 1795; Thom, 1952) and that

early European stock-farmers learned the practice from them (Botha,

1924).

3.3 THE ESTABLISHMENT OF STOCK FARMING ON THE WEST COAST

With the establishment of the settlement at Table Bay, the exploitation

of the pasture resources of the west coast took on a new pattern. One

of the objectives of the Dutch East India Company at the Cape was to

aquire its own herds, thus putting it in competition with the Khoi for

pasture resources, at least in the vicinity of Table Bay. It is clear

from van Riebeeck's journal that the area around Table Bay and even near

the fort were traditional Khoi grazing areas (Thom, 1952). The impact of

European intrusion into the traditional pasture areas of the Khoi was to

lower the carrying capacity of the land for these pastoralists.   At

first the Company had a monopoly of the cattle trade and the intrusion

into Khoi pasture areas was localised. However, farming activities were

soon established on the Peninsula and in adjacent areas, including the

Ysterfontein/Darling and Saldanha areas north of Table Bay. A farm was

already established at Green River (Darling area) in 1705 (Valentyn,

1971).

At the end of the seventeenth century the cattle trade was opened to the

burghers, with two important consequences. 1. The numbers of stock owned

by Europeans increased dramatically 2. Many colonists moved north and

east in search of grazing lands for their stock, and because they were

dissatisfied with the Company (Botha, 1970).

Beyond the Berg River farming was primarily involved with pastoral production, since the climate and distance from Cape Town made other agriculture unfeasible. Cattle and sheep breeding became the occupation of a large proportion of these burghers. In 1703 the first land was loaned out for the grazing of stock (van der Merwe, 1926). The first trek boers went to look for grazing land at those places known to be good hunting spots. Several expeditions undertaken to the north previously had reported areas with suitable grazing and water (Thom, 1952; Valentyn, 1971). Water was an important factor in the location of the loan-farms. During the period 1700-1704 rainfall was low (Penn, 1986) so that the best places in the arid coastal plains would have been readily apparent. These places would have been adjacent to springs and rivers, which would have been the same places the Khoi would fall back on in drought periods leading to competition with the Khoi for resources and ultimately to conflict.

Grazing farms came into being well to the north of the Cape settlement very early on. At Verlore Vlei grazing loan farms were first given out between 1712 (Penn, 1986) and 1717 (Sinclair, 1980). By 1724 loan farms were well established on the west coast: along the Berg River, in the Saldahna Bay area and along the Verlore Vlei River. Not long after, farms were established at the southern edge of the Piketberg and behind the mountains on the edge of the Sandveld, as well as along the Langrivier and Jakkalsrivier (Mossop, 1947).

Nearer the Cape the Dutch East India Company had begun to notice the poor condition of the cattle as a result of the decline in the pasturage.

Private persons on farms next to Company farms were moved off so that the Company could have more grazing. This lead to even more competition for land further north and consequently more pressure on the vegetation and more conflict with the Khoikhoi. By 1728 there are reports of major conflict between graziers and Khoikhoi in the Jakkalsvlei and Langrivier areas, after a severe drought that winter (Penn, 1986).

By 1739 colonists had control of all pastoral land south of Namaqualand (Penn, 1986) and by the end of the eighteenth century stock-farming was well established (Mossop, 1947). Statistics for the Cape and Stellenbosch Districts show that in 1798 there were 110 and 689 loan farms in those districts respectively. (Barrow, 1968)

Loan farms were at first not proper farms, but simply centres of grazing activity. Some of the boers had no fixed homes and used to move around the country in groups, until overgrazing and water problems lead to more exclusive ideas of ownership as well as to increased competition (Penn, 1986). Many of the west coast loan farms were also not occupied by the lessees, who merely kept stock on them tended by their sons or Khoikhoi herders (Botha, 1970). The farms could neither be bought, sold or inherited. All this would have contributed to lack of care for the land.

The severe overgrazing which occurred is recorded by some of the eighteenth century travellers (Lichtenstein, 1928; Barrow, 1968). The main problems with loan farms, as indicated by van der Merwe (1926), were firstly, that the land was colonised without plan or order, and secondly, it was unclear where farms extended to and which land had simply been annexed. In 1715 the loan periods were extended from 1 to 15 years, which would undoubtedly have lead to a greater security of tenure,

and better development and care of the land. In 1732 a system of perpetual loan was instituted. Early in the nineteenth century the British began to survey farms and introduced a system of quit-rent (Bird, 1966), and later began selling the farms (Sinclair, 1980).

The cattle trade with the Khoi had at first been the monopoly of the Dutch East India Company, but towards the end of the seventeenth century the trade was opened to the burghers. This lead to dramatic increases in stock numbers owned by Europeans; from 2951 in 1687 to 13 000 in 1705 and about 80 000 at the end of the eighteenth century (Barrow, 1968). Statistics for 1798 on the agricultural exploitation of the Cape district, (which was that area including the Peninsula and the strip of land about 25 miles wide up the west coast as far as Berg River mouth), showed that less than 1/15 of surface was ploughed, and the main products of the west coast were wheat, barley, pulses and wine. There were 20 957 cattle and 61 575 sheep and goats in the district (Barrow, 1968), which gives average stocking densities of 10 head of cattle and 30 head of small stock per square mile (roughly equivalent to 1 LSU/20 ha). There is some unresolved discrepancy between these figures and others from the same period (de Mist, 1920; Van Ryneveld, 1942). Much of the areas further north along the coast were under loan-farms. Tax returns for these areas are incorporated into the figures for the whole district of Stellenbosch and it is not possible to obtain statistics only for the coastal region.

At the beginning of the nineteenth century most of the stock owned by Europeans was of indigenous Khoi origin. In 1804 van Ryneveld (1942) recommended the development of improved wool-sheep and cattle breeds.

The potential effects of this move relate primarily to the fact that European sheep and cattle breeds were less well adapted to the conditions and to the type of grazing available. Also it is known that merinos are more eclectic feeders than other sheep and therefore selective grazing would undoubtedly have been more of a problem.

Pastoral farming on large land holdings, usually more than 3000 ha, was the primary land-use in most of the western coastal lowlands as a whole until about the 1880's, when grain production became important (Talbot, 1947), primarily as a result of the discovery of diamonds and gold and the building of the railway line into the interior. The Strandveld was not as affected by the increased importance of grain production and remained primarily a stock-farming area. The result is that a large proportion of the Strandveld still exists today, although it may have been altered by 2000 years of exploitation as pasture, particularly the last 250 years.

2.4 PRESENT-DAY LANDUSE AND MANAGEMENT

Agricultural land-use of Strandveld is still primarily stock-farming, with small amounts of crop production. In the south sheep, cattle and grain are important while in the north sheep are important. Crops include potatos, melons and lucerne wherever irrigation is possible. Wheat, grown under strip cultivation is no longer encouraged (Department of Agriculture & Fisheries, 1985a; 1985b).

Other forms of land-use include roads, railways, holiday settlements and recreation as well as commercial fishing and mining in the north.

.West Coast Strandveld has not suffered at the hands of agriculture as much as Renosterveld has, although in the south the pressure on the vegetation has been fairly severe and is likely to increase. Based on aerial survey data for 1972 it has been calculated that only 41% of the natural vegetation in the west Coast Strandveld south of the Berg River remains (Boucher, 1982). In the northern part of the Strandveld 92% of the land is natural grazing (Department of Agriculture & Fisheries, 1985b).

The existing vegetation is not all in satisfactory condition. Bad grazing management practices have reduced the potential of the veld (Department of Agriculture & Fisheries, 1985b). Strandveld is not very grassy today, but Acocks (1953) believed that if used properly and rested sufficiently Strandveld could become grassy. A camp removed from grazing at Nortier experimental farm lends support to this idea.

A major contributory factor to the reduced pature potential in Strandveld is that many of the farms are of uneconomic size, having been subdivided in the past. Average farm size is 1153 ha in the south and 3361 ha in the north, but between 25 and 52% of the farms are too small. 3000 ha is regarded as a minimum for a farm to be economically viable in the Lamberts Bay area (D. Frey, pers. comm., 1985). Grazing management is often ineffective, due largely to the fact that many of the camps are too large. This, together with an over-optimistic assessment of carrying capacity, has lead to the decline in veld condition (Department of Agriculture & Fisheries, 1985b).

Boucher (1981) suggests that since growth of plants in the Strandveld occurs in the wet winter months, this is the season during which stock

65

should graze the natural pastures. Grazing pressure should be removed in spring, before the onset of the dry season to give the plants a chance to flower and set seed. The impact of regular grazing in spring is evident at Nortier Experimental farm, in a camp grazed every year in spring. Many years after removing the grazing pressure the vegetation still had not recovered well.

Degradation of Strandveld vegetation leads to a replacement of scrub by shrubs, then by low inedible dwarf shrubs, perennial herbs and finally annuals (Boucher, 1982). In the north an increase in the proportional cover of succulents occurs.

Two grazing rotations have been tested in the Strandveld (Joubert, 1971); 1. a fixed rotation 4-camp system with a stocking density 1 SSU/ha, 2. a fixed rotation 27-camp system with a stocking density 6 SSU/ha. The veld deteriorated under both regimes, but only animals in the second treatment had to be fed in the summer months. The first system was therefore recommended for Strandveld. The stocking rates, however, only apply to the southern areas of Strandveld.

The carrying capacity of the veld decreases from south to north, primarily reflecting decreased biomass and increased intensity of summer drought. Duckitt (pers. comm. to Brownlie (1982)) suggests a carrying capacity for Coastal Fynbos and Strandveld of 1-2 ha/SSU (6-12 ha/LSU). The Darling soil conservation district proposed 1.7 - 2.6 ha/SSU (10-16 ha/LSU). Recommended safe stocking densities for Strandveld vegetation in the Lamberts Bay area are 4,35 ha/SSU and 25 ha/LSU (Barnard, 1982). Carrying capacities recommended by the Department of Agriculture (1985b) are: 25 - 30 ha/LSU for the south and 30 ha/LSU in the north.

66

Until 1940 pasturing was closely associated with burning of veld (Kruger & Bigalke, 1984). The early use of fire as a veld management tool is recorded by Sparrman (1785) and Thunberg (1795). Opinions vary on the frequency of fires in Strandveld in the past (Boucher, 1981; Kruger & Bigalke, 1984).

Burning of the veld is not generally recommended for Strandveld. Field tests at Bok Bay showed that burning had deleterious effects on the vegetation for the first few years after the burn, although some recovery occurred after that. Bush-slashing or removal of grazing pressure were the best ways of improving the cover of palatable grass species (Joubert, 1969). Flattening the vegetation with a roller, instead of bush-slashing, can also lead to an increase in grass cover, although in an experiment at Nortier the total canopy cover was still lower some years after the rolling than it had been before (D. Frey, pers. comm.)

3.5 IMPACT OF STOCK FARMING ON THE COMPOSITION AND STRUCTURE OF THE VEGETATION

Since Strandveld is primarily exploited for its natural pastures, the impact of man on the vegetation is perhaps not as obvious as it has been elsewhere - Coastal Renosterveld, for example. This generally leads to the assumption that Strandveld has survived relatively intact. However the continual grazing stress must have had some impact over the period of European settlement in the Cape, since the natural ungulates of Strandveld were and still are primarily browsers not grazers. Grey duiker and steenbok still occur, and grysbok, red hartebeest and eland are recorded as having been there in the past (Skead, 1980). There are

no detailed descriptions of the vegetation of the west coast from the seventeenth and eighteenth centuries but there are occasional reports of the shrubbiness of the vegetation and of plentiful grass in some areas - Verlore Vlei, Langvlei, Jakkals River (Thunberg, 1795; Barrow, 1968; Valentyn, 1971). By the late eighteenth century and early nineteenth century, the degradation of the veld was already causing concern (Sparrman, 1785; Thunberg, 1795; Lichtenstein, 1928).

One way to assess what possible changes may have occurred is to study the impact of grazing by domestic stock today.

3.5.1 NORTIER GRAZING EXPERIMENTS

In 1972 a second series of grazing trials was established at Nortier Experimental farm, near Lambert's Bay, with a view to assessing safe stocking rates, the effects on the vegetation and the economics of farming with different types of stock. The data gathered from years of surveys of the various camps provides some interesting information on the impacts of different stock mixes and stocking densities. Unfortunately these surveys did not include the important annual vegetation component.

Three grazing trials were established at first - with cattle (C26), Dorper sheep and cattle together (C&S) and Dorper sheep (S), all at stocking rates of 1 LSU/26.05 ha. In 1977 the trials were extended to include cattle (C20) at a stocking rate of 1 LSU/20 ha (above the recommended safe stocking rate), as well as goats and Merino sheep (Barnard, 1982). Each trial involved four camps, which were grazed for one month at a time (ie. once every three months).

Since the inception of the various trials at Nortier, regular, annual

1000-point surveys, along fixed lines, have been done in each of the camps used. A progress report on the trials (Barnard, 1982) concluded that although there were differences between the trials, grazing management had had a positive effect on the vegetation, with increases in both palatable and unpalatable species over the period of the experiment. Over the 10 years cattle had had the best effect on the vegetation. Total cover increased by 79% for the cattle trial (C26), as opposed to 47% for the sheep trial (S) and 33% for the sheep and cattle trial (C&S). The cover of the palatable species showed the same trend; 87% increase for C26 as opposed to 33% and 27% for S and S&C, respectively. All three trials, however, had a lower canopy cover in 1982 than the veld reserve (a camp set aside from grazing since 1965); 48%, 43.9% and 39.9% for the C26, S and C&S trials respectively as compared with 74.6% cover for the veld reserve. The trials with cattle (1 LSU/20 ha), goats and Merinos all had less positive effects on the vegetation, with large decreases occurring in the cover of the palatable species between 1977 and 1982; 55.2%, 31.8% and 57.5% decreases for the three trials respectively. Total cover was reduced by 38.7%, 18.9% and 37.7%, respectively (Barnard, 1982).

3.5.2 FURTHER ANALYSIS OF THE NORTIER DATA

The survey data from Nortier was made available to me for study by the Department of Agriculture and Fisheries. I have attempted to pick out a few more trends in the vegetation in relation to the impact of three different stock mixes (cattle, sheep and cattle, and sheep) and two different stocking densities - one safe (1 LSU/26 ha) and one too high (1 LSU/20 ha).
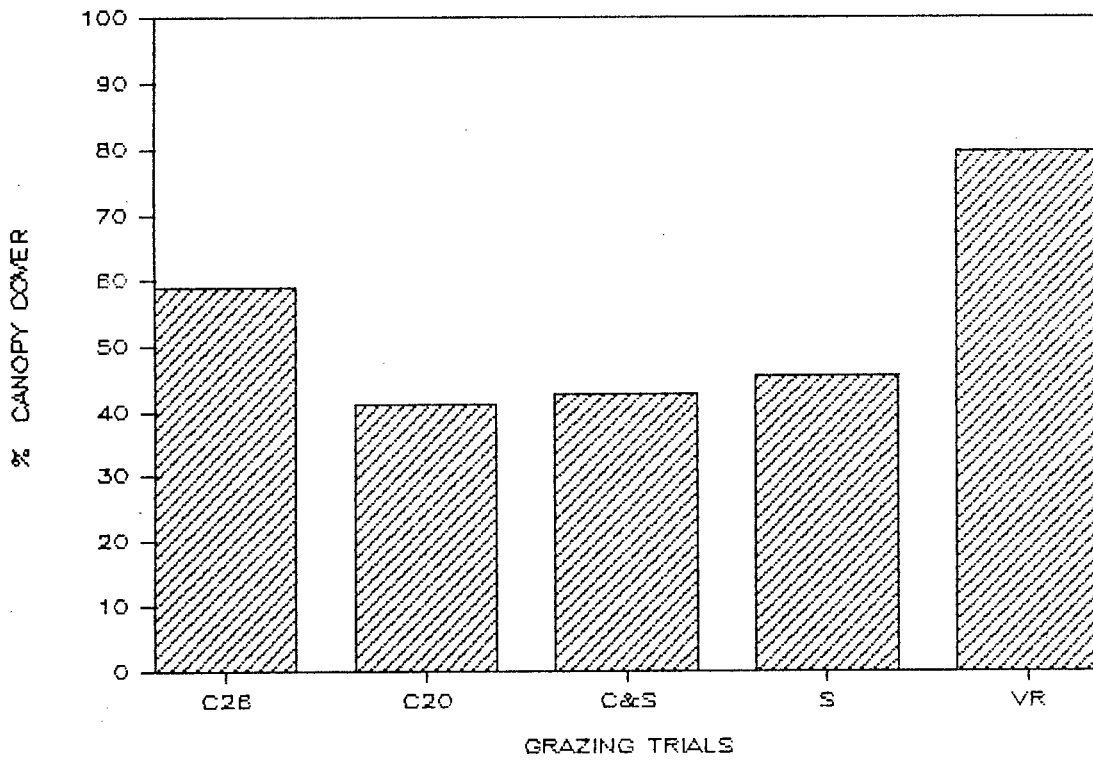
FIGURE 3.1 Total canopy cover of vegetation for four grazing trials and the veld reserve, at Nortier Experimental farm, in November, 1983.

Survey data from 1983, 11 years after the start of the experiments, confirms that cattle at the recommended stocking density are least detrimental to Strandveld vegetation. Other than in the veld reserve, the most dense vegetation (Figure 3.1) and the highest cover of palatable species (Figure 3.2), particularly grasses (Figure 3.3), occurred in the C26 trial. A higher density of cattle, a mix of sheep and cattle, and sheep all resulted in a lower total and palatable species cover, especially that of grasses. The cover of unpalatable species varied little between the trials (Figure 3.2).

A comparison of the cover of grasses (mostly the climax species *Ehrharta calycina*) and *Tetragonia fruticosa* (a pioneer shrub) in the ungrazed veld reserve gives some idea of the maturity of that vegetation (Figure 3.3) - *T. fruticosa* was a minor component of the vegetation and grass dominated. Any grazing by domestic animals has the effect of reducing the grass cover and increasing the *T. fruticosa* cover, thereby preventing the vegetation from reaching a mature successional stage. This was particularly true in the case of the S and C&S trials, for which grass cover was very low. The C20 trial is unusual in that the cover of T. fruticosa was low, yet it is obvious from other data (Figures 3.1 & 3.2) that the vegetation suffered badly from the heavy grazing. This may be the result of heavy browsing of *T. fruticosa* due to the generally low vegetation cover.
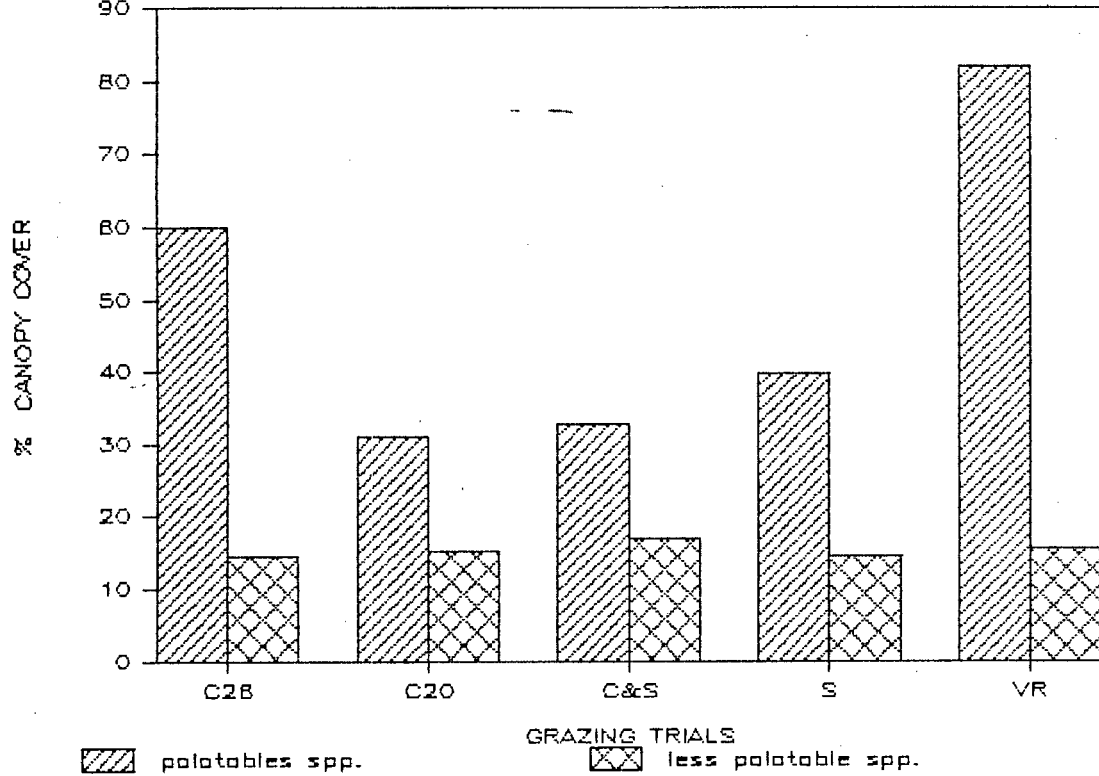
FIGURE 3.2 Cover of palatable and unpalatable species for four grazing trials and the veld reserve, at Nortier Experimental farm, in November, 1983.
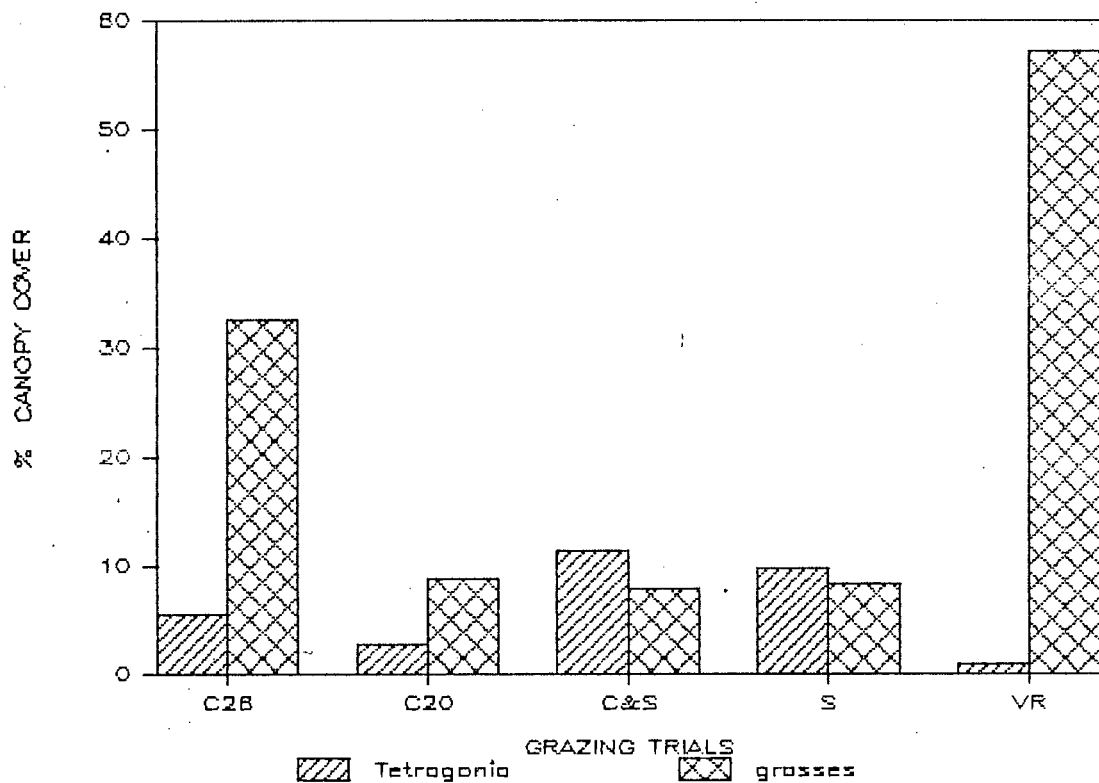

FIGURE 3.3 Cover of grass species and _Tetragonia_ _fruticosa_ for four grazing trials and the veld reserve, at Nortier Experimental farm, in November, 1983.

More interesting than a simple comparison of the resultant differences in the vegetation between the trials, is an examination of the changes that occurred over time. I would like to look more closely here at the recovery of the vegetation after the drought of 1978.

The total cover for all three trials, (C26, C&S and S) increased up to 1977 (Figure 3.4). Since it is obvious from the survey data that the vegetation was in poor condition at the start of the trials, these increases in cover are not unexpected. The vegetation cover crashed the following year, 1978, due to exceptionally low winter rainfall. (50.3 mm for April-September 1978, as opposed to a 20-year average for those six months of 90.5 mm. May-July rainfall for that year was only 20.4 mm (Weather Bureau, pers. comm.).) The ability of the vegetation to recover from a serious set-back such as a growing-season drought is dependant on the other pressures applied to it. By 1983 the vegetation cover of the veld reserve (Figure 3.12) was almost back to where it had been in 1977, as was that of the C26 trial (Figure 3.4). The rate of recovery of the vegetation cover in the C&S and S trials was much slower. Since palatable species account for a large proportion of the vegetation cover in Strandveld, the trends for palatable species cover are similar (Figure 3.6). In the C26 trial grasses recovered remarkably from the drought (Figure 3.8). Under other grazing trials the grasses have struggled to recover, although the grass cover was low before the drought anyway. Strandveld appears therefore not only to be able to withstand grazing by cattle better than that by sheep, but is also able to recover well from stressed situations such as droughts.
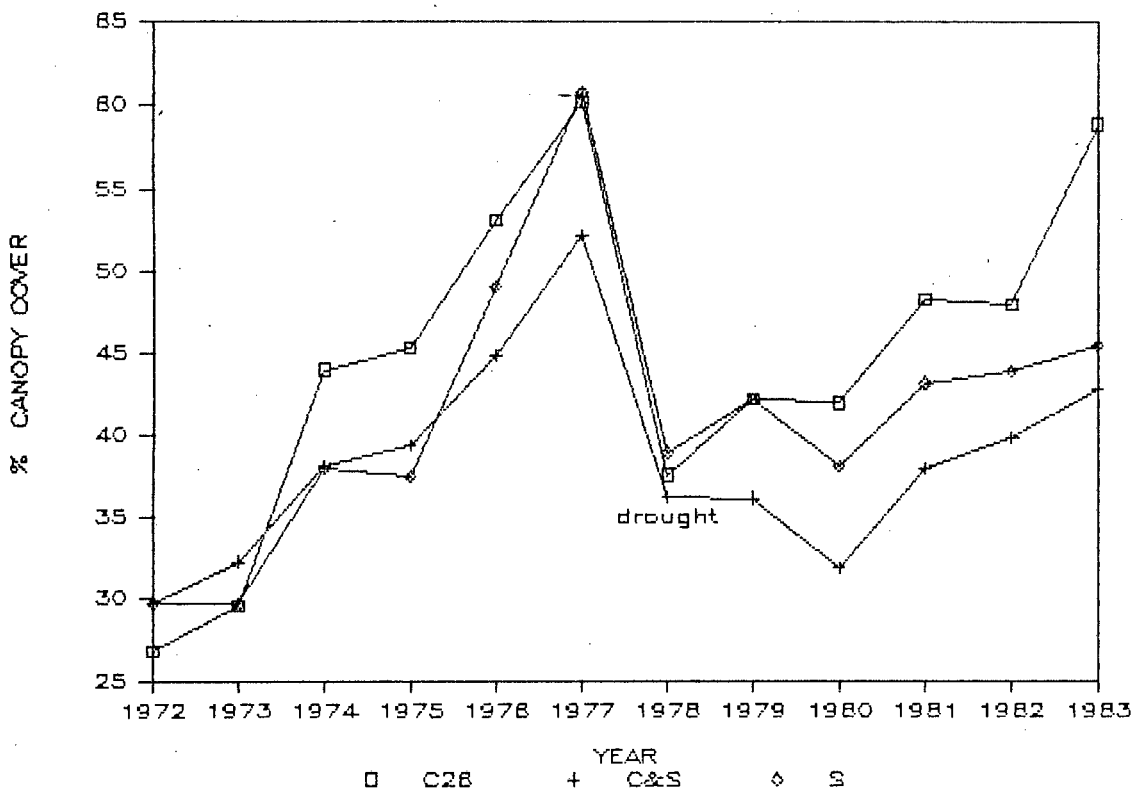
FIGURE 3.4 Total canopy cover for three grazing trials over the period 1972 to 1983. □ cattle + cattle & sheep ◇ sheep
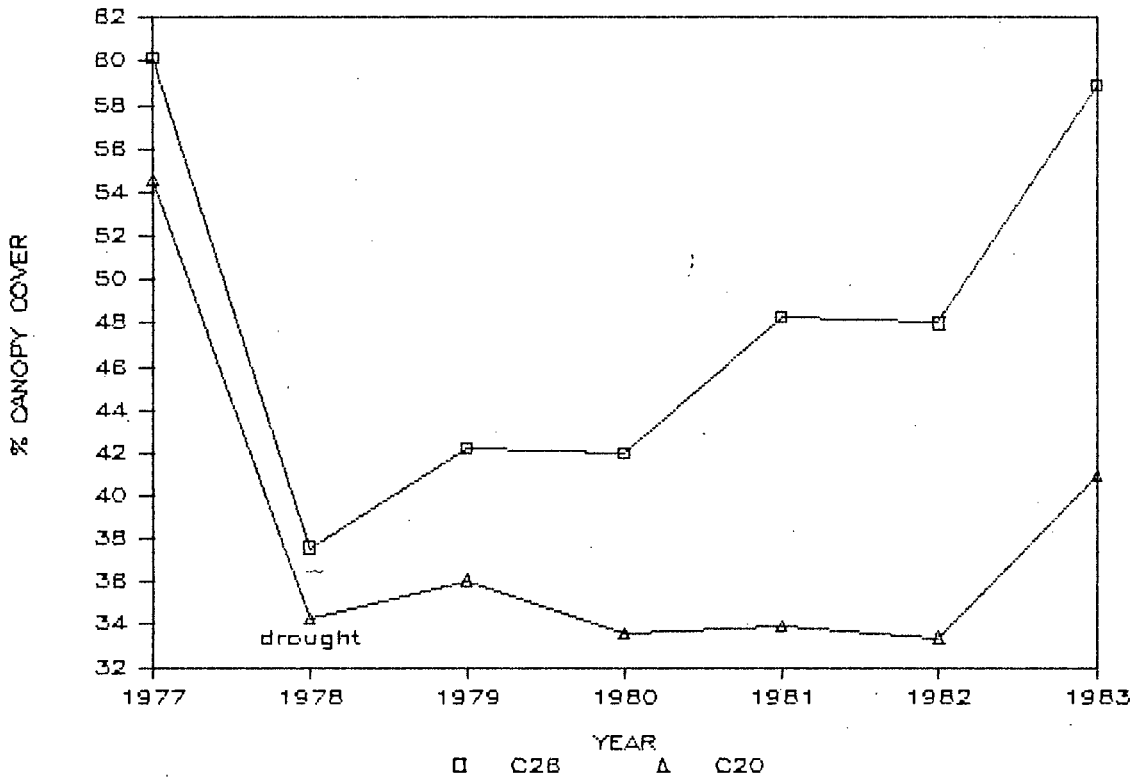

FIGURE 3.5 Total canopy cover for two different stocking densities of cattle over the period 1977 to 1983. □ 1 LSU/26 ha △ 1 LSU/20 ha
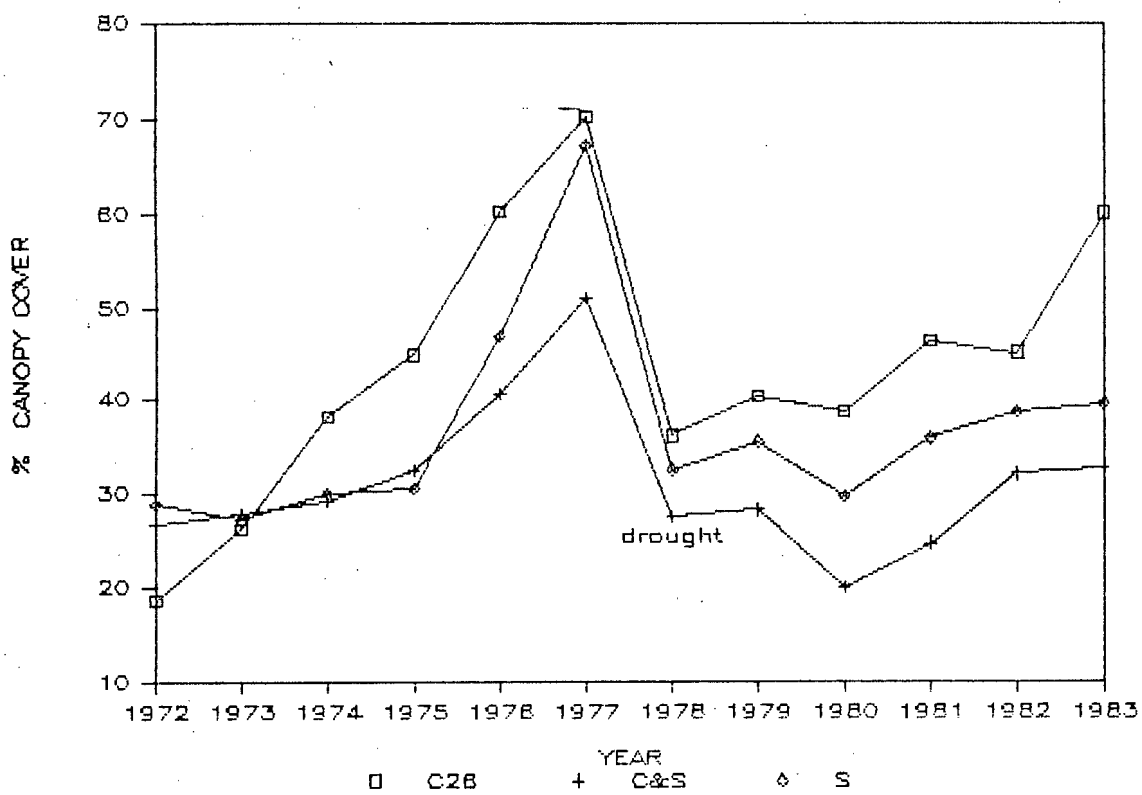
FIGURE 3.6 Cover of palatable species for three grazing trials over the period 1972 to 1983. □ cattle + cattle & sheep ◇ sheep
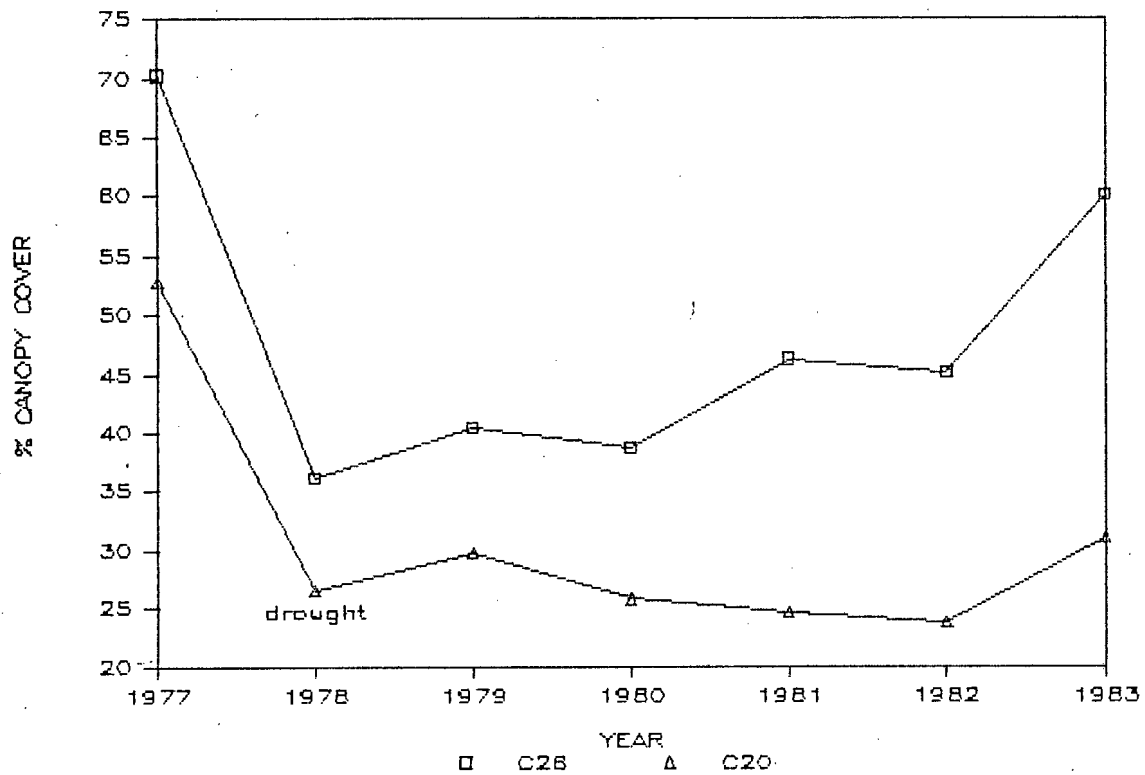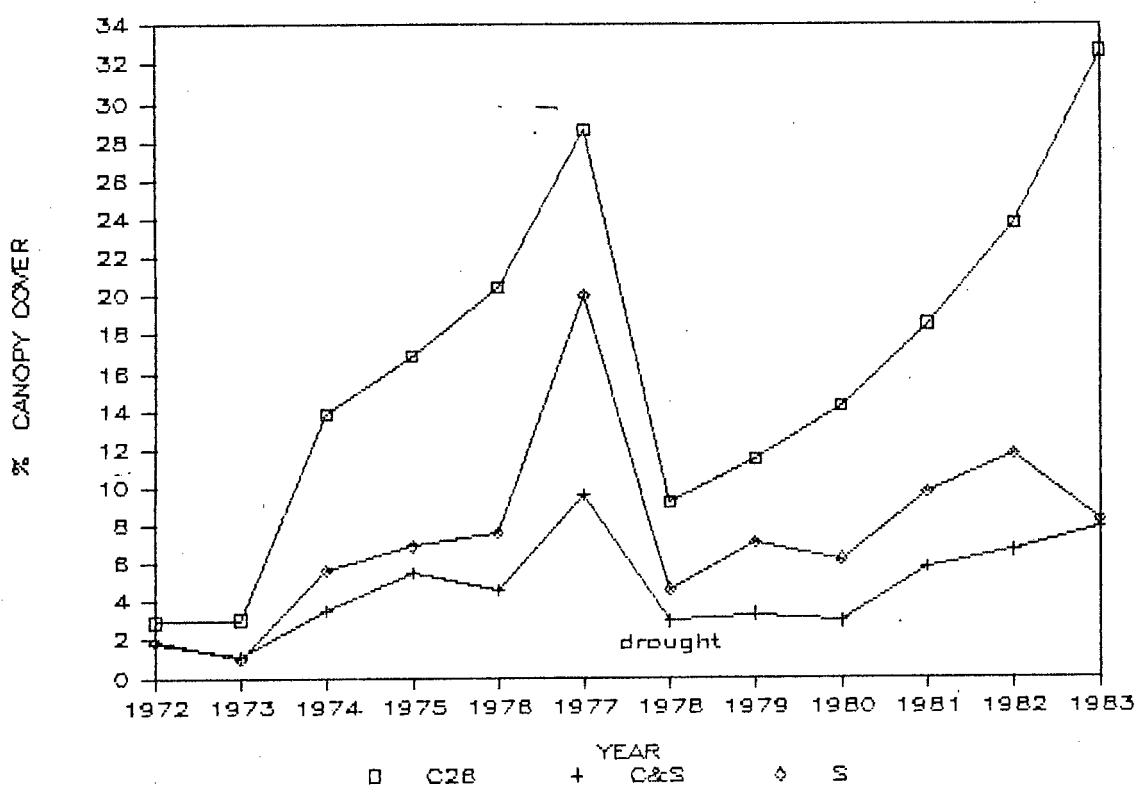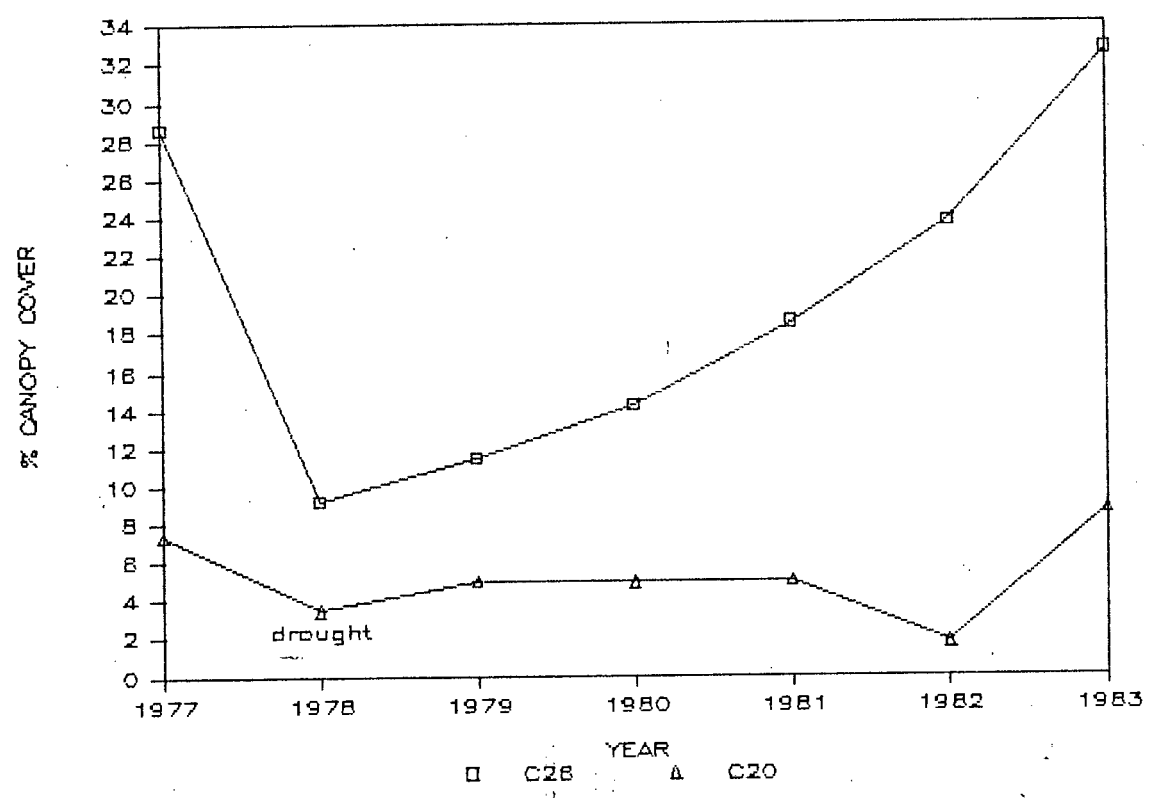

FIGURE 3.7 Cover of palatable species for two different stocking densities of cattle over the period 1977 to 1983. □ 1 LSU/26 ha △ 1 LSU/20 ha

FIGURE 3.8 Cover of grass species for three grazing trials over the period 1972 to 1983.   □ cattle   + cattle & sheep . ◇ sheep

FIGURE 3.9   Cover of grasses for two different stocking densities   of cattle over the period 1977 to   1983.
□ 1 LSU/26 ha   △ 1 LSU/20 ha

76

In the C20 trial, however, cover continued decreasing for four years after the drought (Figure 3.5) as a result of the excessive stress being placed on the vegetation. The cover of palatable species followed the same trend (Figure 3.7), as did the cover of palatable grasses (Figure 3.9). It is evident from a comparison of the C26 and C20 trials that the grass cover responds negatively to high intensity grazing. The grasses of Strandveld are predominantly C3. A reduction in foliage exposes the shoot apices to greater insolation and inhibits growth (Cowling, 1983).

Prior to the drought there had been a steady increase in cover of _Tetragonia fruticosa_, but this species received a severe set-back in the drought and its cover continued decreasing afterwards (Figures 3.10). One would expect that since it is a pioneer, it would be common in the areas where vegetation cover is low. However, since it is palatable, its cover was probably reduced to levels where the impact of grazing was sufficient to prevent its recovery. Only in the trials with sheep, and cattle and sheep, were there slight increases in cover after 1981.

There are no real trends in the cover of the unpalatable species after the drought, except in the C20 trial, (Figure 3.11) where their cover continued to decrease after the drought, up to 1982. One can only infer that this is due to these plants being grazed by the cattle for want of anything better to eat. The combination of drought and heavy grazing pressure appears to be disasterous for Strandveld.

Combining the data for the individual species into four main growth forms showed that not only are there differences between the trials in terms of canopy cover, but also differences in the proportional cover of the different growth forms. The four growth form categories used were
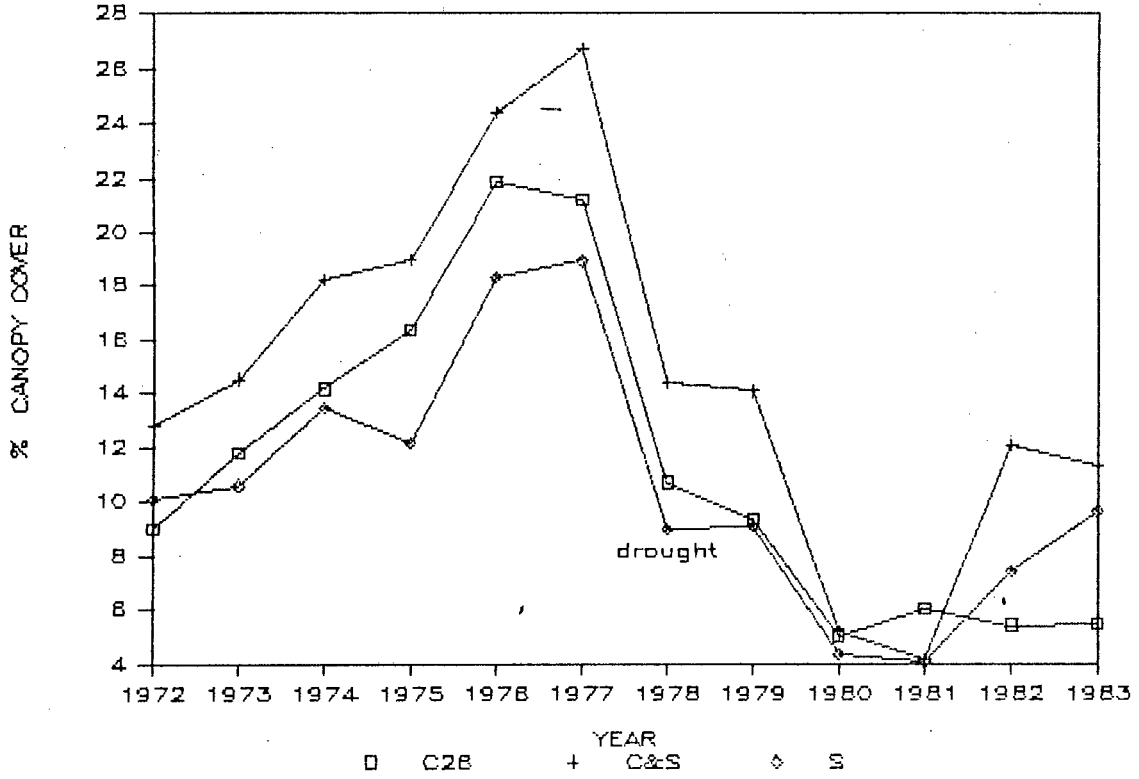
77

FIGURE 3.10 Cover of _Tetragonia_ _fruticosa_ for three grazing trials over the period 1972 to 1983. ☐ cattle + cattle & sheep ◇ sheep
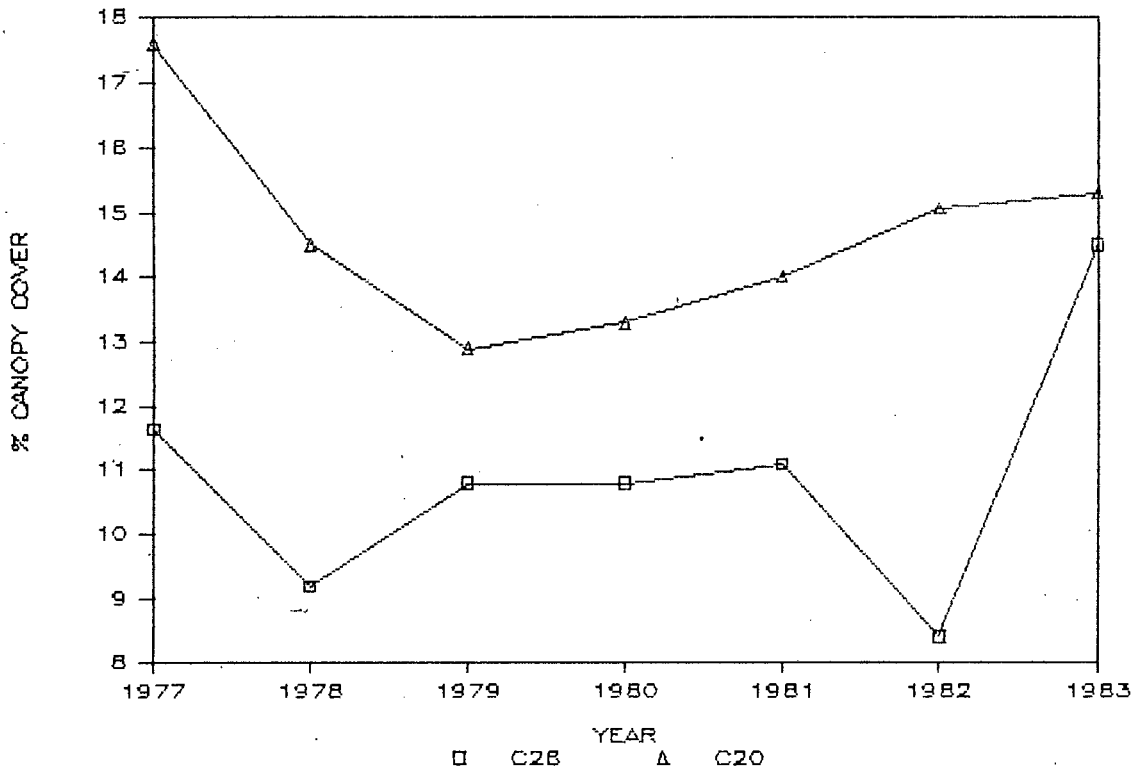

FIGURE 3.11 Cover of less palatable species for two different stocking densities of cattle over the period 1977 to 1983. ☐ 1 LSU/26 ha △ 1 LSU/20 ha
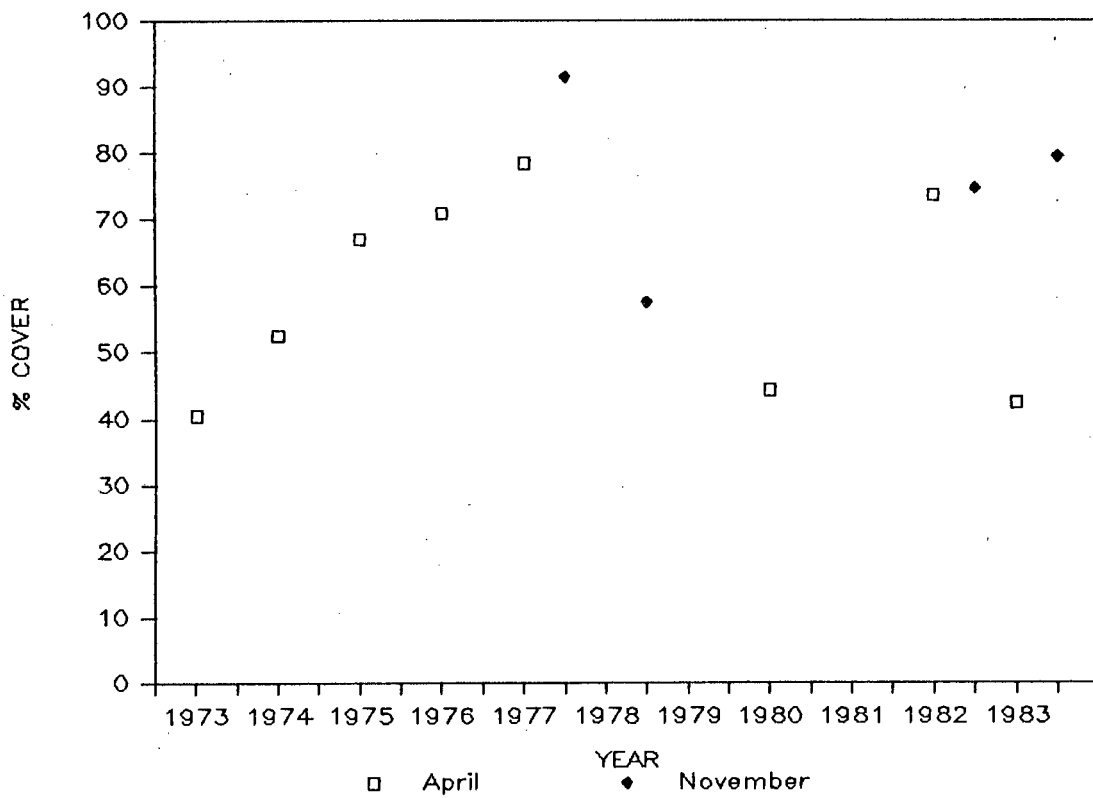
FIGURE 3.12 Vegetation cover in the veld reserve at Nortier from 1972 to 1983

drought-deciduous shrubs, evergreen shrubs, succulents and grasses. The
remaining growth forms ('other' in the figures), such as geophytes,
herbaceous annuals and perennials and restionaceae, form a minor
component of the vegetation.

In 1983 the major difference between the trials was in the proportions of
the cover that were succulents and grasses. The C26 trial (Figure 3.
1(c)) had vegetation most similar to the ungrazed camp (Figure 3.13(c)) -
high grass cover and a lower succulent cover. Sheep, either on their own
(Figure 16(b)), or with cattle (Figure 15(b)), resulted in a higher
proportion of succulent cover. There was a gradation in the proportional
cover of succulents; from ungrazed veld to cattle at 1 LSU/26 ha to
cattle at 1 LSU/20 ha to sheep and finally to cattle and sheep combined.
Sheep farming is more important in the Lambert's Bay area than cattle
farming and the fairly succulent nature of much of the Strandveld in the
area today may therefore be a direct result of sheep grazing.

The changes that occurred in the relative proportions of the growth forms
over the time-period of the trials was quite substantial. In the veld
reserve, the control situation, the major change over the 11 years was a
decrease in the proportional cover of succulents and an increase in
grassiness (Figure 3.13). This was also the case with all the grazing
trials (Figures 3.14 - 3.17), so that it appears that all of the
vegetation was grassier in 1983 than it had been before. However the
magnitude of the changes differ from trial to trial. There was also an
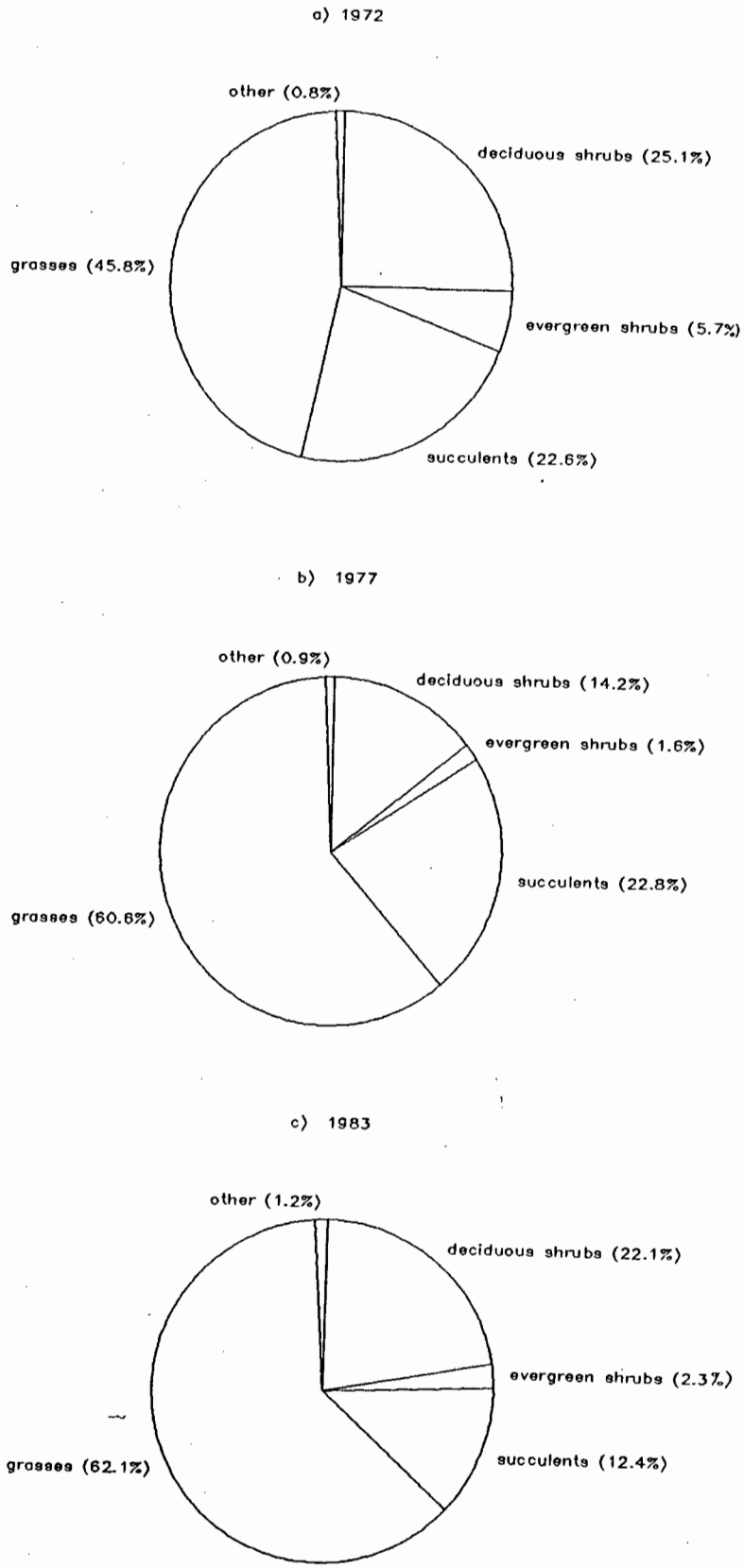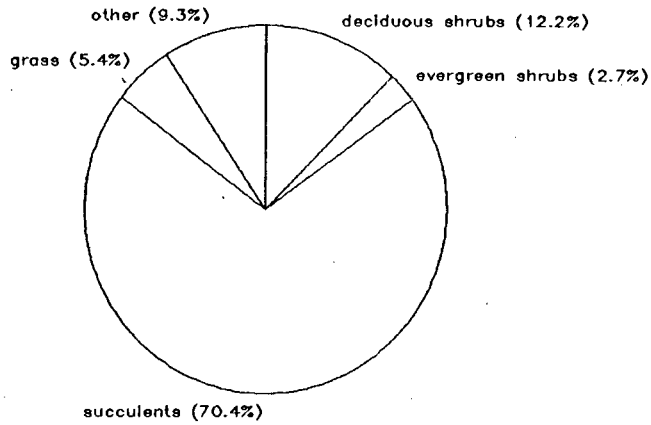increase in the proportion of deciduous shrubs in most cases.

a) 1972

other (0.8%)

deciduous shrubs (25.1%)

grasses (45.8%)

evergreen shrubs (5.7%)

succulents (22.6%)

b) 1977

other (0.9%)

deciduous shrubs (14.2%)

evergreen shrubs (1.6%)

succulents (22.8%)

grasses (60.6%)

c) 1983

other (1.2%)

deciduous shrubs (22.1%)

evergreen shrubs (2.3%)
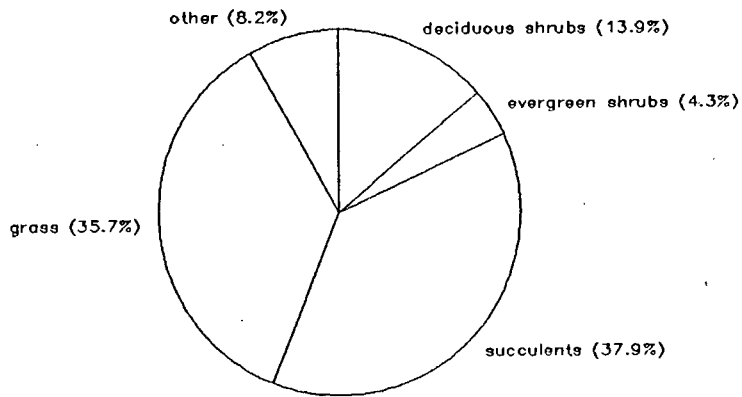
grasses (62.1%)

succulents (12.4%)

FIGURE 3.13 Proportional cover of the main growth forms in
Strandveld vegetation in the veld reserve at Nortier, for
three different years a) 1972   b) 1977   c) 1983

81

a) 1972

other (9.3%)

deciduous shrubs (12.2%)

grass (5.4%)

evergreen shrubs (2.7%)

succulents (70.4%)

b) 1977

other (8.2%)

deciduous shrubs (13.9%)

evergreen shrubs (4.3%)

grass (35.7%)

succulents (37.9%)

c) 1983

other (10.5%)

deciduous shrubs (30.9%)
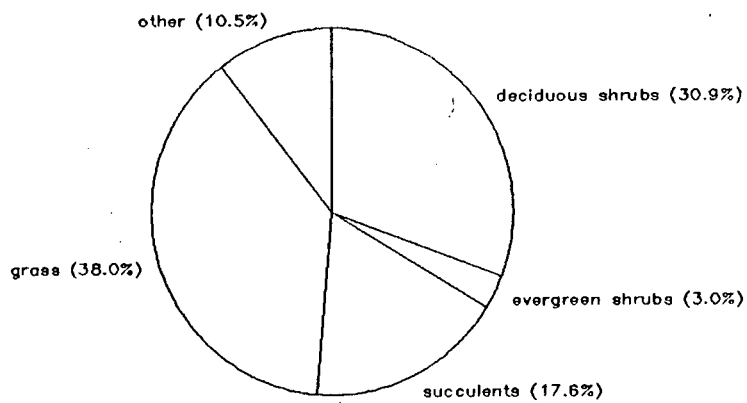
grass (38.0%)

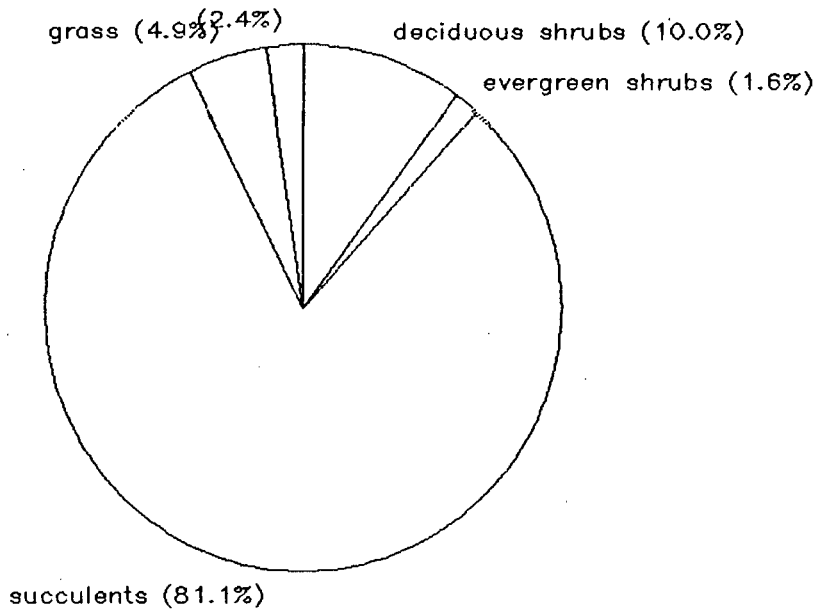evergreen shrubs (3.0%)

succulents (17.6%)

FIGURE 3.14   Proportional cover of the main growth forms in
Strandveld vegetation in the grazing trial with cattle at 1
LSU/26 ha,   at Nortier,   for three different years a) 1972
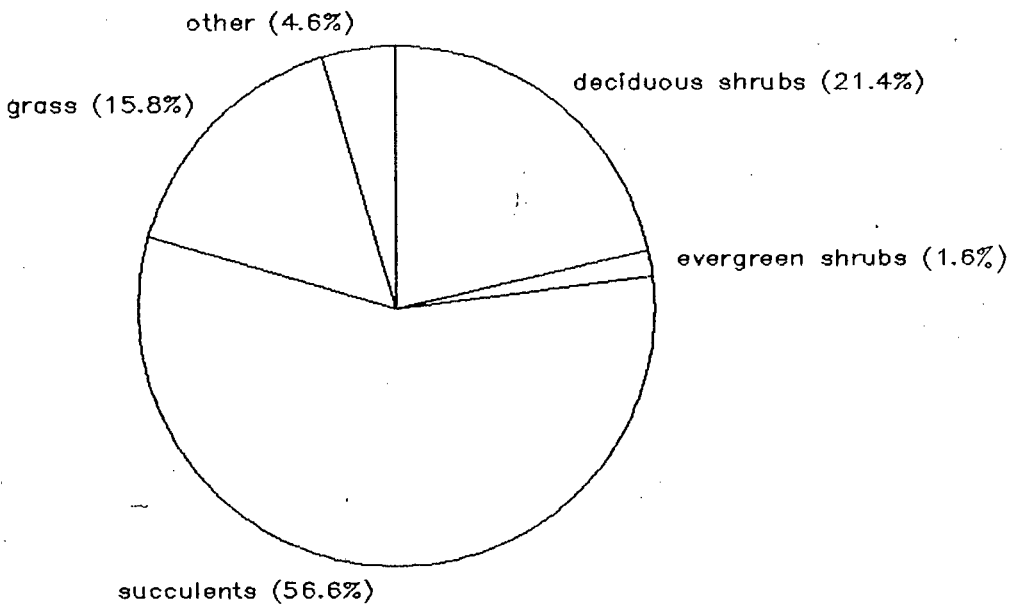b) 1977   c) 1983

a) 1972

grass (4.9%) (2.4%)   deciduous shrubs (10.0%)

                              evergreen shrubs (1.6%)

succulents (81.1%)

b) 1983

other (4.6%)

grass (15.8%)   deciduous shrubs (21.4%)

                                        evergreen shrubs (1.6%)

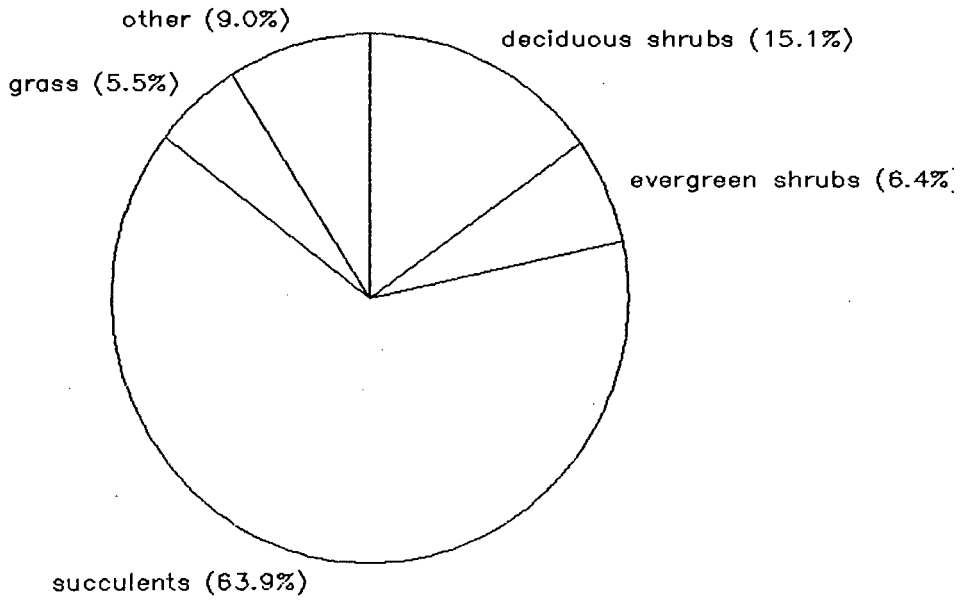succulents (56.6%)

FIGURE 3.15   Proportional cover of the main growth forms
in   Strandveld vegetation in the grazing trial with   cattle
and   sheep,   at Nortier,   for two different years   a)   1972
b) 1983

a) 1972

other (9.0%)

deciduous shrubs (15.1%)

grass (5.5%)

evergreen shrubs (6.4%)

succulents (63.9%)

b) 1983

other (13.2%)

deciduous shrubs (23.5%)

grass (14.7%)

evergreen shrubs (5.2
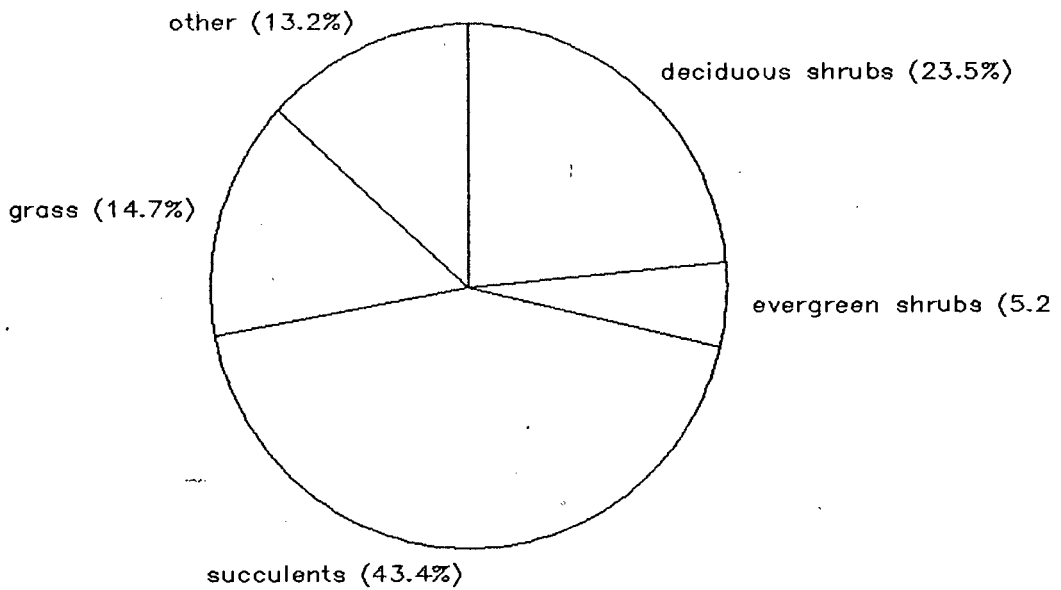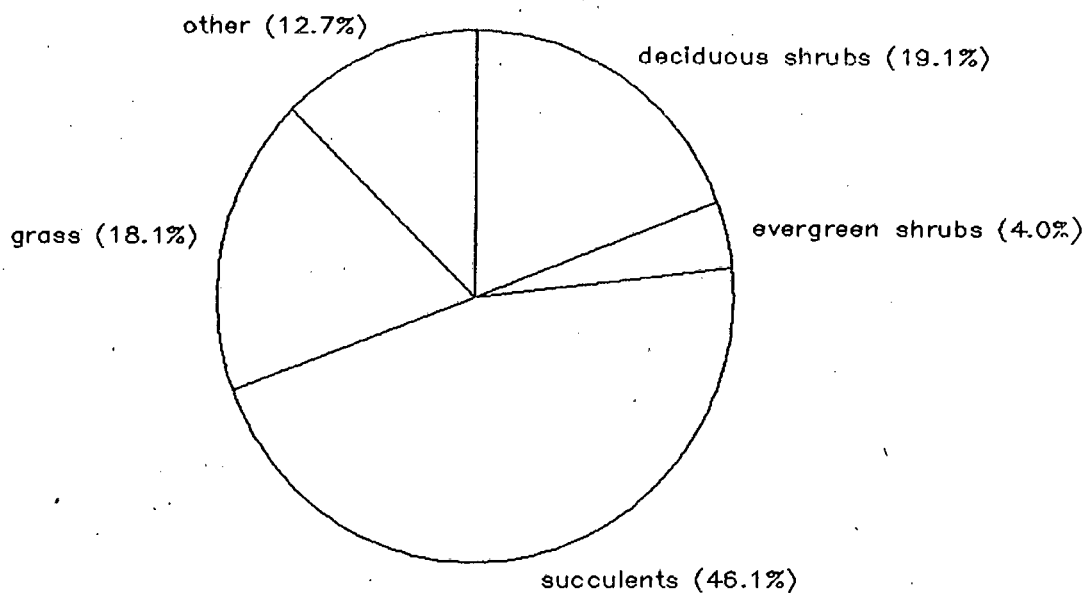
succulents (43.4%)

FIGURE 3.16   Proportional cover of the main growth forms
in Strandveld vegetation in the grazing trial with sheep,
at Nortier, for two different years a) 1972   b) 1983

a) 1977

other (12.7%)

deciduous shrubs (19.1%)

grass (18.1%)

evergreen shrubs (4.0%)

succulents (46.1%)

b) 1983

other (6.7%)

deciduous shrubs (29.1%)

grass (19.6%)
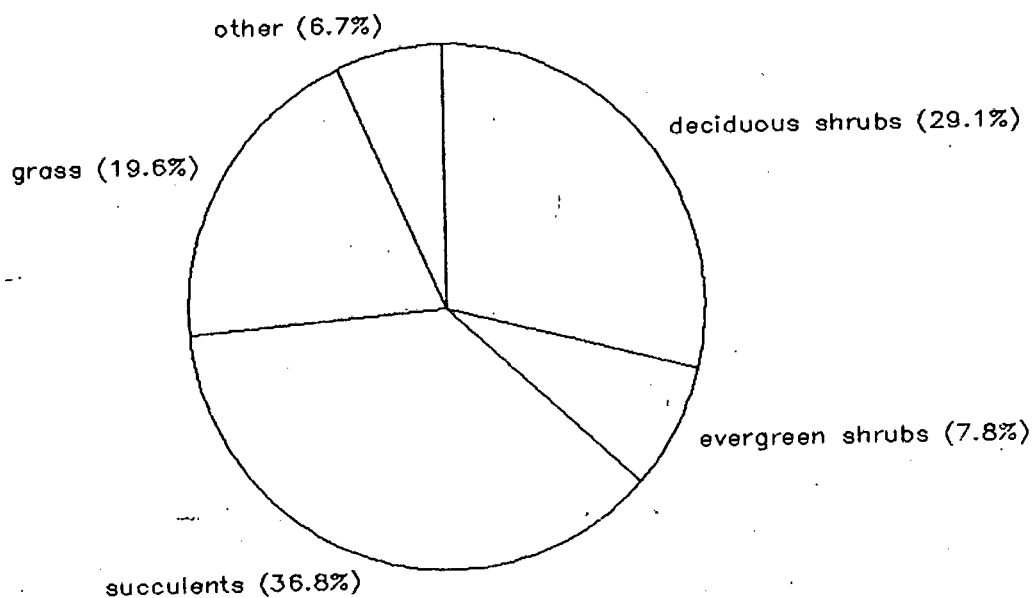
evergreen shrubs (7.8%)

succulents (36.8%)

FIGURE 3.17   Proportional cover of the main growth forms
in Strandveld vegetation in the grazing trial with cattle
at 1 LSU/20 ha, at Nortier, for two different years a) 1977
b) 1983

85

The C&S trial (Figure 3.15) is interesting in that despite having low vegetation cover, there was a large reduction in the proportional cover of succulents from 1972 to 1983. The sheep trial (Figure 3.16) shows this too, but to a lesser extent. It seems that what little vegetation cover there was in these trials improved in terms of pasture quality.

A comparison of the changes that occurred from 1977 to 1983 for the C26 trial (Figure 3.14(b) & (c)) and the C20 trial (Figure 3.17) clearly show the effects of heavy grazing. Although both trials showed a decrease in the proportion of succulents over time , the decrease for the C20 trial was much smaller than that for the C26 trial.

TABLE 3.1 Average number of species recorded per survey line in each grazing trial from 1972 to 1983.

| Year | Grazing trial | | | | |
	C26‡	C20‡	C&S‡	S‡	VR⁎
1972	19	–	20	21	23
1973	23	–	22	21	21
1974	22	–	23	23	15
1975	23	–	23	22	20
1976	23	–	24	23	23
1977	26	25	28	28	23
1978	25	24	27	24	26
1979	26	26	23	24	–
1980	25	25	24	25	24
1981	25	23	27	25	23
1982	23	23	23	23	25
1983	27	27	26	27	25

C26 = cattle at 1 LSU/26 ha; C20 = cattle at 1 LSU/20 ha;
C&S = cattle and sheep; S = sheep; VR = veld reserve (ungrazed)

‡ Average of four 100-point line surveys
⁎ Only 1 survey.

There were no differences in species numbers between the trials, nor was there any difference between the grazing trials and the ungrazed camp (Tabel 3.1). In the first three trials the lowest number of species occurred in 1972. Otherwise there is no trend over time.

The species composition of the various camps within one grazing trial differed quite substantially, making it difficult to detect differences between trials. A list of the species recorded for the combined surveys for each grazing trial appears in Appendix B.

3.5.3 CONCLUSIONS

Since it is obvious from the survey data that the vegetation at Nortier was in poor shape at the beginning of the grazing experiments, any form of controlled grazing was likely to improve the veld. However, low-intensity cattle farming appears to have had the best results. High stocking densities are deleterious to the vegetation - leading to low total cover, low cover of palatable species and increased succulence of the vegetation. Sheep, alone or mixed with cattle, also cause a reduction in cover and increased succulence. This may be due to sheep being more eccletic feeders than cattle, as well as to the increased trampling that occurs. At the same stocking density as cattle, sheep represent 6 times as many hooves.

A lack of basic understanding of Strandveld plants, their phenology, their physiology and their response to such pressures as drought (both the annual summer drought and abnormal winter drought) and defoliation, is one of the main problems in the exploitation and management of Strandveld pastures. Research on the plants of Strandveld and the communication to the farmers of the results of that research is one of

87

the priorities identified by the Agricultural Development Programme (1985b).

The evidence from the Nortier grazing experiments suggests that the nature of Strandveld could have been altered in the past as a result of over-stocking and inappropriate grazing systems. The obvious succulence of a lot of the Strandveld in the north is probably the result of mis-use of the vegetation, which is probably quite different to what it was prior to the establishemnt of stock-farming on a large scale. The veld reserve provides an example of what most of this type of Strandveld perhaps looked like in the past. The vegetation was probably denser, with a maximum cover of up to 80%, grassier, less succulent and perhaps even with more evergreen shrubs. Further south, where Strandveld is shrubbier and less succulent, the changes have probably been different.

3.6 CHAPTER SUMMARY

West Coast Strandveld is and has been used primarily as natural pasture for domestic animals. Prior to European settlement, Khoi herders had been at the Cape for about 1600 years. Historical records point to a high degree of mobility of these people and their animals, grazing any one area intensively for a short time. The use of fire by the Khoi is also documented. There is therefore a relatively long history of herding in the Cape. Soon after the establishment of the settlement at Table Bay, European farmers began moving up the west coast in search of grazing for their animals, and set up grazing farms. This form of herding was more fixed to a single location than was that of the Khoi, and overgrazing soon became a problem. The relative lack of surface water

along the west coast lead to concentrations of grazing farms along rivers and vleis.

Farming with cattle and sheep is still the most important form of agricultural landuse in Strandveld, and this vegetation has not suffered from clearing for cultivation to the same extent as Coastal Renosterveld. The vegetation is not all in satisfactory condition, and its pasture potential has been reduced. A major cause of this is the small size of many farms today, together with an over-optimistic assessment of carrying capacity. Rotational grazing is generally recommended for Strandveld. Stocking rates vary from 10-16 ha/LSU in the south to 30 ha/LSU in the north. Resting of the veld has been found to be a good way of improving veld condition in general, and improving grass cover in particular. Burning of the veld is not generally recommended.

Grazing experiments at Nortier, Lambert's Bay, have shown that farming with cattle is better than farming with sheep or mixed sheep and cattle for maintaining or improving the condition of the veld. The experiments have also shown the damaging effects of high stocking densities. The highest total cover, cover of palatable species and grass cover occurred in the grazing trial with cattle at 26 ha/LSU. The vegetation in this trial also recovered more quickly from the effects of a winter drought than that in other trials. The combination of high stocking density and drought was disasterous for Strandveld. The impact of proper veld management was evident in the change with time in the proportional cover of succulents and grasses. There was a decrease in the proportion of succulent cover in all situations, the decrease being larger for cattle and less for sheep.

It is suggested that the predominantly succulent nature of many parts of the Strandveld in the north is the result of misuse of the veld, and the vegetation was probably different in the past to what it is today.

3.7 REFERENCES

ACOCKS JH 1953. Veld types of South Africa. Memoirs of the Botanical Survey of South Africa No. 28.

BARNARD SA 1983. Die invloed van beveiding deur kleinvee en beeste op die bedekking en samestelling van die Strandveld. Ongepubliseerde vorderingsverslag 1982/1983, Projek Nr. W5471/41/1/1. Departement Landbou Techniese Dienste, Pretoria.

BARROW J 1968. An account of travels into the interior of southern Africa, in the years 1797 and 1798. (Reprint) New York: Johnson Reprint Corporation.

BIRD W 1966. State of the Cape of Good Hope in 1822. (Facsimile Reprint) Cape Town:Struik.

BOTHA CG 1924. Note on early veld burning in the Cape Colony. South African Journal of Science 21, 351-352.

BOTHA CG 1970. Social life and customs during the Eighteenth century. (Second Edition) Cape Town: Struik.

BOUCHER C 1981. Unpublished talk prepared for SABC.

BOUCHER C 1982. Floristic and structural features of the coastal foreland vegetation south of the Berg River, western Cape province, South Africa. IN: Proceedings of a symposium on coastal lowlands of the Western Cape, ed Moll E J. University of the Western Cape.

BROCK E 1959. The nutritive status of the natural pastures on the most important soil types of the Swartland. Unpublished MSc Thesis. University of Stellenbosch.

BROWNLIE SF 1982. The effects of recent land use on a fynbos site. Unpublished final report, CSP, CSIR.

COWLING RM 1983. The occurrence of C3 and C4 grasses in fynbos and allied shrublands in the southeastern Cape, South Africa. Oecologia 58:121-127.

DEACON HJ 1983. The peopling of the Fynbos region. IN: Fynbos palaeoecology: a preliminary synthesis, eds HJ Deacon, QB Hendey and JJN Lambrechts. South African National Scientific Programmes Report No. 75. Pretoria: CSIR. pp 183-204.

DEACON J 1984. The Later Stone Age of southernmost Africa. British Archaeological Reports International Series 213. Oxford: British Archaeological Reports.

DEACON HJ, DEACON J, BROOKER M & WILSON ML 1978. The evidence for herding at Boomplaas Cave in the southern Cape. South African Archaeological Bulletin 33: 39-65.

DE MIST JA 1920. The memorandum of Commisary JA de Mist. Cape Town: Van Riebeeck Society.

DEPARTMENT OF AGRICULTURE AND FISHERIES 1985a. Agricultural Development Program: Swartland sub-region, Winter Rainfall Region. Elsenburg.

DEPARTMENT OF AGRICULTURE AND FISHERIES 1985b. Agricultural Development Program: North-western Sub-region, Winter Rainfall Region. Elsenburg.

ELPHICK R 1985. Khoikhoi and the founding of white South Africa. Johannesburg: Ravan Press.

JOUBERT JGV 1969. Improved grazing in the Strandveld. Farming in South Africa 44(10),17.

JOUBERT JGV 1971. 'n Voorlopige vergelyking tussen twee beweidings- stelsels op weskus Strandveld. Proceedings of the Grasslands Society of southern Africa 6, 78-81.

KRUGER FJ & BIGALKE RC 1984. Fire in Fynbos. In: Ecological effects of fire in South African ecosystems, eds P de V Booysen and N M Tainton. Berlin: Springer Verlag pp 67-114.

LICHTENSTEIN H 1928. Travels in southern Africa, in the years 1803, 1804, 1805 and 1806. Vol. 1. Cape Town: Van Riebeeck Society.

MOSSOP EE (ed) 1947. The journals of Brink and Rhenius. Cape Town: Van Riebeeck Society.

PENN NG 1986. The frontier in the western Cape, 1700 - 1740. IN: British Archaeological Reports (in press).

RAVEN-HART R 1967. Before van Riebeeck. Cape Town: Struik.

SCHWEITZER FR 1974. Archaeological evidence for sheep at the Cape. South African Archaeological Bulletin 29: 75-82.

SINCLAIR S 1980. Recent settlement at Verlorenvlei. In: Verlore Vlei. A challange to conservation. Papers presented at a symposium September 1980, University of Cape Town.

SKEAD CJ 1980. Historical mammal incidence in the Cape Province. Vol. 1 The western and northern Cape. Cape Town: Department of Nature and Environmental Conservation.

SMITH AB 1984. Adaptive strategies of prehistoric pastoralism in the south-western Cape. In: Frontiers: Southern African Archaeology Today, eds M Hall, G Avery, DM Avery, ML Wilson and AJB Humphreys. British Archaeological Reports International Series 207. Oxford: British Archaeological Reports.

SPARRMAN A 1785. A voyage to the Cape of Good Hope towards the Antarctic polar circle and round the world, but chiefly into the country of the Hottentots and Caffres, from the year 1772 to 1776. London: Robinson.

TALBOT WJ 1947. Swartland and Sandveld. Cape Town: Oxford University Press.

TERBLANCHE IL 1966. Aspekte van die voeding en bestuur van die skaapkudde op Nortier-Proefplaas. Unpublished MSc(Agric) Thesis, University of Stellenbosch.

THOM HB 1952. The journal of Jan van Riebeeck. Cape Town: Balkema. 3 volumes.

THUNBERG CP 1795. Travels in Europe, Africa and Asia performed between the years 1770 and 1779. London: William Richardson & John Egerton.

VALENTYN F 1971. Description of the Cape of Good Hope with matters concerning it. Cape Town: Van Riebeeck Society.

VAN DER MERWE JP 1926. Die Kaap onder die Bataafse Republiek 1803 - 1806. Amsterdam: Swets & Zeitlinger.

VAN RYNEVELD WS 1942. Aanmerkingen over de verbetering van het vee aan die Kaap de Goede Hoop, 1804. Cape Town: Van Riebeeck Society.

4. SEASONAL PROCESSES IN STRANDVELD

4.1 INTRODUCTION

Phenology has been defined as the study of the timing of recurring biological events (Pierce & Cowling, 1984a). It has been an important focus of the Fynbos Biome Project and data exist for Mountain Fynbos, Lowland Lynbos, renosterveld, Kaffrarian thicket and Grassy Fynbos (Kruger, 1981: Sommerville, 1983; Pierce & Cowling, 1984a). Only a broad analysis of Strandveld community phenology, as it relates to avian communities, has been published (Siegfried, 1982).

The aim of this paper is to re-examine data collected by J. Sommerville in 1978 and 1979 on the phenology of West Coast Strandveld at two sites, Geelbek and Melkbos. Community phenology and growth form phenology will be discussed, and compared and contrasted with the phenology of other plant communities in the winter rainfall region of the Cape and other mediterranean climate areas.

4.1.1 PHENOLOGICAL THEORY

A number of ideas have been put forward attempting to explain and predict the onset and cessation of the phenophases in plants. An effective model to predict the timing of phenophases could provide an important aid to land-use and management planning. Pierce (1984) provides a good summary of phenological theory. She divides the factors controlling phenophase into: 1. environmental determinants and 2. temporal partitioning of resource use.

4.1.1.1 Environmental determinants of phenophase

It is suggested by some that the triggers initiating phenophases are environmental (Mooney & Kummerow, 1980; Kummerow, 1983; Specht et al, 1983)). Rainfall patterns appear to be a major influence determining the onset of vegetative growth, although it is not the rainfall directly that seems to be effective, but rather its effect on the soil moisture balance. The influence of rainfall is particularly obvious in the case of annuals. Perennials with access to deep ground water are least influenced by rainfall (Kummerow, 1983). Both rainfall and temperature are effective in determining germination, while the length of time that soil moisture is adequate determines the life cycle of the plants. Variations in annual rainfall are reflected in variations in herbaceous biomass production.

Seasonal fluctuations in nutrient availabilty may also be of importance. Groves (1983) predicts that there is increased availability of biotically released nutrients, like nitrogen and to some extent phosphorus, in soils in spring and autumn when the combination of moisture and temperature conditions is optimal. In Strandveld autumn is often dry and one can expect the main flush of soil nitrogen and phosphorus to occur in spring. Geochemically released nutrients are only low in summer due to lack of water.

Other, more indirect, environmental variables have also been suggested as controlling factors, for example minimum air temperature, soil temperature, photoperiod and insolation.

Combinations of factors may also be effective. For example, in Californian chaparral accumulating warming hours have been shown to be important for leaf growth and stem elongation, once a threshhold soil moisture level is reached (Kummerow,1983). In the same vegetation leaf fall of summer-deciduous shrubs appears to be brought on by drought coinciding with long days (Nilsen & Muller, 1980 cited by Pierce, 1984).

The onset of flowering has a high degree of independance from moisture conditions. Temperature is an important trigger (Kummerow, 1983), although photoperiod is probably also effective.

Pierce & Cowling (1984b) found that for their study area phenophases could be explained in terms of temperature and soil moisture. They found that shoot growth and flowering were primarily temperature dependant, while root growth and leaf fall were soil moisture dependant.

There is also the the possibility that endogenous rythms may over-ride environmental triggers.

The role of soil nutrient status in determining phenophase has been formulated in the 'Overstorey/understorey hypothesis' of Specht (Specht, 1982; Specht & Moll, 1983; Pierce, 1984). The idea was put forward by Specht in an attempt to explain the summer growth of heathland shrubs in Australian and South African mediterranean areas. The underlying assumption is that it is the nutrient status of the soil that is the major determinant of vegetation structure, and it is the interplay of moisture availability and nutrient cycling that determines growth phenophases.

Very briefly, Specht's ideas are:

1. On base-rich soils the understorey species sprout in autumn and complete their life cycles by the end of spring. The overstorey species grow in autumn and/or spring and leaf fall follows growth.

2. On nutrient-poor soils the understorey species grow in autumn and/or spring, with leaf loss in summer. Overstorey species, on the other hand, grow in late spring and summer and leaf fall is synchronous with growth.

3. On Ca-rich/high pH soils the growth phenophases should be similar to those for nutrient-poor soils as a result of induced nutrient stress.

Pierce & Cowling (1984b) have critized Specht's model for not taking into account temperature, radiation and biotic factors. They found that the model does not explain some of their findings. For example it does not explain the growth phenophases of thicket on Ca-rich dune sand in the South-eastern Cape, nor does it explain the observation that particular species growing on three soil types of differing nutrient status showed similar phenophases. Pierce & Cowling found in fact that substrate had minimal effect on phenophases. Other of their findings were, however, consistent with Specht's model. The model appears to provide a potential predictive tool for the study of phenophases, but more work is needed to refine and clarify the model, particularly with respect to Ca-rich soils.

Sommerville (1983) has suggested a different explanation for the summer growth of heathland shrubs; many of these shrubs are deep-rooted, thereby having access to ground water resources. It is also possible that the occasional summer rains and high mist precipation in the south-western Cape play a role.

4.1.1.2 Temporal partitioning of resource use

It has been proposed that the effective coexistent of species in a vegetation rich in species and growth forms requires some staggering of resource use in space (growth forms) and time (staggered phenophases) (Kummerow, 1983). Staggering of growth phenophases reduces the intensity of competition between species and allows for greater species packing. However, growth does not neccesarily indicate coincident nutrient uptake, but may be the result of re-allocation of previously stored resources. This makes it difficult to determine relationships between resource use and phenophases. A major problem with the temporal partitioning hypothesis is the lack of basic information on the physiological requirements of plants.

Pierce (1984) feels that this hypothesis is practically untestable, mainly due to the complexity and interdependance of environmental and biological resources. It is felt that the model serves only as a framework for speculation.

Growth forms

In any one plant community, species belonging to a number of different growth form guilds co-exist. Their structural and morphological differences allow them to occupy slightly different spaces and to respond differently to environmental stimuli. Kummerow (1983) found that for Californian chaparral, growth phenophases can be explained in terms of root architecture and water accessibility. A deep-rooted perennial shrub will have different access to water than an annual species and will thus show different growth phenophases. The shallow-rooted herbs start growing at the beginning of the winter rains, followed by the moderately

97

deep-rooted drought deciduous shrubs and then the deep-rooted evergreen shrubs.

The morphological constraints placed on a particular growth form results in similar patterns of periodicity being displayed by members of a growth form guild. Comparable growth forms occupying different spaces should show phenological similarities (Kummerow, 1983). If all members of a growth form guild have a similar pattern of periodicty they would be competing directly for resources, so one would expect some staggering within the growth form. Mooney (1983) found that species of the same growth form co-occuring in the Californian warm deserts have different temperature requirements for growth.

Pierce & Cowling (1984a) in their study in the south-eastern Cape found that general patterns could be determined for the various growth forms in different communities. Pierce (1984) subsequently was of the opinion that variation is too great and that generalizations about the seasonality of growth forms are not really valid. The major reason for the variation is the taxonomic diversity within any growth form guild. Growth form phenology does, however, provide a means of comparing and contrasting different communities.

4.2 STUDY SITES

Both the sites under study, Melkbosch and Geelbek, occur in West Coast Strandveld (See Chapter 2, Figure 2.1). The vegetation is primarily dense scrub with broad-leaved sclerophyllous evergreen shrubs predominant. At Melkbosch the vegetation is quite heterogeneous, the dunes and dune slacks differing in composition and cover. The vegetation

also changes as one moves inland, from dense scrub to more open vegetation with bush-clumps forming. At Geelbek the vegetation is mature with well-developed bush-clumps occurring in a matrix of shorter, more open vegetation comprising herbs, grasses, geophytes and scattered individuals of bush-clump species.

The soils are sandy, relatively high in Calcium (Ca) and Phosphorus (P), with a pH that is neutral to alkaline (Table 4.1). Geelbek has deep, yellowy sand, while that at Melkbosch is darker in colour.

TABLE 4.1 Analysis of soils from two Strandveld sites.

SITE	Melkbos	Geelbek
Oxid. C (%)	1.5	1.7
Total N (%)	0.05	0.08
P Total ‡	285	660
Bray ‡	23	106
Resin ‡	56	485
Exch. K (ppm)	20	49
Ca (ppm)	267	1140
Mg (ppm)	65	91
Na (ppm)	73	67
pH	7	7.75

‡   g P/g dry mass of soil

The rainfall diminishes rapidly up the west coast. Geelbek has a lower annual rainfall and lower May/June/July rainfall than Melkbosch has. The mean summer rain fall is lower too. There is a high degree of year to year variation in rainfall (Table 4.2). Other climatic factors are very similar for the two sites.

TABLE 4.2 RAINFALL DATA FOR TWO STRANDVELD SITES

		Melkbosch	Langebaan
Annual	mean	362.2	263.8
	1978	248.7	214.2
	1979	293.4	164.8
Summer rain	mean	87.6	64.3
	77/78	82.5	155.0
	78/79	66.4	59.1
May/June/July	mean	169.4	129.9
	1978	36.7	22.5
	1979	156.2	77.4

Both areas are used primarily as extensive grazing for cattle and sheep.

4.3 METHODS

The data collection methods used are described in detail by Sommerville (1983). They involve basically the qualitative assessment of phenophase by observation and as such are extensive and non-detailed. The advantage of this method is that it is rapid and allows for large-scale data collection.

The observations were made over a fifteen month period during 1978 and 1979 for each site. At each site individual plants were marked along a transect. In this way common species had many tagged individuals and rarer species few. Thus for common species there were many replicate observations at each monitoring period. This method gives general trends of community phenology. Only the gross phenophases of growth (shoot elongation), flowering, fruiting and leaf fall were recorded. The number of individuals of each species displaying a particular phenophase were

100

recorded at each monitoring period. Pierce (1984) has pointed out that measurements of stem elonagtion give a more detailed picture of growth than simply recording the proportion of individuals that are growing, and that periods of peak growth can differ using the two different methods. There are, however, no stem elongation measurements for the study sites.

For each site bargraphs were constructed for overall community phenophases. The percentage individuals showing a particular phenophase was calculated for each month and plotted. Individual patterns give a better picture of overall community phenology than species patterns do. These latter are more important in evolutionary and biogeographic studies (Pierce, 1984).

Species were then grouped into growth form guilds using categories modified from Pierce & Cowling (1984a) (Table 4.3).

Bargraphs were constructed for the various phenophases for the most important growth forms (woody plants, succulents, grasses and restioids), again using individual patterns rather than species patterns. Phenodiagrams were drawn for species representative of each growth form.

Strandveld data were then compared and contrasted with data from other western coastal lowland veld types and with mediterranean shrublands elsewhere.

In the discussions of the data the following definitions of seasons are used: winter – June, July, August; spring – September, October, November; summer – December, January, February; autumn – March, April, May.

TABLE 4.3 GROWTH FORM CATEGORIES USED

        herbaceous annuals
        geophytes
        non-geophytic forbs
        graminoids
            Poaceae
            restiods
            cyperoids
        succulents
            stem succulents
            leaf succulents
        woody plants
            small leaved shrubs
            broad leaved shrubs.

4.4 RESULTS & DISCUSSION

4.4.1 COMMUNITY PHENOLOGY

An analysis of community phenology for the two Strandveld sites has

already been done (Siegfried, 1982), and is dealt with only briefly here.

Some growth occurs throughout the year in Strandveld, although most

occurs between late autumn/winter and spring (Figures 4.1 & 4.2).

Flowering is concentrated in spring and early summer, and the main period

of fruiting is from spring to summer.   Leaf fall in Strandveld occurs

from summer into autumn.

It is apparent from the bar-graphs that there is some variation between

the two Strandveld sites studied.   In general the various phenophases are

initiated one month later at Geelbek than at Melkbos.   The reasons for

this are probably environmental.   Rainfall is higher at Melkbosch than at

Geelbek.   This may be sufficient to allow the vegetation to start growing

earlier.

GROWTH

FLOWERING
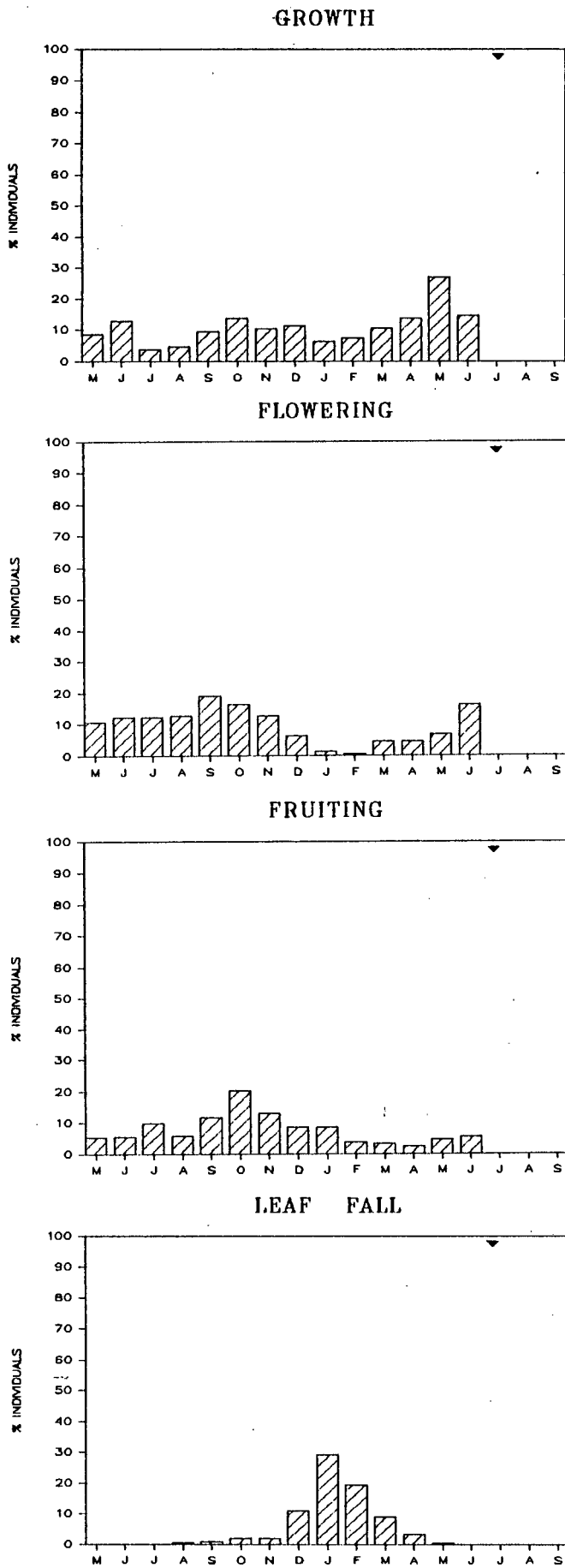
FRUITING

LEAF FALL

FIGURE 4.1   Community phenology in West Coast Strandveld at
Melkbosch.   ▼ indicates begining/end of monitoring period.

GROWTH
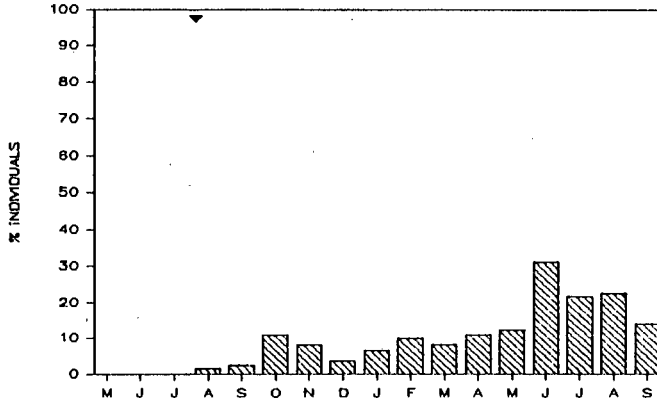
FLOWERING
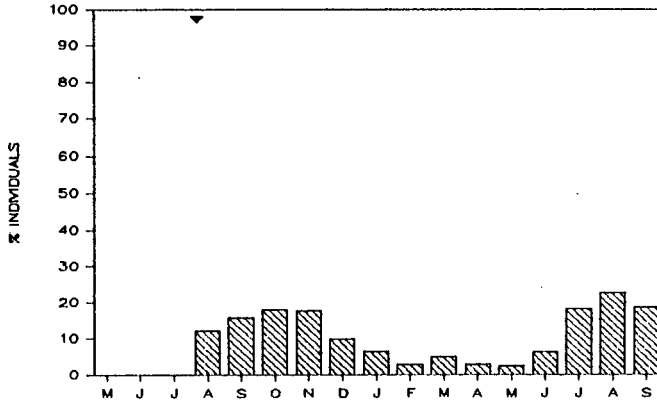
FRUITING
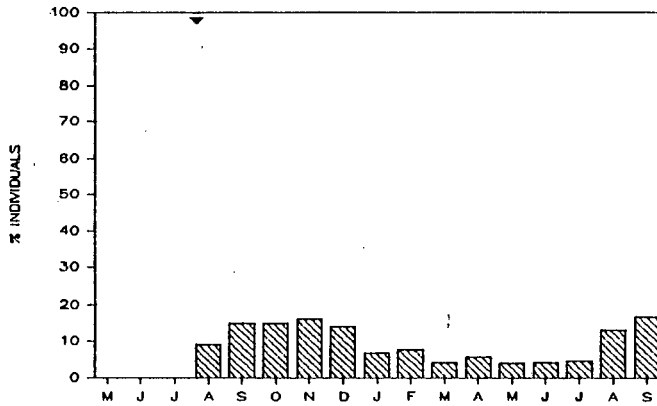
LEAF   FALL
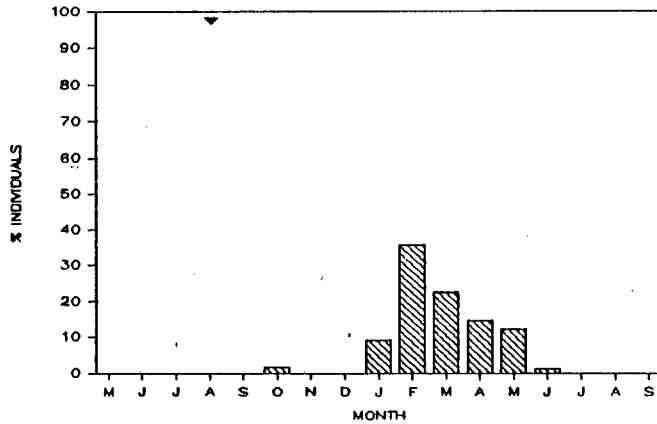
FIGURE 4.2   Community phenology in West Coast Strandveld at
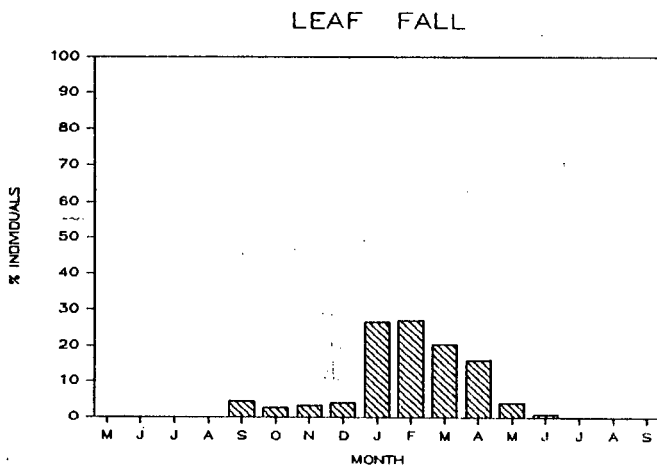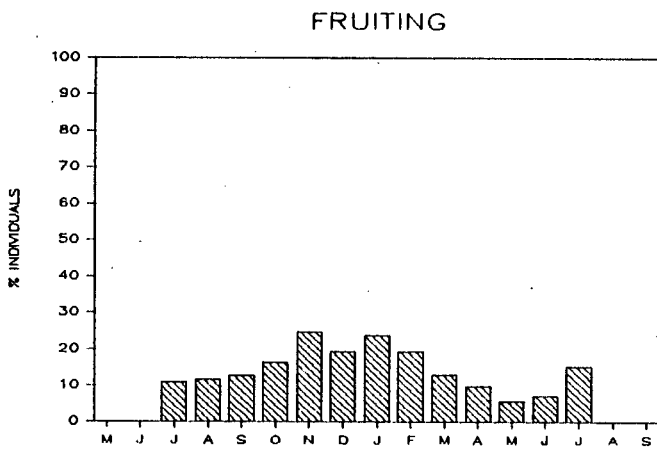Geelbek.   ▼ indicates begining/end   of monitoring period.

104

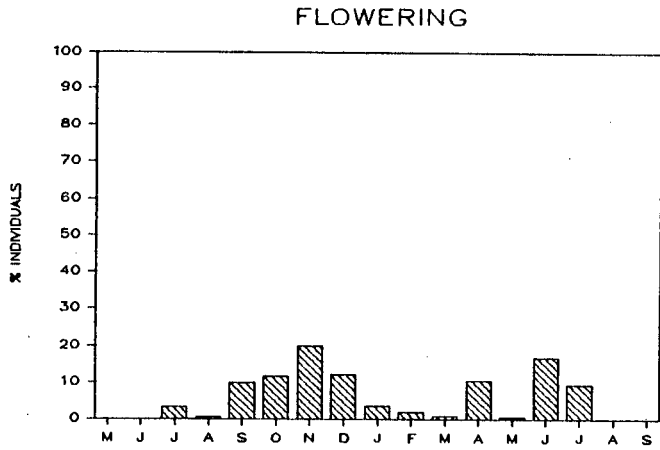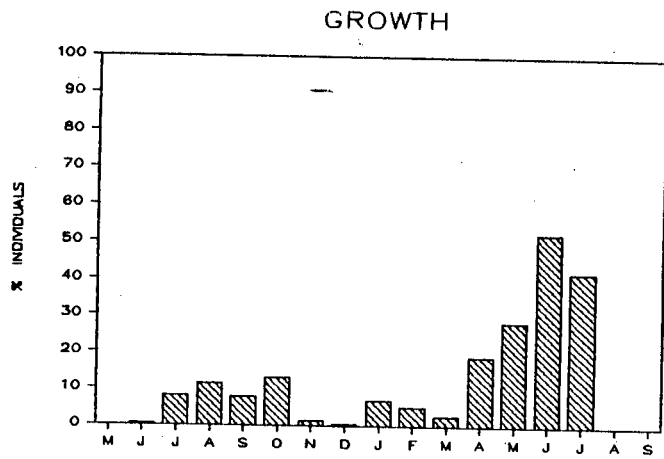FIGURE 4.3 Community phenology in Coastal Renosterveld.
▼ indicates begining/end of monitoring period.

GROWTH

FLOWERING

FRUITING
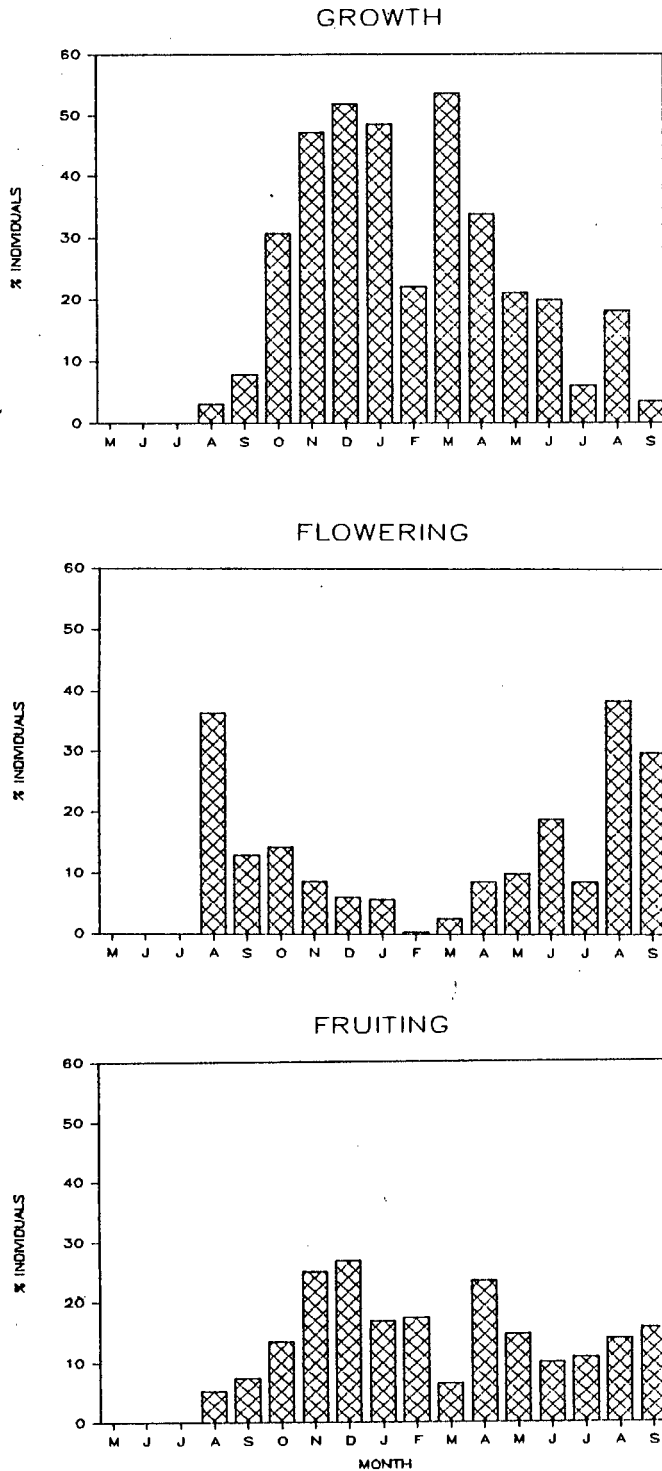
FIGURE 4.4 Community phenology in Sand Plain Fynbos.
▼ indicates begining/end of monitoring period.

The phenophases of Strandveld differ from those of adjacent lowland veld types mainly in their periodicity of growth and flowering. Growth in coastal Renosterveld (Figure 4.3) appears to be concentrated from autumn to spring. In Sand Plain Fynbos, most growth occurs in summer and autumn (Figure 4.4). In Coastal Renosterveld winter to early summer is the main period of flowering, with another, small peak in autumn, and in Sand Plain Fynbos flowering is mainly in winter and spring. Fruiting phenophases are more similar in the three veld types - both Renosterveld and Fynbos have peak fruiting in summer and autumn. Leaf fall in Renosterveld is presumably under the same environmental stimulus as that in Strandveld - being in summer and autumn too.

There are large differences between 1978 and 1979 in the growth of the plants in all three of the above vegetation types, as a result of year-to-year climatic variation. This makes it difficult to determine average patterns. More replications over a longer period are needed.

Pierce & Cowling (1984b) found that in dune thicket on calcareous sands in the south-eastern Cape overstorey species grew mostly in spring and summer/autumn and showed maximum leaf fall in summer.

4.4.2 PHENOLOGY OF GROWTH FORMS

The results for each of the two sites are presented in the form of bar-graphs for each phenophase for the dominant growth-forms (Figures 4.5 - 4.10) and phenodiagrams of species representative of the growth forms (Figures 4.11 & 4.12). Separating the vegetation into growth forms leads to better resolution of the phenological patterns and one can better explain the phenophases in terms of the response of growth forms to the

107

environment. Some variation in phenological patterning does occur within growth form guilds, and in some cases there appear to be sub-groups.

4.4.2.1 Broad-leaved shrubs

In general the growth of these shrubs occurs throughout the year, either more-or-less continuously or scattered (Figure 4.5). *Euclea racemosa*, *Rhus glauca*, *Chrysanthemoides incana* and *Putterlickia pyracantha* are typical examples. Exceptions to this are *Salvia aurea* and *Olea exasperata* which have more or less bimodal growth peaks in autumn and spring (Figures 4.11 & 4.12). Flowering is scattered, with a peak in spring and a lesser peak in winter. *S. aurea* has two flowering periods, spring and summer. Most of the broad-leaved shrubs bear fruit in spring, although some fruit in summer (*Rhus* spp.) and some in autumn (*Putterlickia*). The majority of these shrubs are evergreen and the percentage of individuals losing leaves at any one time is low and several species have no noticable period of leaf fall. However, in those species in which it does occur, leaf fall is mostly in summer and autumn. *Rhus laevigata* and *C. incana* are unusual in that they had leaf fall in spring. In the latter case leaf fall occurred in both periods.

Large-leaved thicket shrubs in south-eastern Cape dune scrub (Pierce & Cowling, 1984a) also show no particular pattern of growth overall, although there is a general tendency for growth to be concentrated in spring and autumn. Some shrubs grow in spring, others in winter, others again in spring and autumn and some all year. There is a tendency for growth to cease in mid-summer and leaf fall to occur. Flowering and fruiting is irregular too, but there are peaks in spring and autumn. Asynchrony of fruit production occurs within species.
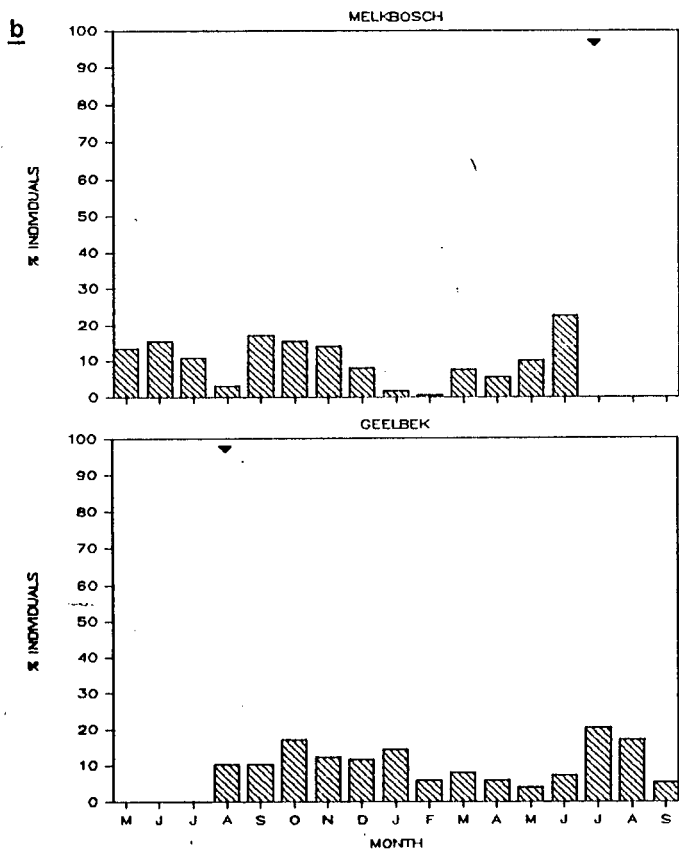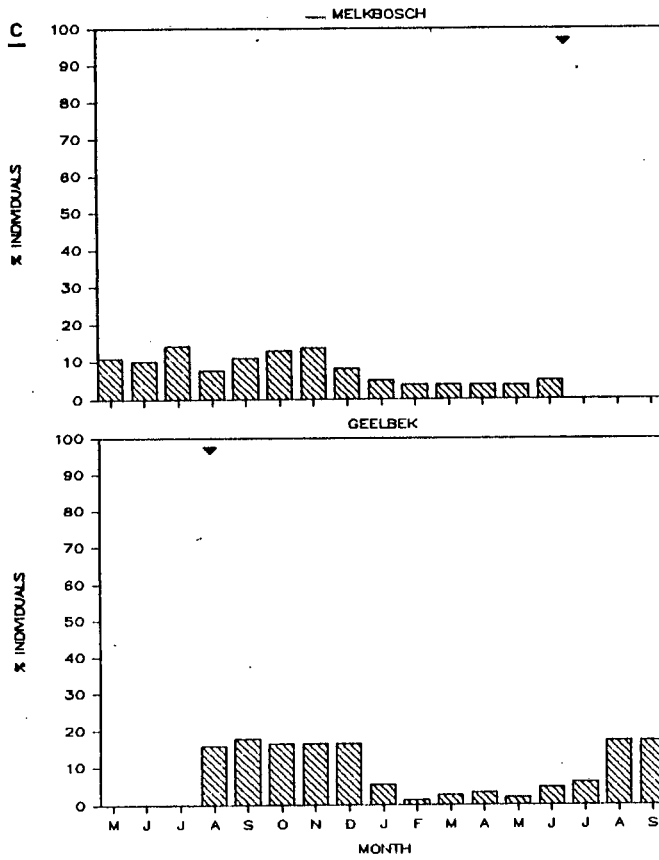
GROWTH

a

MELKBOSCH

GEELGEK

FLOWERING

b
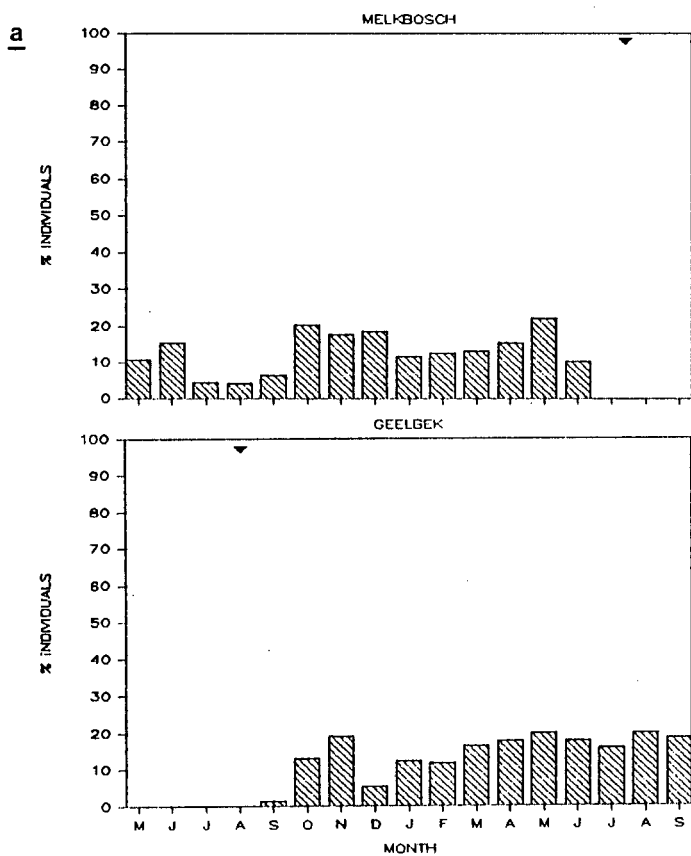
MELKBOSCH

GEELBEK

FIGURE 4.5   (see caption overleaf)

FRUITING

MELKBOSCH
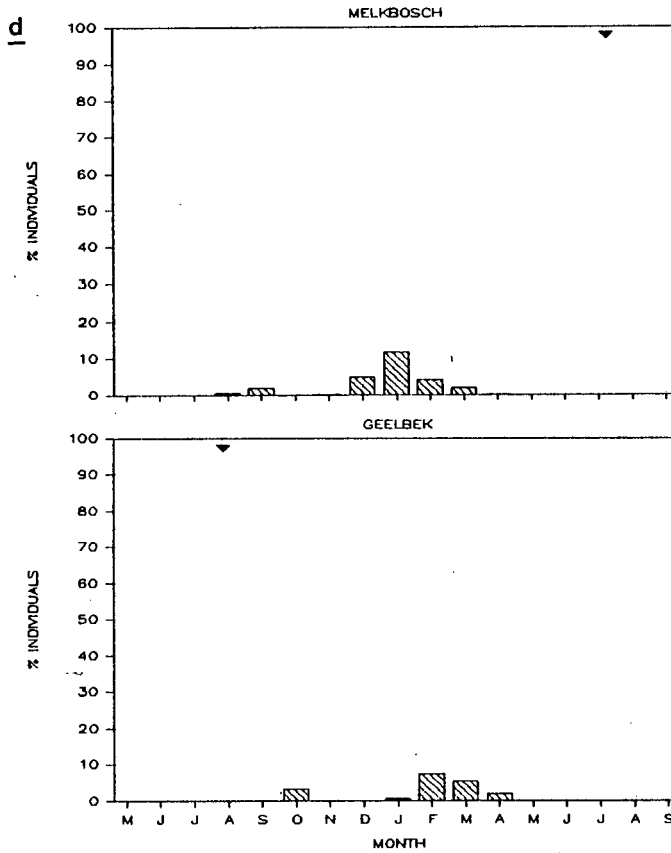

GEELBEK

LEAF FALL

MELKBOSCH

GEELBEK

FIGURE 4.5 Phenophases of broad-leaved shrubs at Melkbosch and Geelbek. ▼ indicates begining/end of monitoring period.
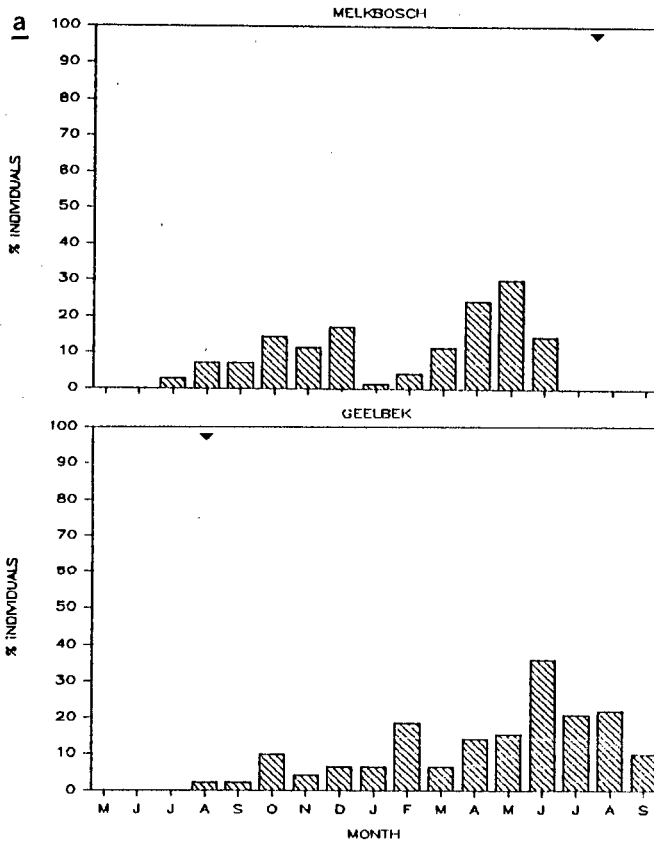a) Stem growth b) Flowering c) Fruiting d) Leaf fall

The phenology of Renosterveld broad-leaved shrubs differs from that of Strandveld in that growth occurs predominantly in autumn/winter, although some have scattered growth throughout the year except in summer (see Appendix C). Flowering and fruiting are concentrated in the summer to autumn period. Leaf fall occurs at the same time as in Strandveld; summer and autumn.

In Sand Plain Fynbos the broad-leaved shrubs are proteoid and have completely different phenological patterns to the thicket shrubs that occur in Strandveld (see Appendix D).

4.4.2.2 Small-leaved shrubs

There is a considerable amount of variation in the periodicity of growth of small-leaved shrubs in Strandveld. Although there is a winter peak, there is growth at most times of the year, including summer (Figure 4.6). This is due mainly to the presence of genera of 'fynbos affinity' such as Phylica, Metalasia and Agathosma, which grow in summer. Flowering also occurs through most of the year, although most occurs in winter through to summer. There are two main groups of shrubs: one group, including Nylandtia spinosa, flowers in winter and the other group, including Eriocephalus racemosa and Aspalathus hispida flowers in spring and summer (Figures 4.11 & 4.12). Fruiting is spread out over the period spring to autumn, with many species bearing fruit during the summer. A small group of species bear fruit in winter - spring, while E. racemosa retains its fruit for most of the year. Leaf loss is highly synchronous and many of the shrubs are summer-deciduous. Leaf loss generally follows the cessation of growth, occurring from late spring to winter but with a peak in autumn. Some plants, such as Protasparagus capensis, continue
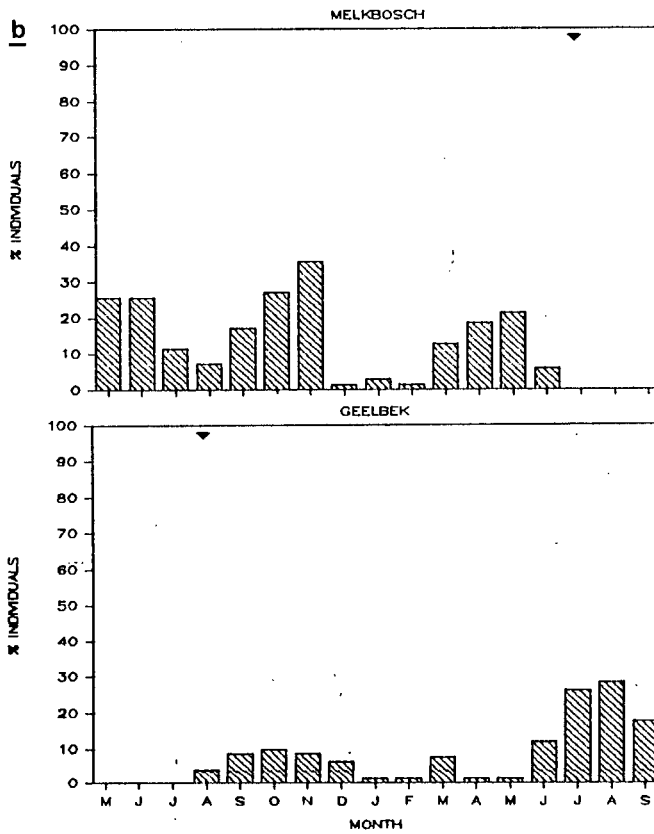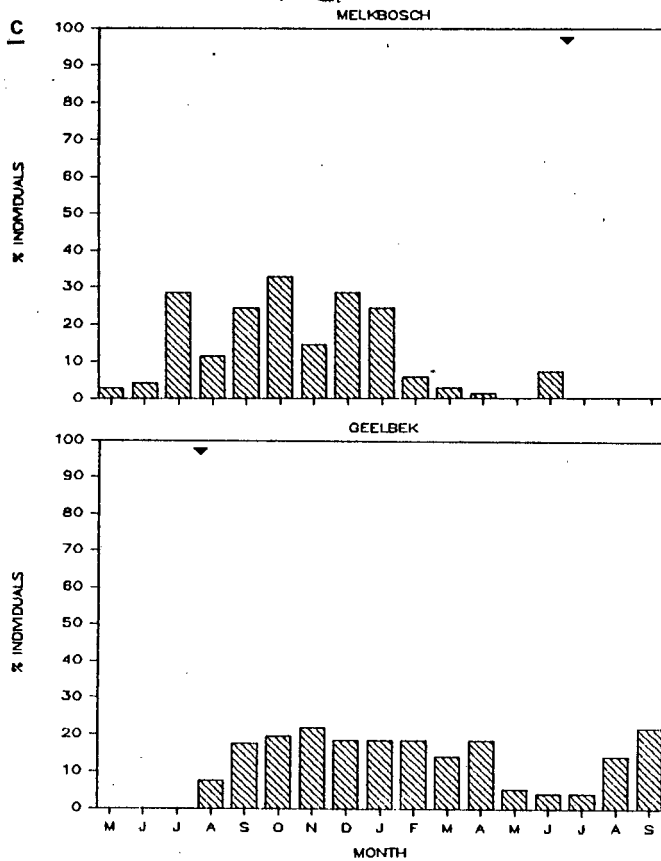
GROWTH

FLOWERING

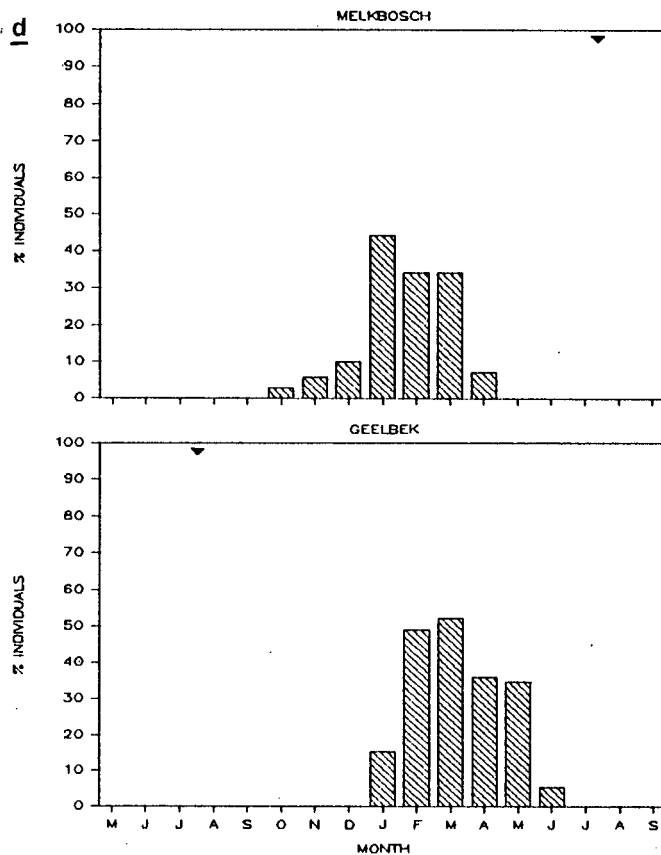FIGURE 4.6   (see caption overleaf)

112

FRUITING

LEAF FALL

FIGURE 4.6 Phenophases of small-leaved shrubs at Melkbosch
and Geelbek. ▼ indicates begining/end of monitoring
period.
a) Stem growth b) Flowering c) Fruiting d) Leaf fall

losing leaves after new shoot growth has begun.

The pattern of growth for small-leaved shrubs in south-eastern Cape dune thicket (Pierce & Cowling, 1984a) is very similar to that in Strandveld, except there is no winter peak; growth occurred in summer or throughout the year. In Renosterveld growth of these shrubs is also variable, but the summer-growing component is absent (Appendix C). Growth is either in winter or scattered throughout the year. Flowering also occurs through the year and again there are two sub-groups: one group of shrubs flowers in autumn-winter and the other in spring-summer. Fruiting follows flowering and leaf fall occurs in summer/autumn. In Sand Plain Fynbos the phenology of the small-leaved shrubs is distinct from that of Strandveld; growth occurs in summer, flowering at any time except summer and fruiting in spring and summer (Appendix D).

These above two growth forms have the most influence on the overall community phenology, resulting in the all-year growth, flowering and fruiting pattern which emerges for the overstorey. The other growth forms have more closely circumscribed phenophases.

4.4.2.3 Succulents

Leaf succulents: Growth occurs from autumn to summer (Figure 4.7). This growth form can be divided into two groups - drought-deciduous (eg. Zygophyllum morgsana, Tetragonia fruticosa) and evergreen (some of the Mesembryanthemaceae and Crassulaceae) - with slightly different phenological patterns (Figures 4.11 & 4.12). For the first group there is a definite period of growth from autumn-winter through to spring. Zygophyllum morgsana also has scattered periods of growth at other times. Cotyledon orbiculata and Ruschia spp. grow in late spring. There was
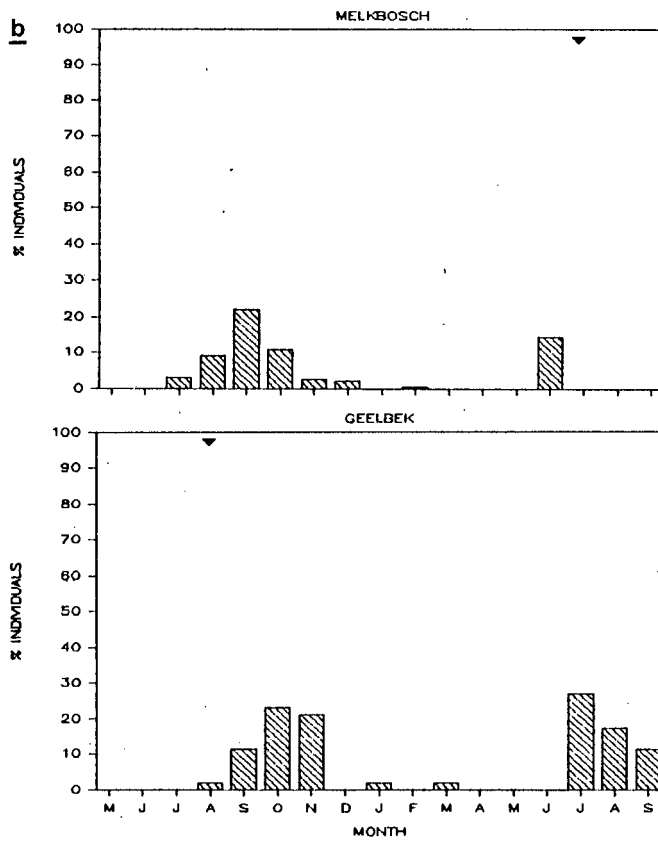
114
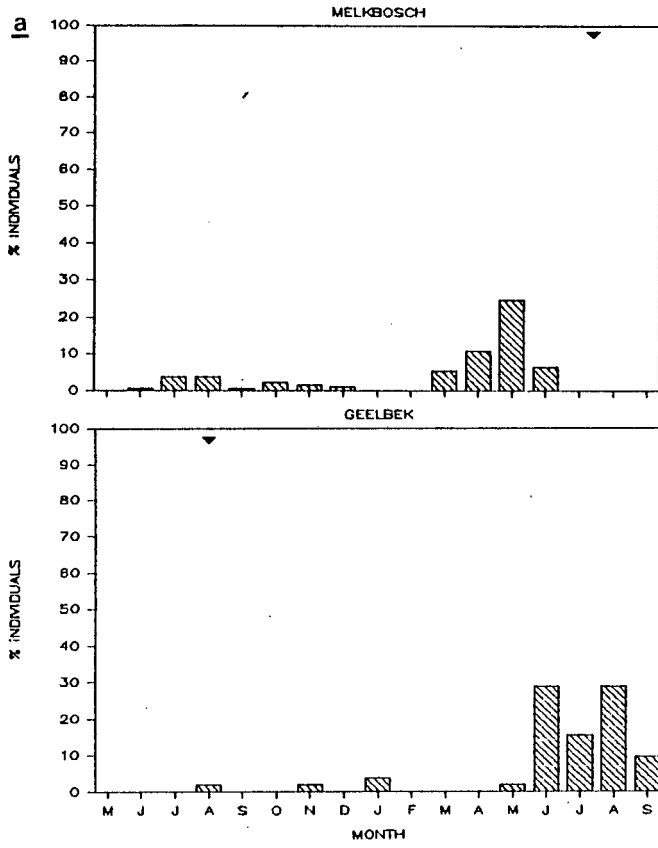
GROWTH

FLOWERING

FIGURE 4.7   (see caption overleaf)

FRUITING

LEAF FALL

FIGURE 4.7 Phenophases of leaf-succulents at Melkbosch and
Geelbek. ▼ indicates begining/end of monitoring period.
a) Stem growth b) Flowering c) Fruiting d) Leaf fall

GROWTH

FLOWERING

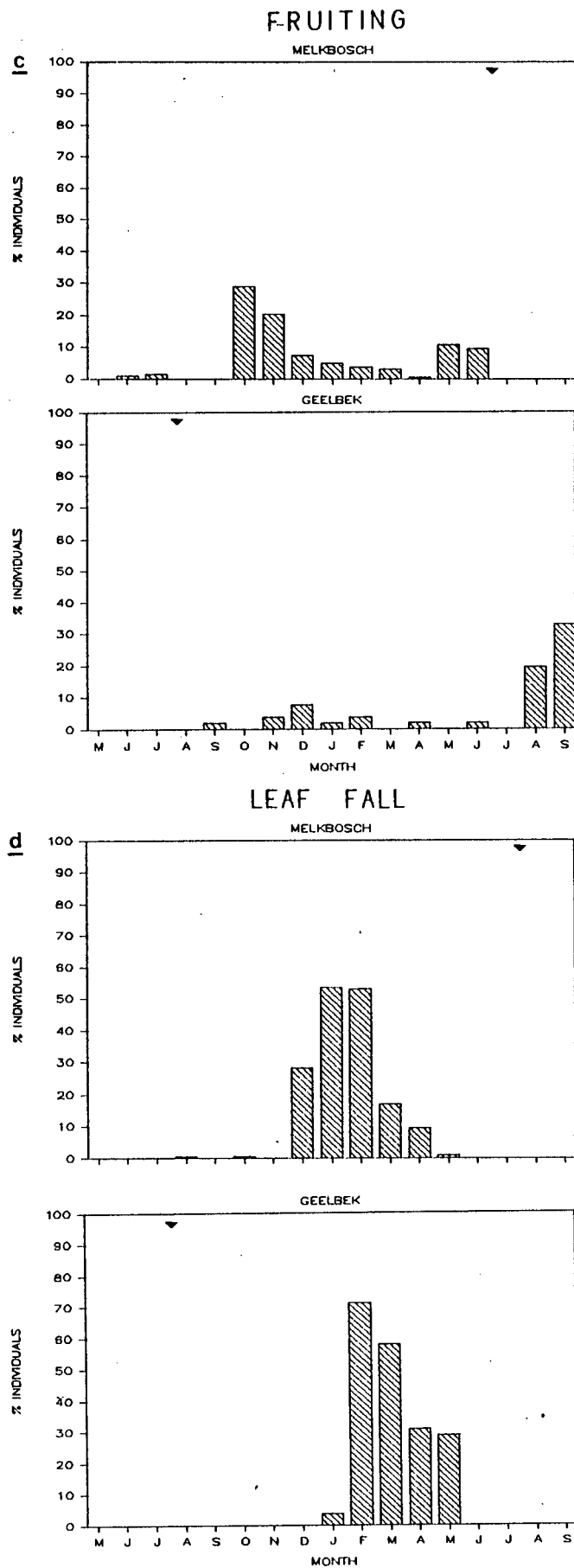FIGURE 4.8   (see caption overleaf)

FRUITING

LEAF FALL

FIGURE 4.8 Phenophases of stem-succulents at Melkbosch and
Geelbek.   ▼ indicates begining/end of monitoring period.
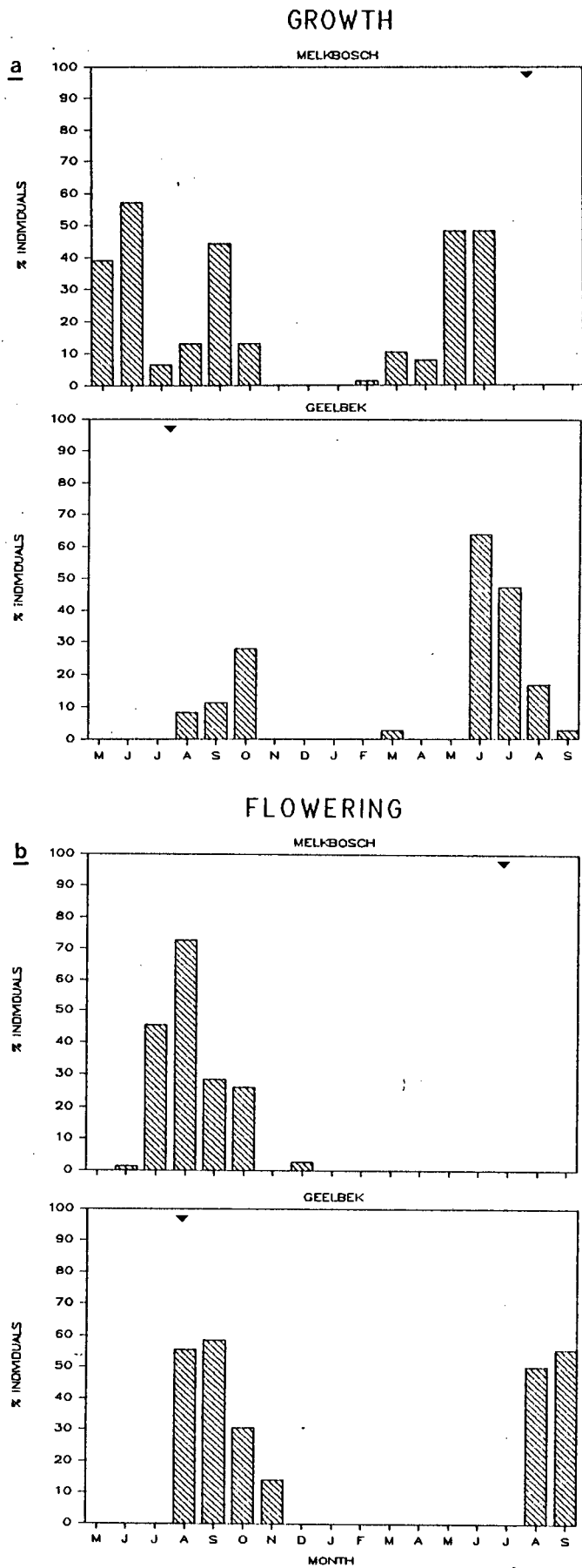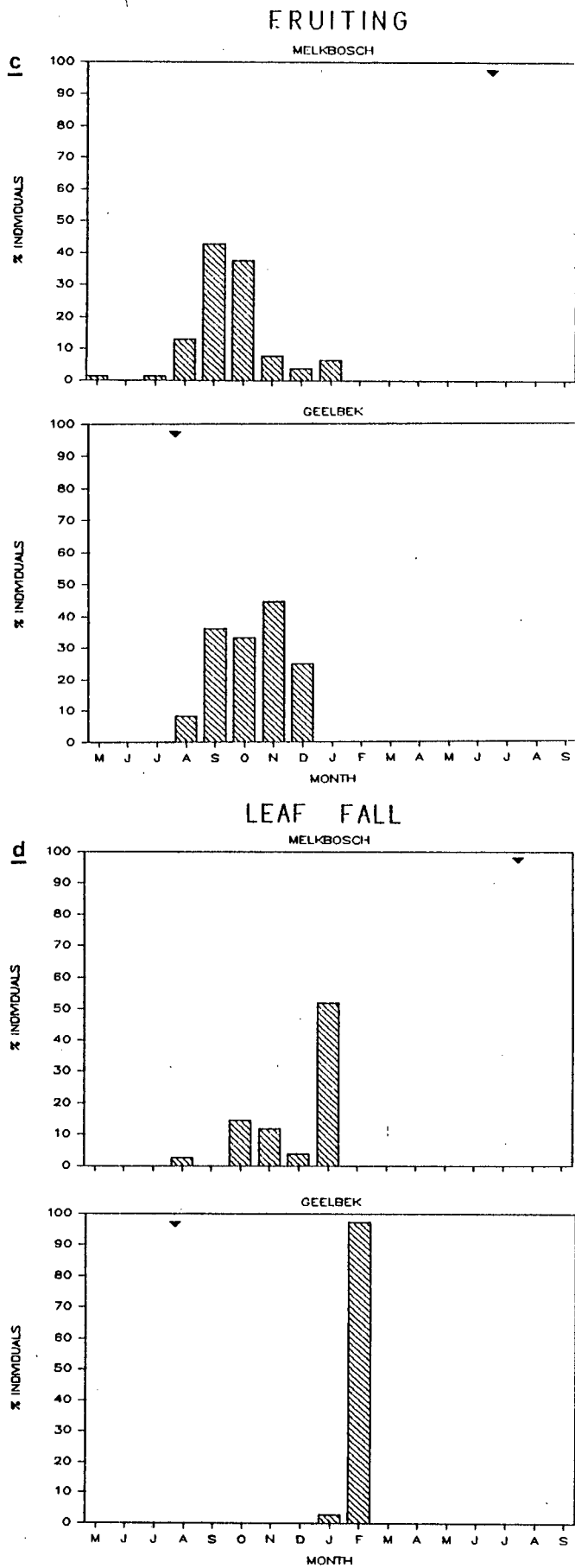a) Stem growth b) Flowering   c) Fruiting   d) Leaf fall

118

generally poor growth of this growth form in 1978 as a result of the winter drought. The proportion of plants that flowered during the study period was also very low for this reason. Most flowering occurs from late winter to late spring with fruiting from spring to summer. In Ruschia and Cotyledon flowering occurs in summer and fruiting in autumn. Leaf fall occurs in summer and autumn, and by February a high proportion of the plants have shed or are shedding leaves.

Stem succulents: At the two study sites these fall within the same genus, Euphorbia, and it is to be expected that their phenophases are very similar (Figure 4.8). Growth occurs from winter to spring, flowering occurs in spring and fruiting from spring to summer. Leaf fall occurs in summer.

In the south eastern Cape dune thickets succulents have peak growth in spring and autumn (Pierce & Cowling, 1984a). Perennial succulents appear not to be a feature of Renosterveld or Sand Plain Fynbos.

4.4.2.4 Graminoids

Grasses: there was little grass in the two study sites, and few species, making it difficult to generalise. There appears to have been little growth of grass in the 1978/79 period (Figure 4.9), presumably as a result of the poor rains. What little there was occurred between late autumn and summer. Flowering occurred in summer and fruiting in summer, together with leaf loss.

The growth of C3 grasses in Pierce & Cowling's (1984a) study area occurred in autumn. In Renosterveld the grasses grow in winter.

119

GROWTH

FIGURE 4.9   (see caption overleaf)

120

FLOWERING

FIGURE 4.9 Phenophases of grasses at Melkbosch and
Geelbek.   ▼ indicates begining/end of monitoring period.
a) Stem growth b) Flowering

121

GROWTH

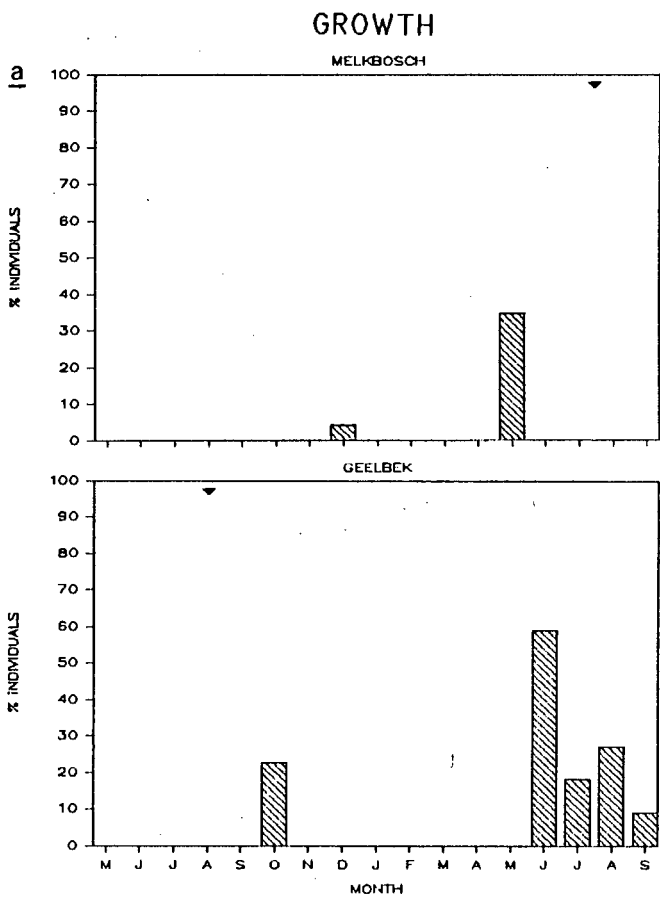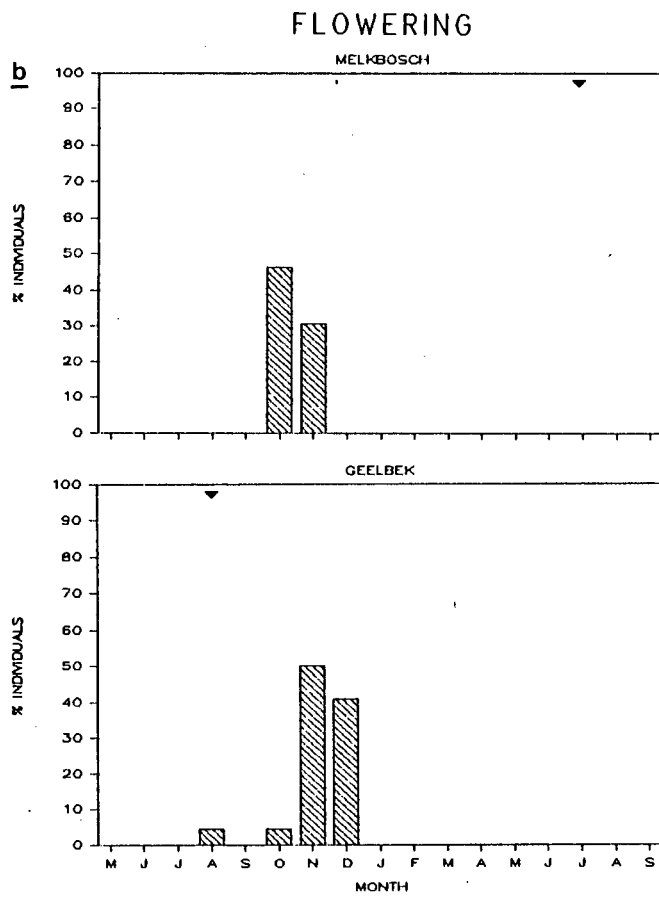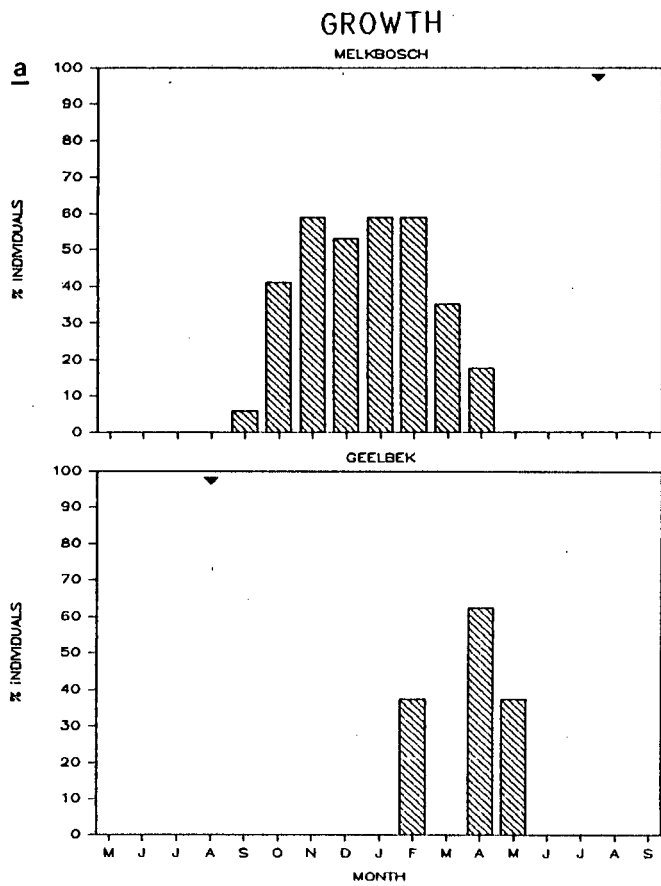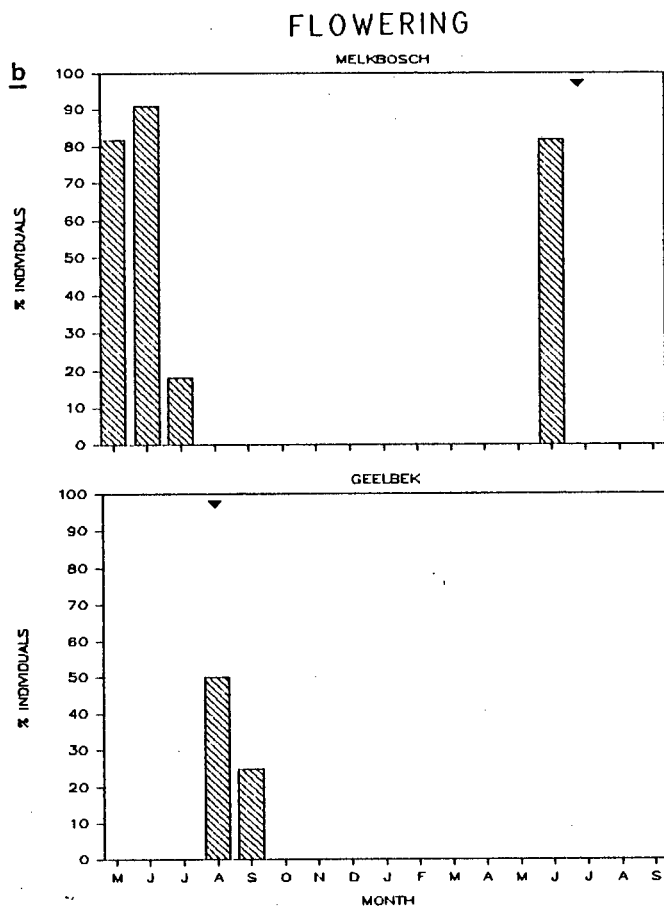FIGURE 4.10   (see caption overleaf)

FLOWERING

FIGURE 4.10 Phenophases of restioids at Melkbosch and
Geelbek. ▼ indicates begining/end of monitoring period.
a) Stem growth b) Flowering

123

Sedges: these grew in autumn and winter, with flowering in winter and spring and leaf fall in autumn.

Restioids: there is quite a bit of variation in the phenophases of Restionaceae. Growth occurs at various times between the beginning of summer and autumn (Figure 4.10). Flowering is in winter and spring and fruiting from winter to the beginning of summer, although some retain their fruit in the summer as well.

Pierce & Cowling (1984a) found a different pattern in the south-eastern Cape dune thicket: restioids there grow in spring and autumn, when most rain falls. The phenological patterns of restioids in Sand Plain Fynbos are very similar to those in Strandveld, except that fruiting appears to be more extended (Appendix D).

4.4.2.5 Annuals and Geophytes

No data exists for these growth forms. From personal observation in Strandveld, both growth forms begin growth early in winter, flower in late winter through spring, fruit in spring and die back quickly with the onset of the summer months.

The pattern is the same in the south-eastern Cape dune thicket (Pierce & Cowling, 1984a).

4.4.2.6 Non-geophytic forbs

The growth of these plants seems to be tightly coupled to the peculiar rainfall distribution during the study period, occurring in autumn and spring. Flowering peaked in spring and summer as did fruiting.
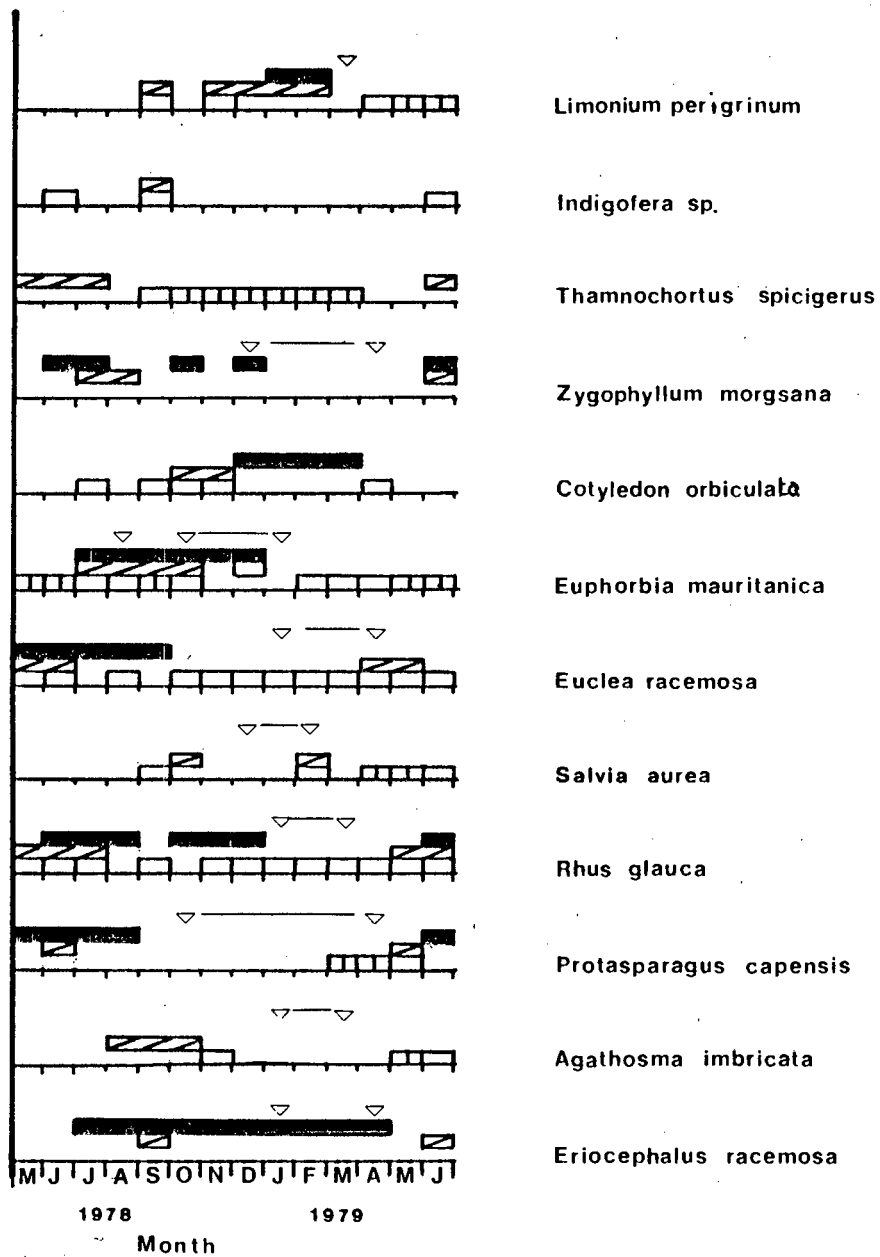
FIGURE 4.11 Phenodiagrams of selected Strandveld species from Melkbosch. ☐☐ <50% individuals growing ☐☐☐ >50% individuals growing ☐☐ flowering ▬▬ fruiting ▽—▽ leaf-fall.
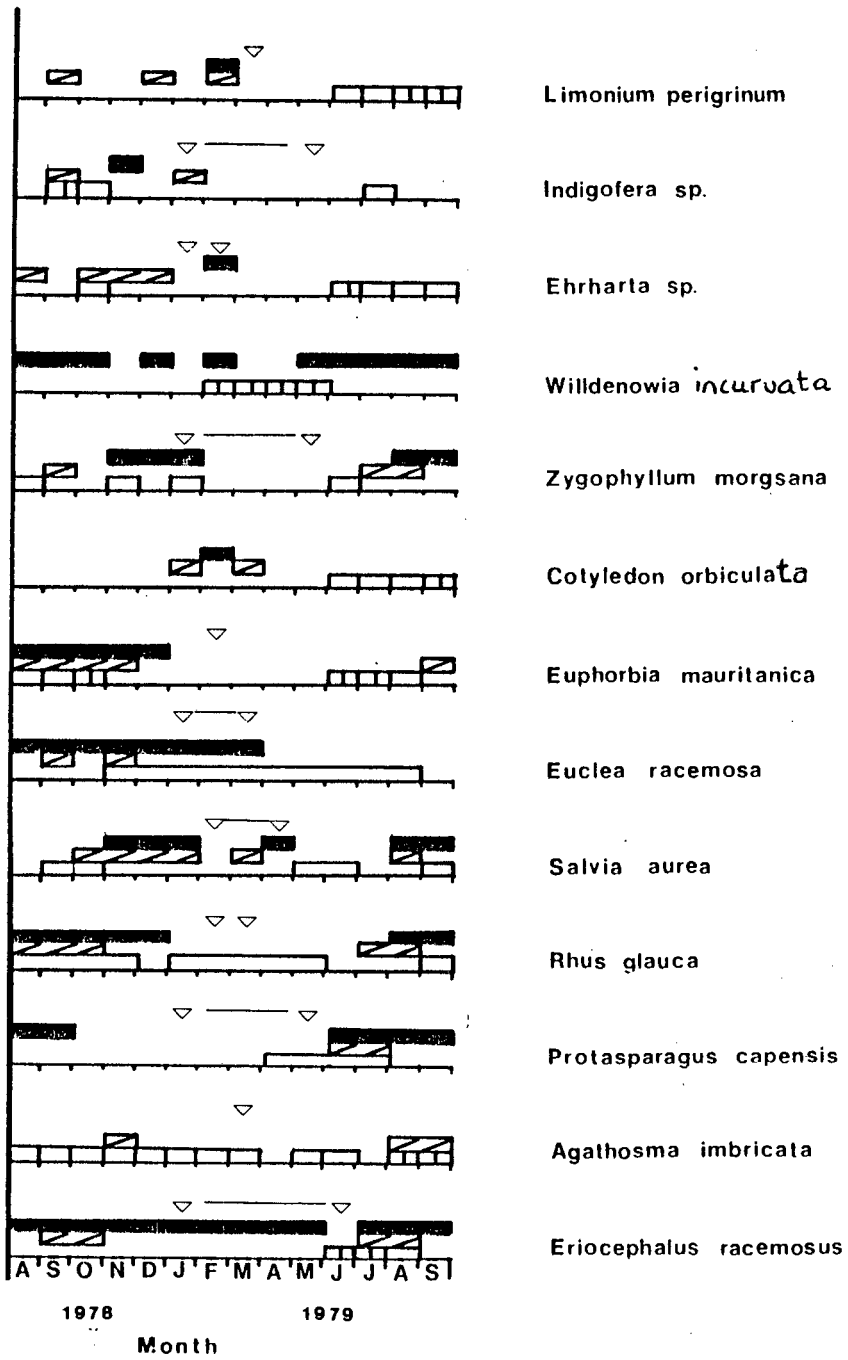
FIGURE 4.12 Phenodiagrams of selected Strandveld species from Geelbek. ☐☐ <50% individuals growing ☐☐☐ >50% individuals growing ▱ flowering ■ fruiting ▽⁻▽ leaf-fall.

Leaf fall occurs in autumn.

4.4.2.7 Parasites

Growth of parasites is scattered, depending probably on the availability
of soil moisture to the host, which is usually one of the broad-leaved
evergreen shrubs. Flowering occurs in spring and summer and fruit are
held on the plants for most of the year, except immediately before new
shoot growth. Leaf fall occurs at two different times: April/May (before
new growth) and January/February (driest time of the year).

4.4.3 ENVIRONMENTAL FACTORS INFLUENCING PHENOPHASES IN STRANDVELD

The Cape West coast has a strongly seasonal rainfall pattern with very
little (<25%) summer rain. This is reflected in the vegetation in a
number of ways. Water is undoubtedly the critical factor limiting growth
and it is not surprising therefore that the peak growth period coincides
with rainfall. With the exception of the 'generalist' evergreen shrubs,
most plants begin growing after the onset of the winter rains. The
controlling influence of rainfall is most obvious in the herbaceous
annuals and perennials - being shallow-rooted and therefore not able to
utilise deep ground water.

It is interesting to observe the effect of the winter drought of 1978
(refer to Table 4.2) on the growth of plants that season. Many plants,
especially in the understorey, showed either little or no growth or
grew very late in the season once adequate rain had fallen. The amount
of growth of herbaceous plants in particular seems to be related to the
amount of rainfall.

It is possible that the onset of flowering in Strandveld plants is temperature dependant, as appears to be the case for other mediterranean shrublands (Kummerow, 1983), since flowering is concentrated in spring but the onset of flowering has been observed to vary from year to year. Flowering and fruiting in many species were adversely affected by the drought in 1978.

Because of the high degree of coincidence of the growth periods of different growth forms there is potentially intense competition during the autumn to spring period for resources, particularly water and nutrients. However, many of the Strandveld shrubs species are resprouters. Their below-ground organs have a substantial capacity for storing nutrients. This can act as a buffer against seasonal variations in the supply and demand of nutrients and may allow these plants to start growing at the same time as the herbaceous layer without competing directly for nutrients. Different season of root growth may also be a factor alleviating competition. Nothing is known of Strandveld root growth and nutrient uptake.

The response of different growth forms to environmental factors such as rainfall may be directly related to their ability to access moisture, ie to their rooting structure and depth. For example, it has been shown in Californian Chaparral that the shallow-rooted herbs start growing at the beginning of the winter rains, followed by the deeper-rooted drought-deciduous species and finally by the most deeply rooted evergreen shrubs (Kummerow, 1983).

Within a growth form there may be different responses to environmental stimuli. For example, broad-leaved shrubs can be split into 1.

128

'generalists' which are opportunistic growers, making use of whatever soil moisture is available. They probably have deeper rooting systems.

2. more 'specialist' plants such as _Salvia aurea_ and _Olea exasperata_ which seem to require a combination of favourable temperature and moisture for growth and therefore grow in autumn and spring.

Evergreen shrubs need a small but continuous supply of moisture (Specht, 1982). They only occur in areas of higher soil water availability such as dune slacks and west-facing slopes that catch the fog. Many of the evergreen shrubs have sub-tropical or temperature forest affinities, but have wide phenological tolerances that can exploit winter rains. Their occurrence in this arid environment is due to their ability to utilize water resources whenever they are available.

Some shrubs appear to have other factors determining growth timing - for example _Phylica stipularis_ and _Metalasia muricata_. These 'fynbos' plants occur in Strandveld where soil moisture in summer is adequate to allow them to grow. Further north where the drought is more severe they disappear from the vegetation.

Using the data from the western coastal lowlands it should be possible to test Specht's model by examining the growth periodicity of the Sand Plain Fynbos, Coastal Renosterveld and Strandveld. The model predicts both the Barhuis (Sand Plain Fynbos) and De Grendel (Coastal Renosterveld) growth phenophases. Generally the phenological patterns in Strandveld are very similar to those in Renosterveld. This similarity in phenology goes against Specht's overstorey/understorey model, since Strandveld occurs on Ca-rich neutral to alkaline soils, and should suffer from induced nutrient stress and therefore have different phenophases to Renosterveld

which occurs on moderately leached soils. Strandveld phenology is better predicted if one considers it to be a mesotrophic soil rather than a Ca-rich soil. Although Ca levels in the soil are high at both Melkbosch and Geelbek, no apparent nutrient stress, particularly P stress, is apparent, because the levels of total phosphorus in the soil are high to begin with (refer to Table 4.1). It may also be that where moisture stress is more crucial than nutrient stress Specht's model needs modification.

Pierce & Cowling (1984(b)) also found Specht's model wanting in the case of communities on Ca-rich soils, ie. dune scrub, in the south-eastern Cape.

Leaf fall of overstorey plants is highly synchronous in Strandveld, brought on by increasing soil aridity as summer progresses. It is thought that the length of the dry period determines to what extent the vegetation is drought-deciduous (Miller, 1982). Where summer drought is long the vegetation tends to be essentially leafless in summer. This leads to the barren appearance of Strandveld further north along the west coast in late summer, the hottest and driest time of the year. A change in the wind patterns, (an increase in dry south-easterly winds), in summer accelerates the decrease in soil moisture.

Since leaf fall occurs after shoot growth in most Strandveld plants there is a maximum of photosynthetic tissue in spring(Specht & Moll, 1983). The extra foliage is an advantage at this time of the year as it boosts photosynthetic production. The disadvantage, however is that it leads to increased evapotranspiration and a reduction in soil water conserved for the summer. Where rainfall is low but temperatures high, rapid use of

water is advantageous or the water will evaporate from the soil. Soil evaporation and high transpiration rates favour drought-deciduous species (Miller, 1982). Since the summer is very dry and hot, maximizing growth during optimal conditions, together with developing mechanisms to survive summer drought, is probably the best strategy open to the plants.

4.4.4 STRANDVELD PHENOLOGY IN COMPARISON WITH THAT OF MEDITERRANEAN SHRUBLANDS ELSEWHERE IN THE WORLD

Based on the data analysed here, the seasonal processes in Strandveld seem to be similar to those of the mediterranean shrublands of California (chaparral and Coastal Sage Scrub) and Chile (matorral), as well as the dry scrub of the Mediterranean Basin.

Californian Coastal Sage is the closest equivalent to Strandveld in terms of plant growth forms and dynamics. It is a mesophyllous drought-deciduous scrub occurring at low elevations in coastal southern California. It is distinct from chaparral in many features, including phenology. Plants are generally shallow-rooted with drought-intolerant leaves. Growth occurs for five to six months after the onset of the winter rains. It is essentially leafless in summer (Gray, 1982; Westman, 1982). Very few species lose all their leaves in summer. A common adaptation to summer water stress in sage shrubs is seasonal dimorphism of leaves (Westman, 1982). This phenological strategy occurs in most of the drier mediterranean-climate regions (Specht et al., 1983). It is best developed in the Mediterranean Basin, but has also been reported from Chile. It does not occur in sclerophyllous shrubs. With the onset of the dry summer season, smaller leaves grow on side shoots developing from the axils of the normal, larger main-shoot leaves, which are shed.

The incidence of this phenomenon in Strandveld needs to be checked.

Of the six important shrub species in Chilean matorral, three grow from mid-winter to summer and three start growing in late spring. The former are shallow-rooted, drought-deciduous or semi-deciduous species and the latter are deeper-rooted evergreen species. Leaf fall of the deciduous species occurs in late summer (Montenegro et al., 1982).

The main shrubs species of Californian chaparral have similar phenophases, with shoot growth from late winter to early summer. Deciduous and semi-deciduous shrubs grow in winter and spring with leaf fall in summer. Evergreen shrubs grow in spring and summer (Kummerow, 1983).

Flowering in chaparral shrubs peaks from May to July (spring - summer), with fruiting following. In matorral on the other hand flowering extends over the whole year, with a slight peak in early summer. Fruiting has a protracted peak in late summer and autumn. Temperature has been shown to be a controlling factor for flowering in chaparral (Kummerow, 1983).

Leaf fall is highly synchronous in both Californian and Chilean shrublands, occurring in the late summer, and is obviously related to decreasing moisture availability. In California and Chile the length of summer drought is thought to control sclerophylly (Miller, 1982). In California where summer drought is <100 days, evergreen shrubs predominate.

In Chile the herbaceous understorey (mainly annuals) of Coastal Matorral grows mainly in winter and early spring. Growth has been shown to vary annually with the amount and distribution of rainfall, which is clearly

the case in Strandveld understorey. Flowering of undergrowth species occurs in spring (Montenegro et al., 1982).

Kummerow (1983) suggests that in both Chile and California the timing of growth initiation is correlated to soil moisture availability and rate of growth is related to ambient temperature.

In Israel mediterranean vegetation grows and flowers predominantly in spring (Schmida & Barbour, 1982). A few species flower in early winter (Kummerow, 1983). Summer precipitation is absent so there is dramatic seasonality of climate and consequently vegetation. The vegetation is characterised by a high diversity of annuals. In 'phrygana', or 'batha', comparable to sage-scrub in California and drier Strandveld, the vegetation is dominated by drought-deciduous subshrubs with shoots that partly die back in summer. Seasonal dimorphism of leaves occurs (Schmida & Barbour, 1982).

In general the seasonal processes of Strandveld plants fit the pattern found in other Mediterranean-type shrublands.

4.4.5 IMPLICATIONS OF STRANDVELD PHENOLOGY FOR ITS MANAGEMENT AS A NATURAL PASTURE

The long-term survival of Strandveld as a natural pasture resource depends on its efficient management and utilization, which in turn rely on a sound understanding of the vegetation and its constituent species. Phenological studies provide one source of information towards understanding the how and why of vegetation dynamics. The correct timing of veld burning and the establishment of suitable grazing regimes require an input of phenological information.

Moll (1987) shows that non-heath shrublands are least susceptible to fire damage during that time of year when they are most likely to burn - mid- to late-summer. In Strandveld few shrubs grow in the summer months and most of the herbaceous understorey is dormant or dead. Most plants have already flowered and set seed by then. Those evergreen species that may grow in the summer are generally resprouters and recover well from fire. Strandveld is unlikely to burn in the wet months as there is little fuel.

Westman (1982) has found that the recovery of coastal sage scrub in California is very sensitive to the time of year of applied stress. Defoliation stresses (fire and grazing) are least damaging in summer and autumn (June to November) and most damaging in winter and spring. The same is almost undoubedtly true of Strandveld.

At Nortier, Lamberts Bay, a camp that was subjected to grazing every spring for a number of years was devastated. Now, some 10 years later, the vegetation has not yet recovered.. Ground cover is sparse. There is very little grass and many small succulents and other unpalatable plants occur. The herbaceous palatable species were virtually wiped out.

On another farm in the area, a two-phase grazing regime has been put into practice with positive effects on the vegetation generally and the grass cover in particular (D. Frey, pers. comm.). During the wet months when most plant growth occurs, a multi-camp, short-rotation system is implemented which allows the herbaceous plants, and the grasses in particular, to recover. In the dry months a few large camps are grazed for several months at a time. At this time of the year little damage can be done to the vegetation. The positive effects of this system are the

result of it fitting in with the seasonal cycle of the vegetation.

There is one other aspect of the phenological behaviour of Strandveld
that has implications for its use as pasture - that the onset of growth,
particularly of the herbaceous plants, depends on the onset of ·the·
winter rains, and the amount of growth depends on the amount of rainfall.
The herbaceous layer therefore varies annually, as well as seasonally.
An effective pasture utilization strategy should be flexible enough to
accommodate this variability.

4.5 CONCLUSIONS

This has been a descriptive account of the phenology of West Coast
Strandveld in the Melkbos - Langebaan area, and of the growth forms that
occur in it. The data presented here are really only valid locally, but
serve to give an indication of the seasonal processes that occur in this.
vegetation type as a whole. The general applicability of the pattern
described here requires testing with further data. Year-to-year
differences in the amount and distribution of rainfall can result in
large differences in growth from one tear to the next, making the
determination of general phenological;patterns more difficult. Longer-
term studies are needed.

Based on the qualitative data analysed here it is clear that West Coast
Strandveld has highly seasonal growth, flowering and leaf fall. Growth
is primarily in the wet months from autumn to spring, flowering occurs
mainly in spring and leaf fall is concentrated in late summer. This fits
the patterns that have been determined for comparable mediterranean
shrublands elsewhere in the world. Most of the growth forms found in

Strandveld vegetation have similar phenophases: grasses, annual herbs, geophytes, succulents and some shrubs all grow at the same time. Differences in rooting systems and underground storage organs may account for their ability to compete with each other.

It would seem that the major factor controlling the onset of growth in Strandveld is moisture availability, which is related to the pattern of rainfall. Flowering is more dependant on temperature and photoperiod. However, the details of these controlling mechanisms and the interplay between the various factors are unknown. Comparative quantitative measurements of shoot growth along the rainfall gradient that exists on the west coast may provide some insight into the nature of the relationship between growth and moisture. Detailed autecological and physiological studies are required. No data exist, for example, on root architecture and its effect on the availability of soil moisture to plants, or on root growth of Strandveld plants. Research is also needed on nutrient cycling in Strandveld. Such data would allow the testing of hypotheses regarding the control of phenophases.

A better understanding of Strandveld dynamics would inevitably lead to better management of the vegetation, both for agricultural and conservation purposes.

4.6 CHAPTER SUMMARY

The main factors controlling the seasonality of growth, flowering, fruiting and leaf fall in vegetation are factors of the environment and partitioning of resource use by the plants. Climatic factors such as amount and distribution of rainfall, air temperature and photoperiod have been demonstrated as factors controlling the initiation of various

phenophases. The role of soil nutrient status has also been shown. The partitioning of resource use in both time and space is more difficult to determine empirically. Plants of different growth forms occupy slightly different spaces and respond differently to environmental stimuli. This allows greater co-existence of species.

The phenology of Strandveld scrub was studied at Melkbosch and Geelbek. Growth of the community as a whole occurs at all times of the year, but is concentrated from winter to spring; flowering is concentrated in spring and early summer, followed by fruiting. Leaf fall is highly synchronous, occurring in late summer/autumn.

The phenological patterns for the most of the plant growth forms follow a similar pattern to that of the community as a whole. The exceptions are the shrubs, both broad-leaved and small-leaved. Many evergreen broad-leaved shrubs grow at any time during the year, although some seem to have spring and autumn peaks. Flowering is scattered as is fruiting. Small-leaved shrubs include both winter/spring growers and summer growers. Flowering and fruiting are also spread out. Leaf- and stem-succulents grow from autumn to spring, flower in spring and lose their leaves in summer. Grasses grow in winter and spring and flower in summer, while sedges grow in autumn and winter and flower in winter and restioids grow in summer and flower in winter.

The annual rainfall pattern, wet winters and hot dry summers, is the primary factor controlling the onset of growth and leaf fall. The onset of the winter rains triggers growth in most growth forms, but the deeper-rooted evergreen shrubs can grow whenever they have access to ground-water. Leaf fall occurs as summer advances and moisture becomes

limiting. The combination of favourable moisture and temperature conditions in spring controls the onset of flowering.

Competition between plants for nutrients and water is probably reduced as a result of different rooting strategies, different periods of root growth and nutrient uptake and nutrient storage. Nothing is known about these in Strandveld.

The phenology of West Coast Strandveld fits the pattern predicted by Specht's model, if Strandveld is considered to occur on mesotrophic soils. Strandveld phenology is similar to that of mediterranean-type shrublands elsewhere in the world. It has been found that these shrublands are most sensitive to applied stress in winter and spring and least sensitive in summer and autumn. This relates directly to the phenological patterns of these shrublands. An understanding of Strandveld phenology is therefore important for the sound use and management of the vegetation.

4.7 REFERENCES.

GRAY J T 1982. Comparative nutrient relations in adjacent stands of Chaparral and Coastal Sage Scrub. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 306 - 312.

GROVES RH (convener) 1983. Introduction: the origins and characteristics of mediterranean ecosystems. IN: Mineral nutrients in mediterranean ecosystems, ed Day JA. South African National Scientific Programme Report No. 71, Pretoria: CSIR. pp 1-17.

KRUGER F J 1981. Seasonal growth and flowering rythmns: South African heathlands. IN: Heathlands and related shrublands of the world. B. Analytical studies, ed Specht R L. Amsterdam - Oxford - New York: Elsevier.

KUMMEROW J 1983. Comparitive phenology of mediterranean-type plant communities. IN: Mediterranean-type ecosystems: the role of nutrients, eds FJ Kruger, DT Mitchell & JUM Jarvis. New York: Springer. pp 300 - 317.

MILLER P C 1982. Nutrients and water relations in mediterranean-types ecosystems. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 325 - 330.

MOLL EJ 1987. Phenology of mediterranean plants in relation to fire season. (in press)

MONTENEGRO G, ALJARO M E, WALKOWIAK A & SAENGER R 1982. Seasonality, growth and net productivity of herbs and shrubs of the Chilean Matorral. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 135 - 141.

MOONEY H A 1983. Carbon-gaining capacity and allocation patterns of mediterranean-climate plants. IN: Mediterranean-type ecosystems: the role of nutrients, eds FJ Kruger, DT Mitchell & JUM Jarvis. New York: Springer.

MOONEY H A & KUMMEROW J 1980. Phenological development of plants in mediterranean-climate regions. IN: Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 303 - 307.

PIERCE S M 1984. A synthesis of plant phenology in the Fynbos Biome. South African National Scientific Programmes Report No. 88, Pretoria: CSIR.

PIERCE S M & COWLING R M 1984(a). Phenology of fynbos, renosterveld and subtropical thicket in the south eastern Cape. South African Journal of Botany 3(1): 1 - 16.

PIERCE S M & COWLING R M 1984(b). Seasonal growth of the overstorey and understorey in mediterranean-type shrublands and heathlands in the south eastern Cape, South Africa. South African Journal of Botany 3(1): 17 - 21.

SHMIDA A & BARBOUR M 1982. A comparison of two types of mediterranean scrub in Israel and California. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58, United States Department of Agriculture. pp 100 - 106.

SIEGFRIED W R 1982. Trophic structure of some communities of Fynbos birds. IN: Proceedings of a symposium on coastal lowlands of the western Cape, ed E Moll. University of the Western Cape. pp 31 - 45.

SPECHT R L 1982. General characteristics of mediterranean-type ecosystems. IN: Proceedings of the symposium on dynamics and management of mediterranean-type ecosystems. General Technical Report PSW-58,

United States Department of Agriculture. pp 13 – 19.

SPECHT R L & MOLL E J 1983. Heathlands and sclerophyllous shrublands
– an overview. IN: Mediterranean-type ecosystems: the role of
nutrients, eds FJ Kruger, DT Mitchell & JUM Jarvis. New York: Springer.

SPECHT R L, MOLL E J, PRESSINGER F & SOMMERVILLE J 1983. Moisture
regime and nutrient control of seasonal growth in mediterranean
ecosystems. IN: Mediterranean-type ecosystems: the role of nutrients,
eds FJ Kruger, DT Mitchell & JUM Jarvis. New York: Springer. pp 120 –
132.

SOMMERVILLE J 1983. Seasonal processes in coastal fynbos. Unpublished
M.Sc. thesis, University of Cape Town.

WESTMAN W E 1982. Coastal Sage Scrub succesion. IN: Proceedings of the
symposium on dynamics and management of mediterranean-type ecosystems.
General Technical Report PSW-58, United States Department of Agriculture.
pp 91 – 98.

5 FIRE IN STRANDVELD

5.1 INTRODUCTION

Deacon (1983) believes there is a long history of burning of the veld in the fynbos region. The food-getting strategies of the hunter-gatherers relied on fire management; to encourage the growth of underground parts, like corms of watsonias, and as a means of providing attractive grazing for game. Hunter-gatherer ethnography provides some evidence for this, for example Bleek's reports cited by Hitchcock & Ebert (1985).

The advent of pastoralism in the Cape would have introduced a new aspect to veld burning, particularly in the lowlands, in that burning for improving grazing would have increased the frequency of fires (Edwards, 1985). There are a number of reports of veld being burnt in the accounts of early travellers and settlers (Sparrman, 1795; Thom, 1952; Raven Hart, 1967). Botha (1924) reviewed early burning practices and legislation, and cites Kolbe as writing that the Cape farmers learnt veld burning from the Khoikhoi who burnt grass when it became old. Burning of grazing lands apparently occurred about every three years, which impoverished the flora and caused the vegetation to change from shrubland to low bushes, annuals and graminoids (Marloth, 1924; Pillans, 1924).

Controls were introduced very early in the history of the settlement of the Cape. In 1658 burning was forbidden in summer, and in 1687 penalties were introduced for illegal fires. The purpose of these laws was, however, not conservation of the vegetation but the protection of property (Edwards, 1985). Botha (1924) notes that scant attention was paid to these laws, and veld was burnt regularily and regardless of season.

Much of the early writing on burning of the veld usually referred to the mountains or to the south-western Cape generally. There are no specific historical records on burning in the western coastal forelands, but since Strandveld provides relatively good natural pasture it may have suffered as a result of regular burning as much as any other area. Kruger & Bigalke (1984) feel that Strandveld has had few fires in the past, due to its sparse canopy and abundant succulents. This may be true of Strandveld further north. Boucher (1982) on the other hand suggests that Strandveld has been exposed to frequent burning.

In their review of fire in the Fynbos Biome Kruger & Bigalke (1984) state that patch burning is still prescribed in some lowland areas, particularly on the south coast; usually on about a six-year cycle, and at the end of the wet season prior to the introduction of stock. Burning of the veld in the coastal lowlands of the south-western Cape is primarily for the reduction of unpalatable plant material and the stimulation of new growth as pasture for domestic stock.

Although there does not appear to be much regular burning of the Strandveld today, burning of veld was practised in the past and still is in some areas. Burning occurred on about a six- to ten-year interval (Mr. B. Duckitt, pers. comm.). That part of the veld subject to burning is the more open vegetation, not the dense thicket of the dune areas, which does not burn readily. Wild fires have swept through some areas over the past few years, for example in the Darling district.

Guidelines for veld-burning in the west coast 'sandveld' (a region including both Strandveld and Sand Plain Fynbos) have been established by agricultural extension officers in that region (Viljoen, 1987).

142

Accordingly the same area of veld may not be burnt again for less than 10 years after a fire, and coastal dune veld should never be burnt. The period in which burning may occur is March to June, which does not correspond to the fire season for the coastal areas (December - February) as defined by van Wilgen (1984a). Specific weather conditions are suggested as unsuitable for burning. For example, days with hot north-easterly winds or westerly winds should be avoided as they apparently cause a hot, fast burn and result in a longer recovery period for the vegetation.

In this study, two aspects of fire in Strandveld were looked at briefly: 1 the post-fire succession; 2 fire behaviour.

5.2 POST-FIRE SUCCESSION OF STRANDVELD

5.2.1 INTRODUCTION

There are four ways in which plants survive fire: as seed, as geophytes, by resprouting from root-crowns, lignotubers or epicormic buds or by insulation (eg. thick bark). In Strandveld many of the dominant shrubs are resprouters and the herb layer contains sprouters, annuals and geophytes. Most plants in Strandveld should be able to regenerate fairly quickly after a fire.

The recovery of vegetation after a fire and its progression to stable mature communities depends to a large extent on the nature of the fire. Fire intensity, frequency and season of burn all influence the composition, structure and dynamics of vegetation (Kruger & Bigalke, 1984). High intensity fires can lead to mortality of sprouters, while

143

low intensity fires apparently favour graminoids and restioids. The effect of fire frequency depends on the time taken by plants to reach reproductive maturity, and their growth form. Short intervals between fires can change tall shrubland to low herbaceous shrubland, with a concommitant reduction in above-ground biomass. A low frequency of fires is thought to favour sprouting shrubs (Kruger & Bigalke, 1984). The impact of season of burn depends on the season of growth and reproduction of the plants. In a highly seasonal vegetation such as Strandveld fires during the dormant period will have different consequences to those of fires in the growth period. Season of fire influences the intensity of the fire too.

Joubert (1969), in a series of experiments on the vegetation at Bok Bay, found that the veld deteriorated badly as a result of burning and that recovery was slow. Three years after the fire total basal cover was half what it had been before burning, and there was no increase in palatable vegetation as a result of the fire. The following year grass cover increased significantly, pushing total basal cover to above what it had been before. At Nortier fire was found to encourage grasses and Restionaceae, but the shrubs struggled and recovery time is long (D. Frey, pers. comm.). Variations in rainfall probably influence recovery significantly.

The development of plant communities after fire can be divided into a number of stages (Kruger, 1977; Kruger & Bigalke, 1984). 1. the immediate post-fire stage (about 12 months), which is dominated by hemicryptophytes, annuals and geophytes, which all reach reproductive maturity. During this stage most of the species start to regenerate. 2. youth stage (about 4-5 years), during which sprouting shrubs,

Restionaceae and grasses flourish and cover reaches about 80% of the pre-
burn level. Sprouting shrubs usually reach reproductive maturity at this
stage. 3. the transitional stage (up to 10 years after the fire) during
which most species become reproductively mature. 4. the mature stage,
where tall shrubs reach their maximum height. 5. senescence. Although
this successional scheme was devised for mountain fynbos, it is general
enough to apply to other vegetation types.

Duckitt (1985), in a study of mixed Strandveld - Sand Plain Fynbos, found
that structural changes were more important than floristic changes after
fire. He found a general increase in total cover and litter cover with
increasing post-fire age, with a concommitant reduction in bare ground.
He also found that herbaceous species comprised a larger proportion of
the total species in the first year than in subsequent years, which from
what Kruger & Bigalke (1984) have suggested is a feature of the immediate
post-fire stage of succession. Duckitt also found that that proportion
of the cover consisting of woody species increased dramatically from year
1 (30%) to year 2 (80%). There was very little grass found throughout
the plots, probably a consequence of grazing by domestic animals. The
number of geophyte species peaked one year after the fire and dropped off
after that.

5.2.2 AIMS AND METHODS

In order to further examine the post-fire succession in Strandveld and
the effects of fire on composition and structure, a study was undertaken
comparing the composition and cover of three patches of vegetation (Table
5.1) of differing post-fire age in the Darling area. The patches were
relatively close to each other, with no obvious differences in habitat.

145

One patch was dense mature vegetation, unburnt for a long period. The second patch was younger (about 10-12 years (Mr. B Duckitt, pers. comm.)), fairly dense shrubland, probably reaching the end of the transitional stage. The third patch had been burnt two and a half years previously, and was therefore in the juvenile stage.

A Braun-Blanquet quadrat, 50x20 m in area, was set out in each of three patches of Strandveld and cover-abundance values were estimated in the usual way on a modified Braun-Blanquet scale (see Table 5.2) for each species present in the quadrat. Cover was also estimated for each of the strata and for the different life-forms and growth-forms. The data from the three areas was compared and contrasted.

5.2.3 RESULTS

The major successional changes that occur in Strandveld after a fire relate to the structure of the vegetation rather than the floristic composition. There is a large increase in the cover of broad-leaved evergreen shrubs with increasing age of the vegetation and a concommitant decrease in bare ground. A decrease in the cover of fine-leaved shrubs occurs, while that of succulents increases. Litter cover also increases (Table 5.2).

Total cover was low in the plot 1 (30%). Annuals and geophytes were common, but contributed only a small proportion of the cover. Hemicryptophytes had also recovered well from the fire. The shrubs, mostly resprouters, were slower in their recovery. Only Eriocephalus africanus resprouted rapidly and well, and was highly visible in the

146

TABLE 5.1. Structural differences between plots of different age

PLOT	AGE	STRUCTURE
1	2.5 years	Low open graminoid shrubland
2	uncertain, 10 - 12 years?	Mid-high mid-dense shrubland
3	unknown, but old	Mid-high dense to closed shrubland

TABLE 5.2. Differences in cover between the three plots (50m x 20 m)

	PLOTS		
	1	2	3
HEIGHT (m)	1	1.5	1.5
TOTAL COVER (%)	30	60	85
SHRUB STRATUM COVER (%)	20	50	80
GROUND LAYER COVER (%)	10	15	20
BRAUN-BLANQUET COVER-ABUNDANCE VALUES ‡			
Raunkier life-forms:			
Phanerophytes	2	3	5
Hemicryptophytes	1	2	+
Chamaephytes		+	+
Geophytes	+	+	+
Therophytes	+	+	+
Parasites		+	+
Growth forms:			
Woody plants - Broad-leaved	1	2	4
- Fine-leaved	2	1	1
- Evergreen	2	3	4
- Deciduous	1	1	1
Succulents - leaf succulents	r	+	1
- stem succulents		+	1
Climbers		+	+
Litter	+	1	2
Bare ground	4	3	1

‡ Cover scale   r rare

+ sparsely/very sparsely present <1%   3 any number, cover 26-50%
1 plentiful, small cover value 1-5%   4 cover 51-75%
2 very numerous, cover 5-25%   5 cover >76%

147

vegetation, having flowered and set fruit. Most of the typical Strandveld shrubs were present, except _Euclea racemosa_ and _Pterocelastrus tricuspidatus_.

Plots 2 and 3 had a much higher cover of shrubs, and a slightly higher cover of the herbaceous layer as well (Table 5.2). The degree of overlap between the two strata increased with age. There was an increase in the height of the vegetation between plot 1 and plots 2 and 3.

The floristic composition of the three plots was similar (Appendix B), although there were several species present in plots 2 and 3 that were absent in plot 1 and vice-versa. There was only a small increase (3) in the numbers of species present in plot 3 as opposed to plots 1 and 2 (Table 5.3). The proportions of species in the different growth forms varies between the three plots. The number of shrub species was slightly lower (2) and the number of succulents higher in plot 3 than in the other two plots. The number of geophytes was highest in the youngest vegetation. Climbing species and geophytes only occurred in plots two and three.

The relative abundances of the various shrub species changes from plot 1 through to plot 3; from _Eriocephalus africanus_ and _Colpoon compressum_ being dominant to _Euclea racemosa_ dominance (Table 5.4).

TABLE 5.3. The number of species in various growth forms

GROWTH FORM		PLOT 1	PLOT 2	PLOT 3
Woody species	– broad-leaved	6	7	8
	– fine-leaved	8	7	4
	– evergreen	12	10	8
	– deciduous	2	4	4
Succulents	– leaf	2	3	7
	– stem	2	2	1
Herbs	– annual	6	4	6
	– perennial	7	9	9
Geophytes		8	2	3
Climbers		-	4	3
Parasites		-	1	1
TOTAL NUMBER OF SPECIES		39	39	42

TABLE 5.4. Dominant shrub species in each plot

SPECIES	BB COVER VALUE Plot No.		
	1	2	3
Salvia aurea	1	+	
Phylica stipularis	1	+	
Phylica cephalantha	1	+	
Colpoon compressum	2	1	
Rhus tomentosa	1		+
Olea exasperata		1	+
Pterocelastrus tricuspidatus		2	2
Euclea racemosa		+	3
Nylandtia spinosa			1
Eriocephalus africanus	2	1	+
Euphorbia mauritanica	+	+	2
Chrysanthemoides monilifera	+	+	1
Putterlickia pyracantha	1	2	1

(Cover-abundance symbols as for Table 2)

5.3.4 <u>DISCUSSION</u>

Some of the results obtained here confirm some of Duckitt's (1985) findings: namely that the general increase in total cover and litter cover with increasing post-fire age, with the concommitant reduction in bare ground.

The change in the relative abundances of the various shrubs species is related to the successional status of the various species. <u>Eriocephalus</u> <u>africanus</u> can be thought of as a 'pioneer' shrub, very quick to resprout and reach reproductive maturity. <u>Euclea</u> <u>racemosa</u>, <u>Pterocelastrus</u> <u>tricuspidatus</u> and <u>Olea</u> <u>exasperata</u>, on the other hand, are regarded as climax Strandveld species, dominating in dense thickets.

The high cover of hemicryptophytes in plot 2 is due to <u>Willdenowia</u> <u>incurvata</u> being abundant in that plot. Little of the hemicryptophyte cover was grass, due primarily to regular grazing of the veld by cattle (in plot 1, within six months of the fire (Mr. Duckitt, pers. comm.)).

The relatively similar species composition of the plots fits with Kruger & Bigalke's (1984) statement that within a year of a fire most species have regenerated. The floristic change that does occur is mainly due to 1. the establishment of climbers (<u>Microloma</u> <u>sagittatum</u>) and parasites (<u>Viscum</u> <u>capense</u>) once the shrubland has begun to reach maturity, 2. an increase in succulent species and 3. a decrease in geophyte species with increasing post-fire age. This last phenomenon is happens elsewhere in the south-western Cape (Kruger & Bigalke, 1984; Duckitt, 1985).

The apparent differences in the total species numbers and in the number of woody and herbaceous species is most likely due to the the inherent floristic variation in the composition of the vegetation. Since there was only time to complete one Braun-Blanquet plot in each patch of vegetation, variation within the patches has not been accounted for. The need for replicated plots is obvious.

It was evident that the shrubs were burnt right to the ground, implying a fire of reasonably high intensity. Kruger & Bigalke (1984) have stated that high intensity fires in fynbos cause abnormally high mortality in sprouters. However, in chaparral, which is highly flammable when old and carries fires of high intensity (Philpot, 1977), shrubs regenerate vigorously after fire, by both resprouts and seedlings, and quickly (within 5-6 years) regain their dominance (Hanes, 1981). In garrigue in France the dominant _Quercus coccifera_ also regenerates rapidly after fire, sprouting from root crowns and root suckers, but it has been shown that intense fires, usually occurring in summer and autumn, cause a reduction in sprouting (Trabaud, 1981; 1982). I can only suggest that this is the result of heat damage to the buds. A similar effect may occur in Strandveld and may explain the slow regrowth of shrubs after an intense fire.

Gill (1977), on the other hand suggests that intensity of fire mainly effects the resistance of shrubs and trees to fire and that season of burn and frequency effect sprouting response. None of these three aspects of fire - season of burn, intensity and frequency - have been studied for Strandveld.

It seems from Duckitt's study that it takes about 15 years for the evergreen shrubs (such as _Rhus lucida_ and _Euclea racemosa_) to become an important component of the vegetation, and for it to become very dense. Certainly in the 10-12 year old vegetation in this study, evergreen shrubs were dominant, although the vegetation was not very dense. In Mediterranean-type shrublands elsewhere in the world it has been shown that the dominant shrubs re-assert themselves within a very short time after a fire. In chaparral, the shrubs that were dominant before a fire regain that position in about five or six years (Hanes, 1981). In garrigue ten years after a fire the vegetation is back to its original state (Trabaud, 1981), and in open mallee scrub in Australia regeneration of the mallee eucalypts from lignotubers is also rapid (Specht, 1981). There does not appear to be a post-fire progression from pioneer species to climax species in mediterranean-type shrublands. Key species generally persist throughout the regeneration period.

The long term impact of recurrent burning of Strandveld is not known. As can be seen from the examples above fire does not prevent the vegetation from returning to its former state. Godron et al. (1981) have referred to mediterranean shrublands as having 'elasticity' - the ability to bounce back after disturbance. However factors such as season of burn, intensity and frequency will influence the recovery. Frequency of fires influences the structure of the vegetation particularly. Godron et al (1981) found that a high frequency of fire lead to a progressive reduction in cover of woody species and a change in the structure of the vegetation, with the lower strata becoming dominant. This was a consequence of the vegetation not being able to recover fully before the next fire. The rate of return of the vegetation to its pre-fire

condition is influenced to a large extent on the length and intensity of the summer drought and the variability of the rainfall.

It seems that recurrent burning at short intervals (less than 10 years) in Strandveld would probably have the effect of opening up the shrub stratum and maintaining a shorter vegetation with low shrubs and greater cover of herbaceous plants and sub-shrubs. These ideas are, however, only speculative, and require long-term monitoring studies to verify or dispute. Detailed studies of the responses of individual species to fire are necessary if we are to understand the impact of fires in Strandveld. Noble & Slatyer (1977, 1980) have developed a model to predict the impact of recurrent disturbances on vegetation. The gathering of data on the vital attributes of Strandveld species and the application of this model could provide some indication of what long-term changes can and may have occurred as a result of recurrent fires.

5.2.5 CONCLUSIONS

The major impact of fire is to reduce shrub cover and lead to increased open ground. The successional changes following fire are mainly structural. Changes in the relative abundances of the various shrub species also occur. Strandveld recovers well from fire, as many of the plants have mechanisms to survive fire. Fire intensity is probably crucial to the recovery of the vegetation through its effect on the resprouters. The length of time between fires is also crucial, and recurrent fires at intervals shorter than the time taken for the vegetation to reach maturity can result in permanent changes in the vegetation. Data is needed on the responses of the individual species to fire and their subsequent life histories, as well as their 'vital

attributes' (Noble & Slatyer, 1980), in order to predict the effects of
recurrent fires on Strandveld vegetation.

5.3 PREDICTING FIRE BEHAVIOUR IN STRANDVELD - A MODELLING EXERCISE

5.3.1 INTRODUCTION

The south-western Cape is an extremely fire prone region. A ranking of
the major Köppen climatic zones in order of descending fire-weather
severity puts the Cs type at the top of the list, with the Bs type fifth
from the top. These two climatic types account for most of the south-
western Cape. This makes the development of a system of fire danger
rating extremely useful to land managers and farmers. A system used in
the United States of America has been adapted for the fynbos region (van
Wilgen,1984a, b; van Wilgen & Burgan, 1984)

A number of fire-climatic zones have been defined for the south western
Cape (Figure 5.1). These are areas that have similar climates and
similar potential risk of fire (van Wilgen,1984a). This concept is an
important aid in fire-weather forecasting, wild-fire control and
management of prescribed burning programmes.

The two most important factors determining fire potential of the
vegetation are weather and fuel load. Weather is important because of
its influence on fuel moisture content.

The delimitation of fire climates is based on an energy release component
(ERC) which relates to potential fire intensity. It is calculated from
weather data and fuel model data. Coastal areas have lower fire
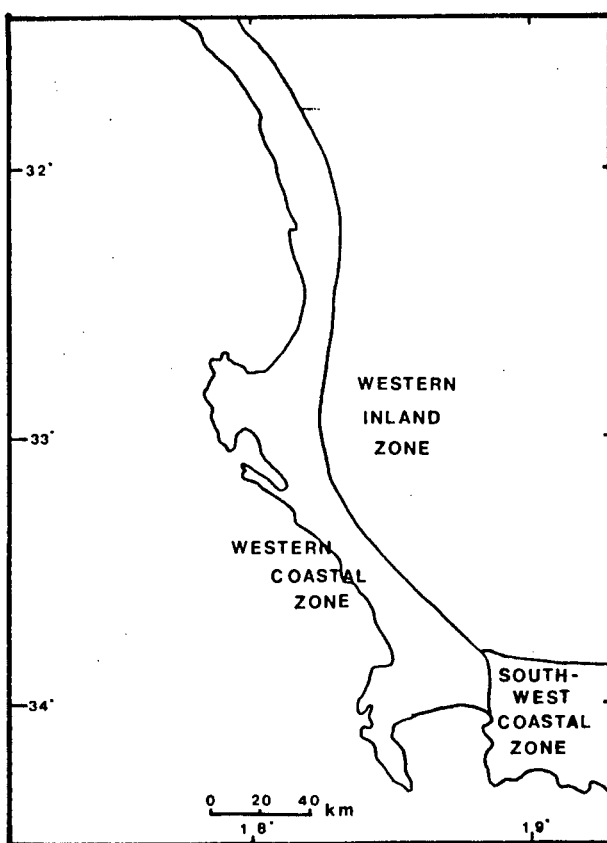potential than inland areas. The western coastal zone stretches from the

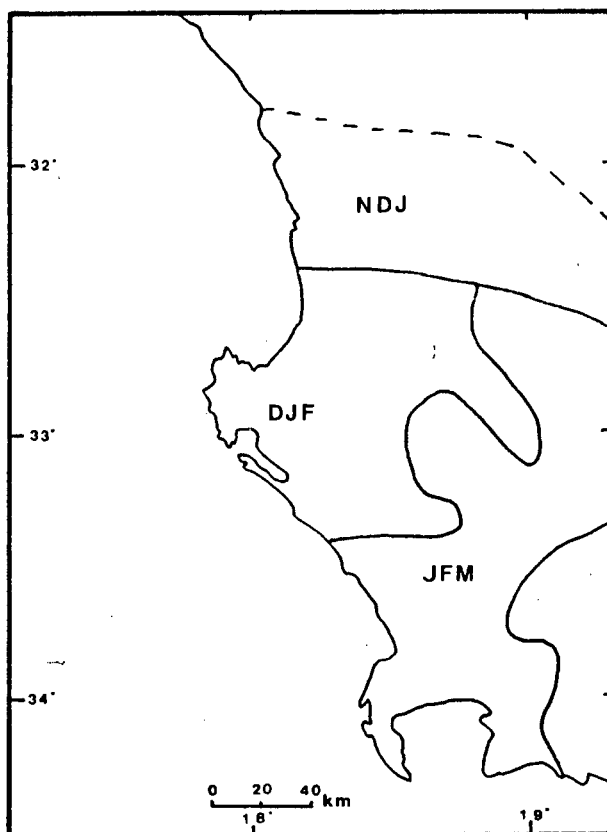FIGURE 5.1 Fire climatic zones of the western Cape. (redrawn from Van Wilgen, 1984a)

FIGURE 5.2 Fire seasons (three-month period with highest mean energy release component) of the western Cape. (redrawn from Van Wilgen, 1984a)

Cape Peninsula northwards in a fairly narrow strip (about 10km wide) along the coast. The mean ERC for this zone is between 10 and 20. The lowest ERC is in winter, but the seasonal fluctuations are not marked. Fires are most likely under extreme conditions of high temperature, low relative humidity and high wind in summer.

The south-western Cape has also been divided into areas of different fire season (Figure 5.2). A fire season is defined as that three-month period with the highest mean ERC. In the western Cape ERC has a summer peak, although the fire season differs from north to south, being December-February for the Vredenburg area and January-March further north (van Wilgen 1984a).

5.3.1.1 Fuel modelling and fire behaviour prediction

The fire danger rating system that has been adapted for the Fynbos Biome (van Wilgen, 1984b; van Wilgen & Burgan, 1984), is based on a fire spread model which predicts a number of parameters of fire behaviour based on a fuel model and fuel moisture levels (Burgan & Rothermel, 1984).

A fuel model is essentially a collection of data representing the fuel properties of vegetation which is used as input for the fire-spread model. The data required are the fuel loads for live and dead fuel in different size classes, fuel moisture content, surface area to volume ratios, fuel energy content and dead fuel extinction moisture content. Fuel load is either measured or estimated from cover and depth values. Live fuel only includes that portion of live woody vegetation fine enough to burn. A cut-off of 6mm diameter of twigs is used (Burgan & Rothermel, 1984). For Fynbos about 32% of woody shrub mass is fine enough to be considered as fuel (van Wilgen, 1984b). In Strandveld at Lambert's Bay

many of the shrubs are drought deciduous and there is a considerable amount of stem die-back in summer. These dry portions of shrubs are considered dead fuel. Most herbaceous vegetation is fine enough to burn.

Dead fuel load is estimated by size classes (<6mm, 6 - 24.5mm, 24.5 - 73.5mm), which represent the time-lag classes (1-hour, 10-hour, 100-hour) as defined by Burgan & Rothermel (1984). Most dead fuel is in the finest size class, or 1-hour time-lag class. Dead fuel includes litter, dead herbaceous material and standing dead wood.

The data are gathered for each of the major components of fuel; shrubs, grass, litter and slash. New data for the program is gathered using simplified procedures that minimize fieldwork. All that is required is:

1. use of a photo series to determine the general vegetation type and density,

2. visual assessments of the percentage of the areas covered by grass. litter and shrub components of fuel, and

3. measurements of the depths of the fuel components.

All the other variables required for the model, heat content of fuel, surface area to volume ratios and moisture of extinction, are estimated based on previous fuel models, such as the Fynbos fuel model (van Wilgen, 1984b).

The data are processed using the BEHAVE system, which is a set of interactive computer programs for predicting fire behaviour unmder various conditions. There are two subsystems; the FUEL subsystem includes NEWMDL, and the BURN subsystem which includes FIRE 1. It is

NEWMDL that accepts values of cover and depth of the fuel and estimates load from existing load:depth relationships defined in the program. The total fuel load is broken down into size-class loads. NEWMDL then formulates the model and stores it in a fuel model file. This file is used to predict fire behaviour, using FIRE 1. Three parameters of fire behaviour are calculated for different conditions of wind and fuel moisture content; rate of spread of the fire front, fire-line intensity and flame length.

5.3.2 METHODS

It has been suggested that Strandveld will burn only in summer (Moll, 1987) and that fires will be small and infrequent (Kruger & Bigalke, 1984). However, large runaway fires have occurred, in the south, probably under extreme weather conditiions. In order to better understand the behaviour of fire in Strandveld, data were gathered on the characteristics of the plant fuel and used to generate a fuel model. The fuel load data was collected using data sheets derived from Burgan & Rothermel's (1984) manual on the BEHAVE system.

Data for the fuel model were collected for mature Strandveld at Nortier, Lanbert's Bay, in April (end of dry season) and August (wet season). For each component of the fuel proportional cover was estimated and the height of the plants measured in 12 - 15 1m2 quadrats and an average was calculated.

A heat of combustion value of 20 000 J/g was used, which van Wilgen (1984b) has found represents a heat of combustion of most of the fuel in the Fynbos Region. This falls within the range found by Durand (1981) -

18 225 - 20 677 J/g.   Surface area to volume ratios were estimated at 2200 for 1-hr fuel, 1800 for live herbaceous fuel and 1500 for live woody fuel. A 1-hr fuel moisture of extinction of 19% was used.

The data were analysed using the BEHAVE system on the computer at Jonkershoek Forestry Research Centre.   Two fuel models were formulated, one for each season, and values predicted for rate of spread, intensity and flame length at various levels of wind speed and 1-hr fuel moisture content (Table 5.5).   The predicted values for the two seasons were compared and contrasted with each other and with values obtained from an existing fynbos fuel model.

5.3.3   RESULTS

Results were given in Imperial Units and had to be converted into metric units, hence the strange intervals on the X-axis of the graphs. The results of the fire behaviour prediction exercise are presented as a set of fuel models (Tables 5.6 & 5.7) and a series of graphs of the predicted values (Figures 5.3 - 5.11).

5.3.3.1 Seasonal fire behaviour in Strandveld:

In winter rate of spread (Figure 5.3), fire intensity (Figure 5.4) and flame length (Figure 5.5) are all very low, in some cases an order of magnitude lower than in summer (eg. fire intensity).   Increasing wind speed only causes increases in the predicted values for the lower end of the wind scale. The values rapidly reach a maximum, above which increasing wind speed has no effect.   At the lowest 1-hr fuel moisture content (2%) maxima are reached at 12-15 miles per hour. With increasing moisture content, the wind speed at which maxima are reached is reduced.
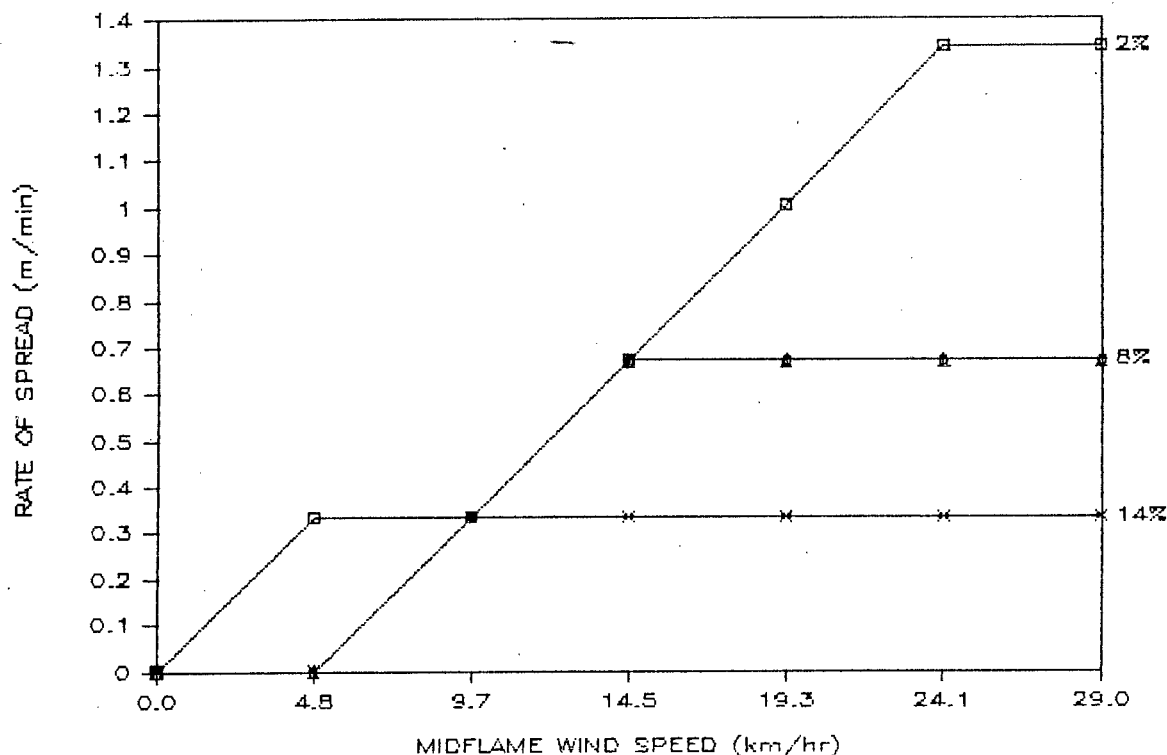
FIGURE 5.3 Predicted values for rate of spread of fire-front in Strandveld in the wet season, at different wind speeds and fuel moisture contents.
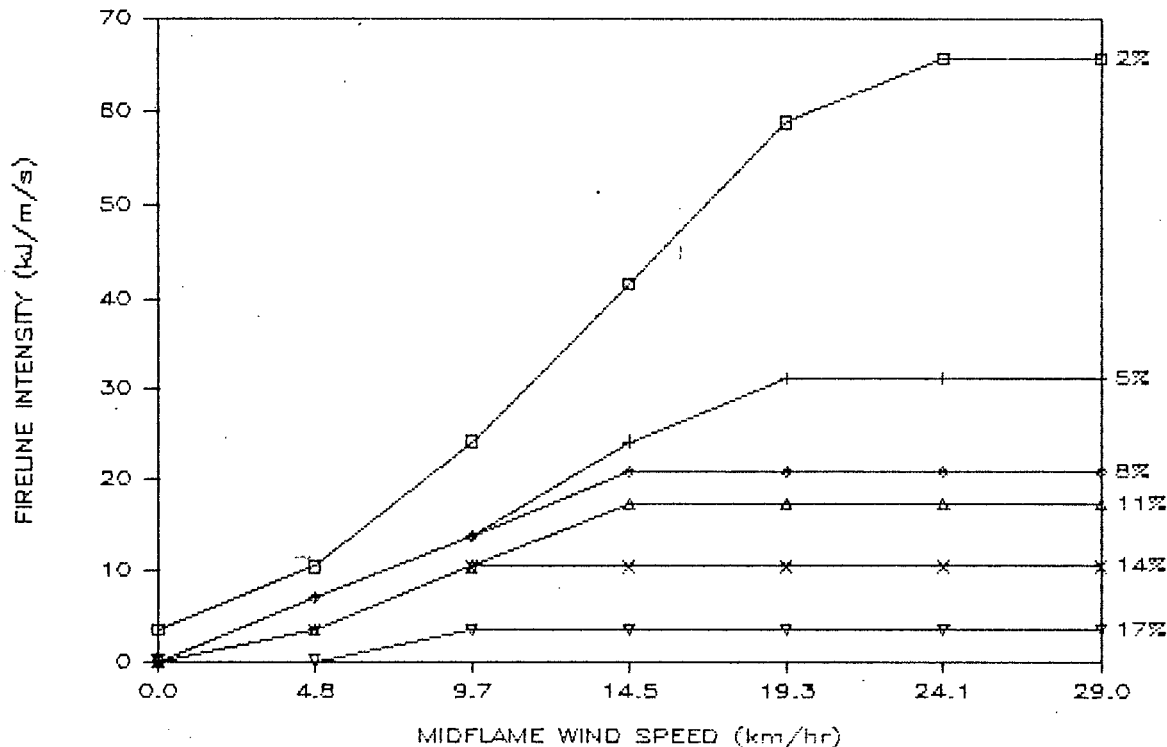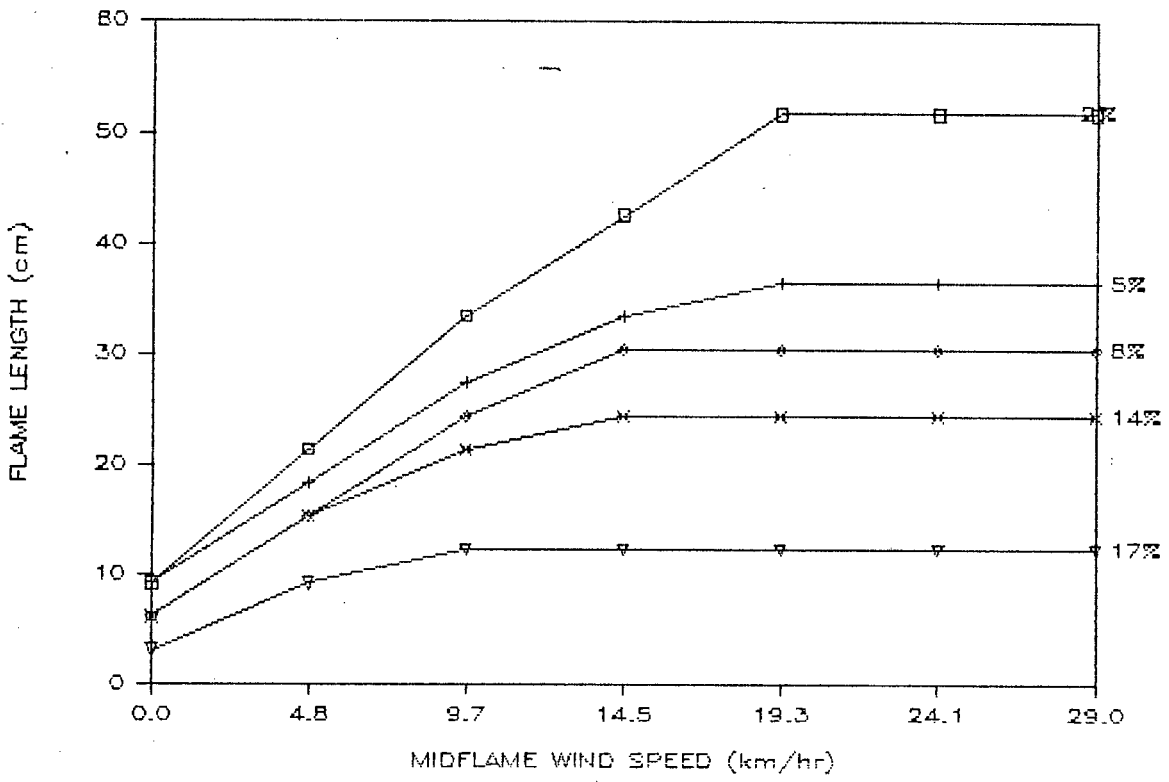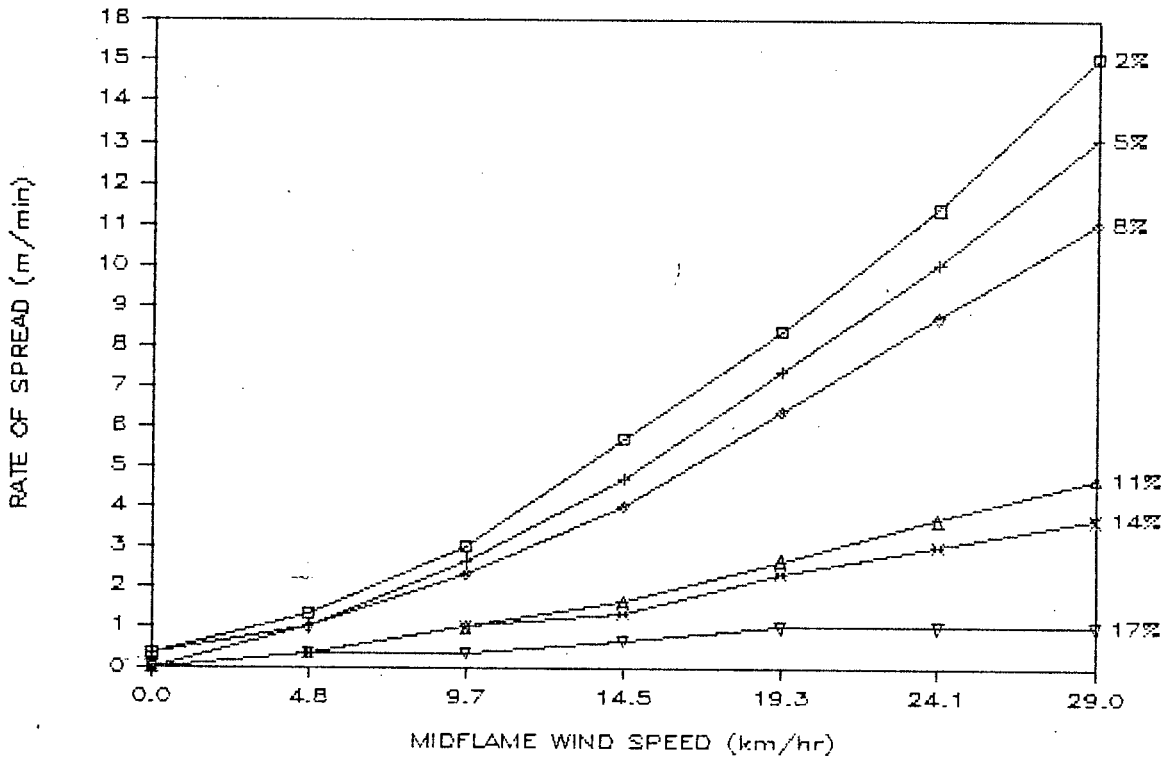

FIGURE 5.4 Predicted values for fireline intensity in Strandveld in the wet season, at different wind speeds and fuel moisture contents.

In the dry summer months on the other hand there is a continuous increase

TABLE 5.5   VALUES ASSIGNED TO VARIABLES USED IN PREDICTING FIRE BEHAVIOUR
             (Used for all three sets of data; dry season
             Strandveld, wet season Strandveld and fynbos)

1-hr fuel moisture (%)	2, 5, 8, 11, 14, 17, 20
10-hr fuel moisture (%)	8
100-hr fuel moisture (%)	8
live herbaceous moisture (%)	100
live woody moisture (%)	100
mid-flame wind speed (km/hr) ‡	0, 4.8, 9.7, 14.5, 19.3, 24.1, 29
slope	0

    ‡ converted from miles/hour

TABLE 5.6   FUEL MODEL - DRY SEASON STRANDVELD

load (t/ha)		s/v ratios		other	
1 hr	4.01	1 hr	2200	depth (m)	0.14
10 hr	0.9	live herb	1800	heat content (J/g)	20000
100 hr	0.31	live wood	1500	ext moisture (%)	19
live herb	0.16				
live woody	5.76				

TABLE 5.7   FUEL MODEL - WET SEASON STRANDVELD

load (t/ha)		s/v ratios		other	
1 hr	1.79	1 hr	2200	depth (m)	0.14
10 hr	1.14	live herb	1800	heat content (J/g)	20000
100 hr	0.29	live wood	1500	ext moisture (%)	19
live herb	1.14				
live woody	7.35				

in the three predicted values (Figures 5.6, 5.7 & 5.8) with increasing
wind speed at all moisture levels except 20%, where no fire occurs at
all.

In the winter the predicted rate of spread of the fire (Figure 5.3)
becomes zero where the moisture content >14%.   Relatively big increases

161

FIGURE 5.5 Predicted values for flame length in Strandveld in the wet season, at different wind speeds and fuel moisture contents.

FIGURE 5.6 Predicted values for rate of spread of fire-front in Strandveld in the dry season, at different wind speeds and fuel moisture contents.
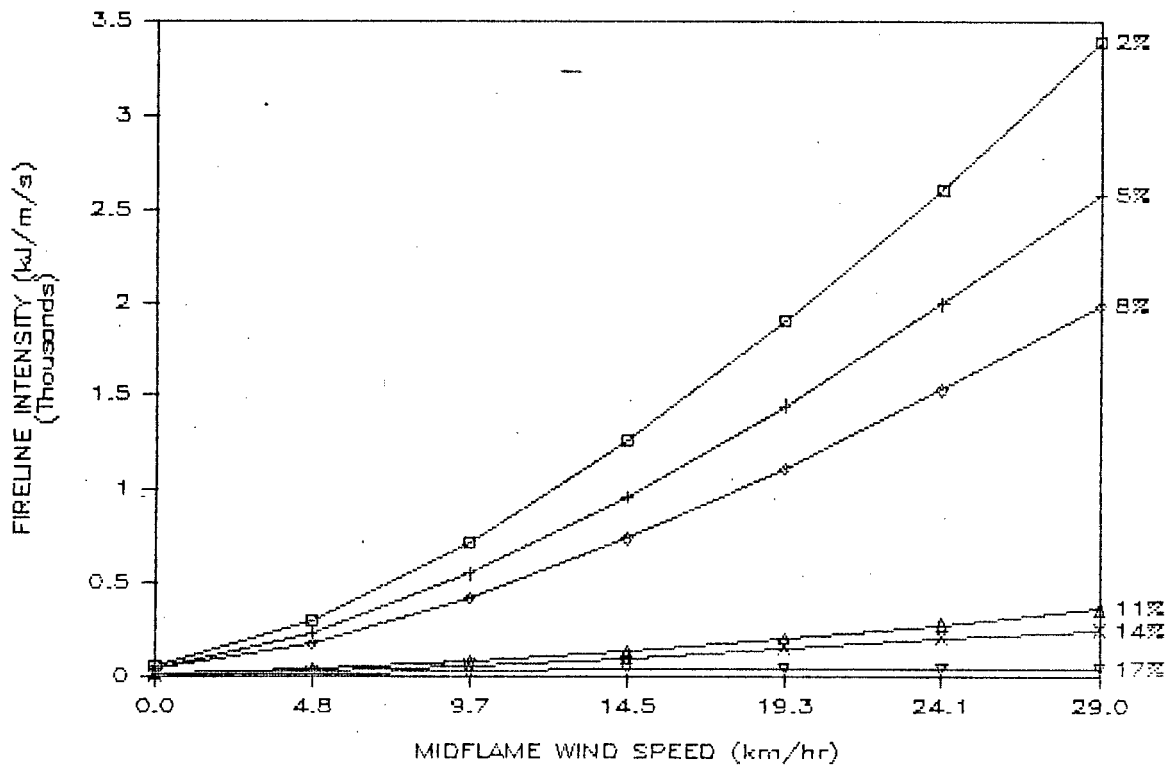
162

FIGURE 5.7 Predicted values for fireline intensity in Strandveld in the dry season, at different wind speeds and fuel moisture contents.
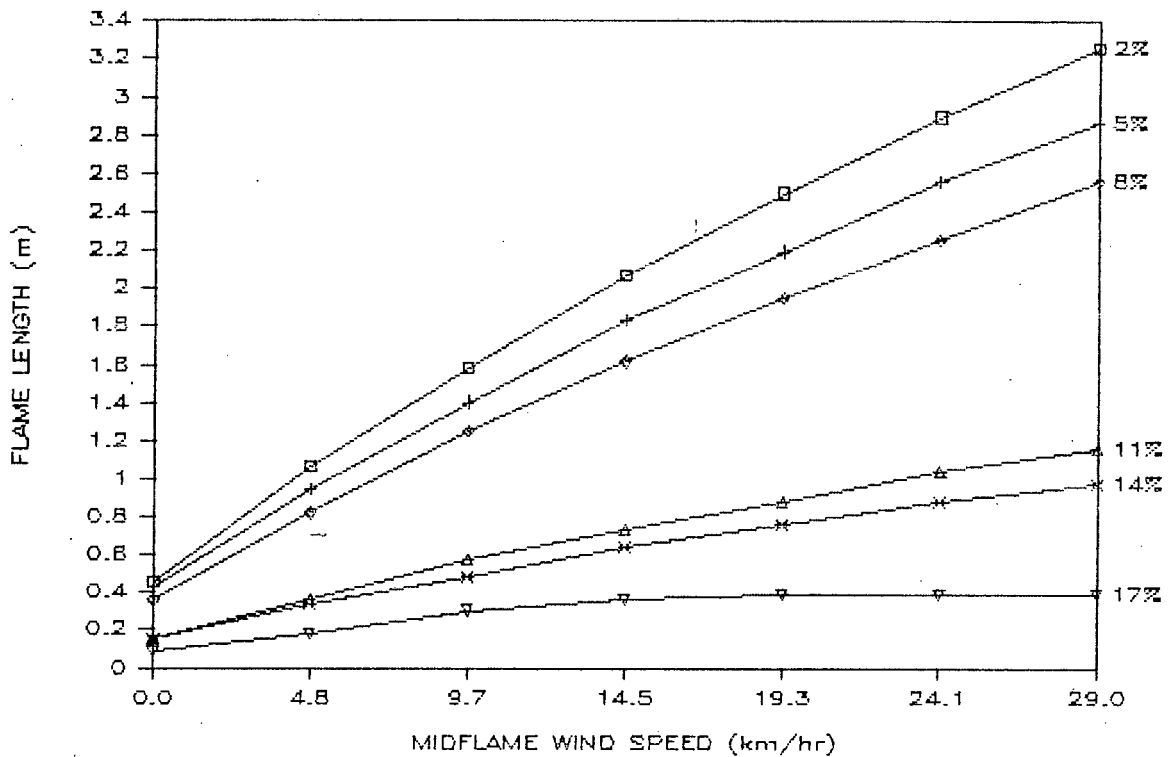

FIGURE 5.8 Predicted values for flame length in Strandveld in the dry season, at different wind speeds and fuel moisture contents.

in maximum values occur between the 2% to 5% moisture levels and from 14%
- 17%.   In the summer large differences occur in the predicted values of
all three parameters when the moisture level increases from 8% to 11%.

5.3.3.2 Strandveld fire behaviour vs fynbos:

When dry season Strandveld (Figures 5.6, 5.7 & 5.8) is compared with
fynbos (Figures 5.9, 5.10 & 5.11) the trends are similar, but everything
occurs on a much smaller scale in Strandveld.   In both there is a
continuous increase in the predicted values with increasing wind speed.
No maxima are reached.   The differences between Strandveld and fynbos
are: 1. there is an order of magnitude difference between the values for
the two areas, those for Strandveld being lower;   2.   there is a large
'jump' in values between 8% and 11% moisture content for Strandveld, but
not for fynbos;   and   3.   at 20% moisture content Strandveld will not
burn, even in summer and all values are zero.   Fynbos will burn, but
there is very little difference between the predicted values for 17% and
20% moisture.

5.3.4   Discussion

Both climatic factors and features of the vegetation determine whether or
not vegetation will burn.   In mediterranean-climate areas fires generally
occur from spring to autumn.   The long dry summers produce many days of
high fire potential, often associated with dessicating off-shore winds.

Features of the vegetation that control flammability are the chemical,
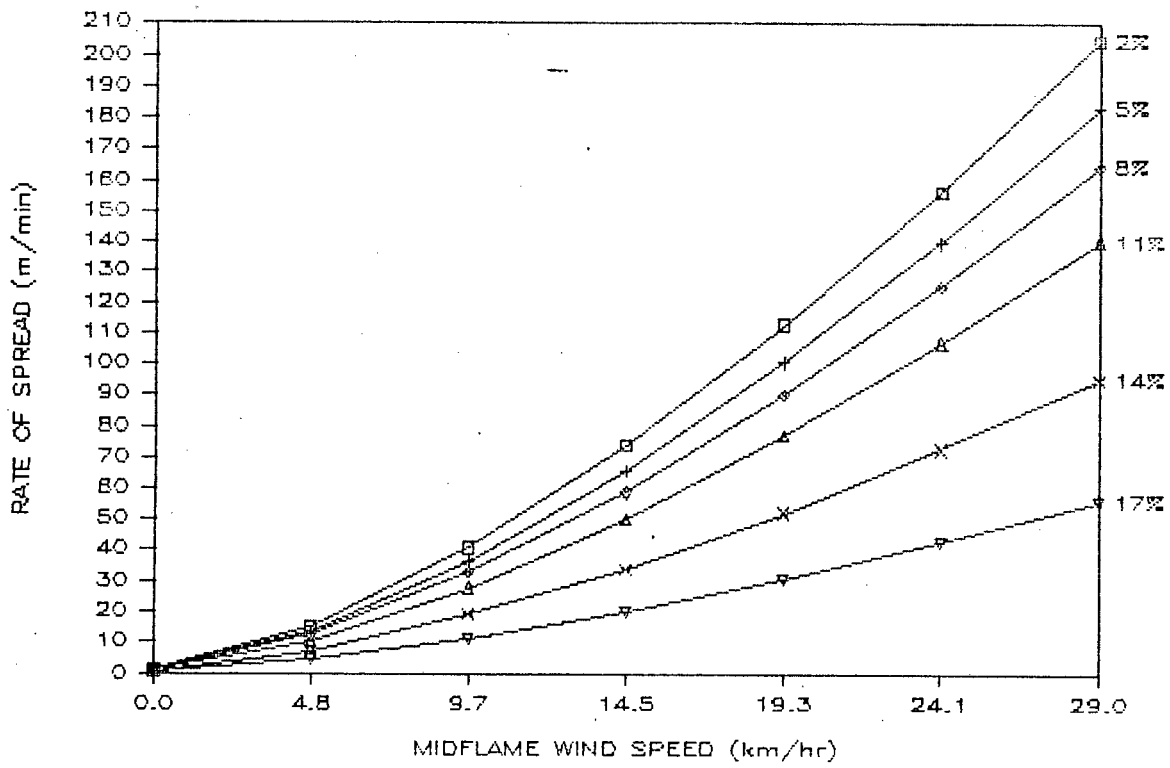physical and physiological characteristics of the vegetation (Philpot,
1977).

FIGURE 5.9 Predicted values for rate of spread of fire-front in Fynbos, at different wind speeds and fuel moisture contents.
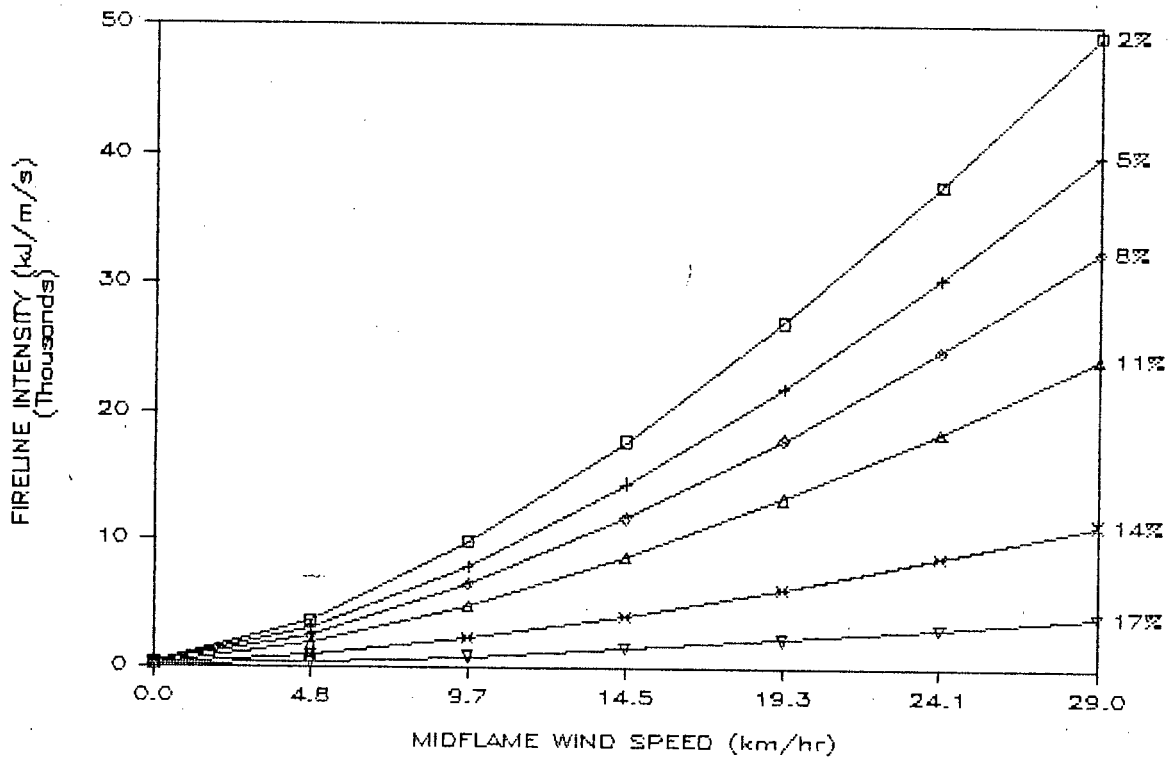

FIGURE 5.10 Predicted values for fireline intensity in Fynbos, at different wind speeds and fuel moisture contents.
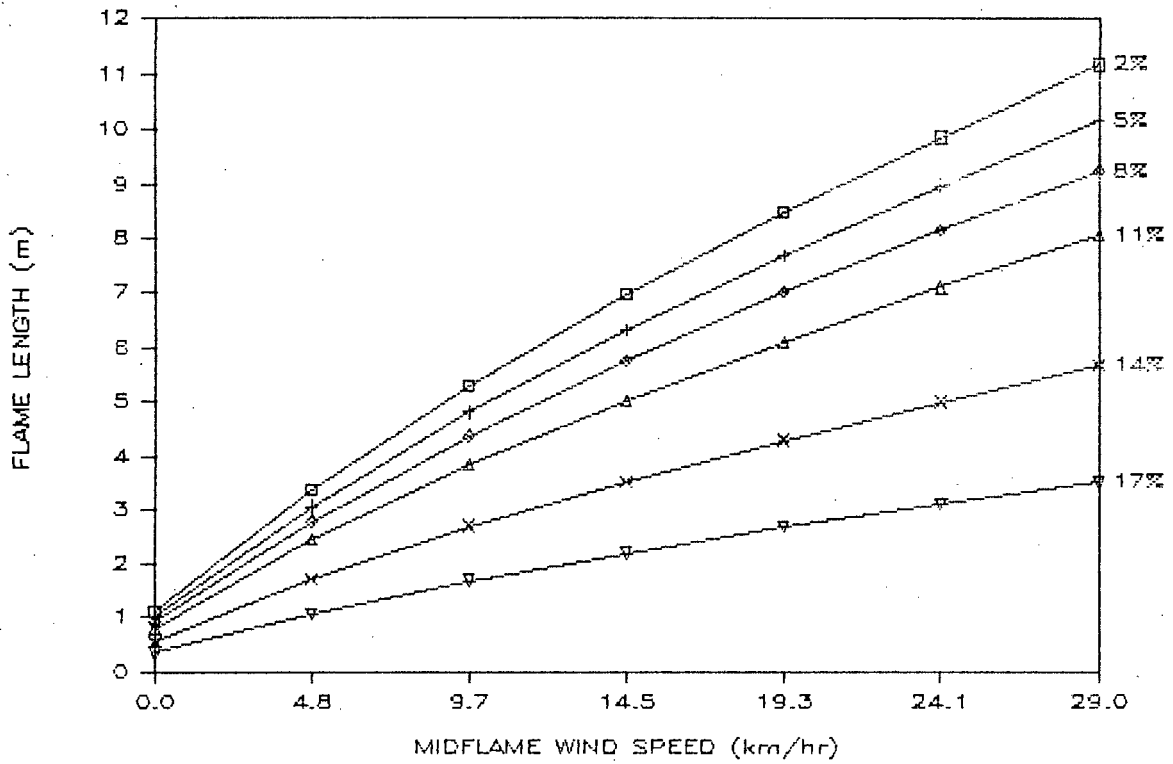
165

FIGURE 5.11 Predicted values for flame length in Fynbos, at different wind speeds and fuel moisture contents.

As already mentioned, it has been suggested that fynbos will carry fire at any time of the year if certain weather conditions occur (Kruger, 1977; Moll, 1987), but that Strandveld will only burn in summer (Moll, 1987). This is borne out by the results obtained here. The predicted values for the parameters of fire behaviour suggest that fires that may occur in winter will be small and of low intensity and will be relatively unaffected by wind speed.

Differences between summer and winter fire behaviour can be ascribed to a number of factors: 1. differences in the proportion of live herbaceous material 2. the deciduous habit of many of the shrubs, which shed leaves and have stem die-back in summer, leading to an increase in the amount of standing dry woody material. These are related to the lack of water in summer.

The differences between fynbos and Strandveld are related to differences in crown cover, community structure, growth habits and possibly flammable secondary compounds. Succulents in the Strandveld vegetation under study have the effect of reducing the fire potential of the vegetation. There are also differences in the utilization of the two vegetation types. Strandveld is utilised largely as natural pasture, especially in the north, and this will influence the behaviour of fires through its impact on vegetation cover. The effect of grazing by domestic animals is mainly to reduce the cover of the herb layer, hence the flammability of the vegetation. The result is probably smaller fires. Fynbos, especially Mountain Fynbos, is not utilized to any great extent as pasture.

In a comparison of predicted values for rate of spread between fynbos and chaparral, van Wilgen (1984b) has shown that fires spread faster in

167

chaparral than in fynbos. This is as a result of the very different nature of the fuel load and volatile flammable compounds in the leaves. Thus, by inference, chaparral fires behave quite differently to fires in Strandveld. Both types of shrubland are, however, most prone to fires in the late summer. Van Wilgen (1984b) also points out that chaparral vegetation is prone to fires at two stages in its post-fire development: 1. during the herbaceous stage, lasting up to five years after a fire, and 2. once enough dead material has accumulated, usually more than 20 years after the last fire. The lack of herbaceous undergrowth in chaparral precludes fire between these two stages.

5.3.5 CONCLUSIONS

It is clear that fires behave differently in Strandveld than in fynbos. The rate of spread, intensity and flame length are much lower than for fynbos fires under equivalent conditions. Fynbos will burn readily when the moisture content is >14% while Strandveld fires will be small or absent. Strandveld will in all likelihood only burn in summer, when the vegetation is dry, as Moll (1987) has suggested.

The behaviour of fires in Strandveld, as predicted above, is only hypothetical. It would be useful to test the fire behaviour model by doing a controlled burn. This would enable one to determine the differences between the predicted values discussed here and actual measured values and thereby refine the fuel model. Variables such as heat of combustion and leaf surface area:volume ratios may differ from those for the fynbos fuel model and need to be defined specifically for Strandveld.

The predicted behaviour also applies only to the drought-deciduous open Strandveld of the Lambert's Bay area. To the south Strandveld is less deciduous, less succulent, more sclerophyllous, taller and denser, with a sparser understorey than in the north. All of these factors will impact on the fuel model and result in a different predicted fire behaviour. Fires would probably be less frequent since the vegetation is less likely to burn, even in summer. The vegetation would probably only burn under extreme conditions of high temperatures and dessicating, off-shore winds in summer. In order to formulate a general Strandveld fuel model, data need to be obtained for a variety of sites from south to north.

5.4 CHAPTER SUMMARY

Fire has long played a role in determining the nature of the vegetation in the south-western Cape, more so since the advent of pastoralism and later stock-farming in the area. Historical records of burning of the veld and the effects of fire generally refer to the whole region, not Strandveld specifically. The frequency of fires in the past in Strandveld is a contentious issue. Little burning occurs today, but wild fires do occur.

Two aspects of fire were examined; post-fire succesion and fire behaviour prediction.

The recovery of the vegetation after fire goes through four stages; 1. the immediate post-fire stage, 2. youth stage, 3. transitional stage, 4. mature stage. In Strandveld, structural changes are more important than floristic changes after fire. There is a general increase in height, cover and litter with increasing post-fire age. In the youth stage

hemicryptophytes are important and annuals and geophytes are common. Most of the shrubs have resprouted. There is a large increase in the cover of broad-leaved and small-leaved shrubs and succulents from the youth to the transitional stage. There is a change in the dominance of shrubs species with increasing age. A lot of the floristic change that does occur is the result of the establishment of climbers and parasites as the vegetation matures. Strandveld takes about 15 years to recover from fire. The long-term effects of recurrent are not known, but would depend on fire intensity, season of burn and fire frequency.

The behaviour of fires can be predicted from data defining the fuel load of the vegetation and climatic variables. The fuel properties of the vegetation are represented in a fuel model, which serves as input to a fire-spread model. Data gathered for Strandveld in the Lambert's Bay area was analysed using the BEHAVE set of programs. The model predicts values for rate of spread, intensity and flame length. The fire behaviour model predicts completely different behaviour of fire in the dry and wet seasons. This is not unexpected, since Strandveld is a highly seasonal vegetation. Fires in the wet winter are likely to be small and of low intensity, whereas in summer an increase in dry fuel leads to larger, more intense fires. Summer fires increase in rate of spread and intensity with increasing wind-speed and decreasing fuel moisture, whereas in winter fires are relatively unaffected by these factors.

Summer Strandveld fires behave in a similar manner to fynbos fires, but the predicted values of rate of spread, flame length and intensity are orders of magnitudes smaller for the former. Fynbos differs from Strandveld in that fires are likely to occur at any time of the year,

170

given the right weather conditions. There is also little grazing in fynbos, which in Strandveld reduces the herbaceous layer, which is critical to the spread of fires.

Testing of the model for Strandveld is suggested.

5.5 REFERENCES

BOTHA CG 1924. Note on early veld burning in the Cape Colony. South African Journal of Science 21:352.

BOUCHER C 1982. Floristic and structural features of the coastal foreland vegetation south of the Berg river, western Cape Province, South Africa. IN: Proceedings of a symposium on coastal lowlands of the western Cape, ed EJ Moll. University of the Western Cape. pp 21-26.

BURGAN RE & ROTHERMEL RC 1984. BEHAVE: fire behaviour prediction and fuel modelling system - FUEL subsystem. General Technical Report INT-167, United States Department of Agriculture.

DEACON H J 1983. The peopling of the Fynbos region. In: Fynbos palaeoecology: a preliminary synthesis, eds H J Deacon, Q B Hendey and J J N Lambrechts. South African National Scientific Programmes Report No. 75, Pretoria: CSIR. pp 183-204.

DUCKITT S 1985. Structural changes in Coastal fynbos-Strandveld communities due to burning and farming practices. Unpublished BOT 302F project, University of Cape Town.

DURAND BJ 1981. A study of the short-term responses of fynbos to fire in the Kogelberg State Forest, South Africa. Unpublished M.Sc. thesis, UCT.

EDWARDS D 1985. Fire regimes in the Biomes of South Africa. IN: Ecological Effects of fire in South African Ecosystems, eds P de V Booysen & NM Tainton. Ecological Studies 48. Berlin: Springer.

GILL AM 1977. Plant traits adaptive to fires in mediterranean land ecosystems. IN: Symposium on the environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report WO-3, United States Department of Agriculture. pp 17-26.

GODRON M, GUILLERM JL, POISSONET J, POISSONET P, THIAULT M & TRABAUD L 1981. Dynamics and management of vegetation. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 317-344.

HANES TL 1981. Californian chaparral. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 139-174.

HITCHCOCK RK & EBERT JI 1985. Foraging and food production among Kalahari hunbter-gatherers. IN: From hunters to farmers. The causes and consequences of food production in Africa, eds JD Clark & SA Brandt. pp 328-348.

JOUBERT JGV 1969. Improved grazing in the Strandveld. Farming in South Africa 44(10),17.

KRUGER FJ 1977. Ecology of Cape fynbos in relation to fire. IN: Symposium on the environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report WO-3, United States Department of Agriculture. pp 230-243.

KRUGER F J & R C BIGALKE 1984. Fire in Fynbos. In: Ecological effects of fire in South African ecosystems, eds P de V Booysen and N M Tainton. Berlin: Springer Verlag pp 67-114.

MARLOTH R 1924. Note on veld burning. South African Journal of Science 21:352.

MOLL EJ 1987. Phenology of mediterranean plants in relation to fire season.

NOBLE IR & SLATYER RO 1977. Post-fire succesion of plants in mediterranean ecosystems. IN: Symposium on the environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report WO-3, United States Department of Agriculture. pp 27-36.

NOBLE IR & SLATYER RO 1980. The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances. Vegetatio 43: 5-21.

PHILPOT CW 1977. Vegetative features as determinants of fire frequency and intensity. IN: Symposium on the environmental consequences of fire and fuel management in mediterranean ecosystems. General Technical Report WO-3, United States Department of Agriculture. pp 12-16.

PILLANS NS 1924. Note on veld burning. South African Journal of Science 21:352.

RAVEN-HART R 1967. Before van Riebeeck. Cape Town: Struik.

SPARRMAN A 1785. A voyage to the Cape of Good Hope towards the Antarctic polar circle and round the world, but chiefly into the country of the Hottentots and Caffres, from the year 1772 to 1776. London: Robinson.

SPECHT RL 1981. Mallee ecosystems in southern Australia. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 203-232.

THOM H B (ed) 1952. *The journal of Jan van Riebeeck*. Cape Town: Balkema. 3 volumes.

TRABAUD L 1981. Man and fire: impacts on mediterranean vegetation. IN: *Ecosystems of the world 11. Mediterranean-type shrublands*, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 523-538.

TRABAUD L 1982. Effects of past and present fire on the vegetation of the French Mediterranean Region. IN: Symposium on Dynamics and management of Mediterranean-type ecosystems. *General Technical Report* PSW-58, United States Department of Agriculture. pp 450-457.

VAN WILGEN BW 1984a. Fire climates in the southern and western Cape Province and their potential use in fire control and management. *South African Journal of Science* 80:358-362.

VAN WILGEN BW 1984b. Adaption of the United States Fire Danger Rating System to Fynbos conditions. Part 1. A fuel model for fire danger rating in the Fynbos Biome. *South African Forestry Journal* 130: 13-17.

VAN WILGEN BW & BURGAN RE 1984. Adaption of the United States Fire Danger Rating System to Fynbos conditions. Part 2. Historic fire danger in the Fynbos Biome. *South African Forestry Journal* 129: 66-78.

VILJOEN B 1987. Golden rules of veld burning. *Farmer's Weekly*, February 13. pp 24-25.

6 GENERAL DISCUSSION

This thesis has attempted to collate the research that has been done in West Coast Strandveld. Aspects of the functioning of some of the plant communities are described.

Strandveld is one of the Cape's mediterranean-type shrublands. Like other mediterranean-type shrublands (Di Castri, 1981), it occurs in the drier parts of the mediterranean climate zone (moisture index 0,2 or less). It is clear that Strandveld differs from the heathlands of the south-western Cape, in both composition and functioning. Although it has some floristic affinities to fynbos, it has strong affinities to the Karoo-Namib region, as well as the Tongaland-Pondoland region (Taylor, 1978; Tinley, 1985). The distribution of Strandveld is determined by factors of both the soil and climate. On soils of lower nutrient status it gives way to heathland. At the dry end of its distribution Strandveld gives way to Succulent Karoo.

Strandveld varies in composition and structure from south to north, as annual rainfall decreases, and the intensity of summer drought increases. Differences in soil type probably also contribute to the change in the vegetation. It would seem that this vegetation type can be divided into two types, based on its floristics and structure: 1. the evergreen sclerophyllous scrub thicket typical of the Melkbos – Langebaan area and 2. the low, open, drought-deciduous scrub typical of the Lambert's Bay area. The phytogeographical affinities of the two differ. Elements of the Capensis flora are more common in the Melkbos area than at Lambert's Bay, and vice-versa for the elements of the Karoo-Namib flora. This would concur with Werger's (1978) phytogeographical regions.

This south - north gradient in climate and vegetation is similar to those that occur in Coastal Matorral in Chile (Rundel, 1981) and Coastal Sage Scrub in California (Westman, 1983). The change from evergreen, sclerophyllous shrubs to drought-deciduous (or dimorphic) shrubs and succulents that occurs in Strandveld is repeated in these other two mediterranean regions. Different plant associations are recognised along the climatic gradients in Chile and California.

Strandveld is a highly seasonal vegetation, with a fairly distinct growing season, during the cooler, wet months. In this it differs significantly from the adjacent heathland (Sand Plain Fynbos) - which has growth in summer. Flowering in Strandveld is concentrated in spring, like most of the vegetation of the south-western Cape. Most growth forms have similar phenophases, as a result of the seasonal availability of moisture. Several of the shrub species, though, have more extended phenophases, especially stem growth. This may relate to the rooting depth of these plants (Kummerow, 1983). This is an aspect that needs investigation.

Strandveld shows many broad similarities to other mediterranean-type shrublands; in overall vegetation structure, phenology and response to fire. The particular climatic conditions and geological factors of the Cape west coast will obviously result in differences in details. The mediterranean-type shrublands of both California and Chile have been intensively studied and it would be useful to add to the existing body of knowledge on these shrublands information from Strandveld.

The phenological patterns of Strandveld undoubtedly have important consequences for the impact of fire and grazing. The differences in behaviour of fire between the wet and dry seasons have been pointed out. These would in turn influence the recovery of the vegetation after fire, since fire intensity is different in the two seasons and is known to be a factor in determining the nature of post-fire vegetation (Kruger & Bigalke, 1984).

From the little known about fire in Strandveld, both the impact of and behaviour of fires differs from those of fynbos vegetation. This relates to the differences in structure of the vegetation and its growth forms. The predicted behaviour of Strandveld fires, as discussed in this thesis, is only valid for the Lambert's Bay area, since the fuel properties of the vegetation vary from one area to another. Unfortunately comparisons between the different parts of Strandveld were not done. The fuel model data base needs to be expanded to allow a general Strandveld fuel model to be formulated.

Similarily, the study of the response of Strandveld to fire applies only to the particular area investigated. More post-fire stands of vegetation, of varying age, need to be examined to enable generalisations to be made. Season of burn and frequency also need consideration. It is not possible to extrapolate from the work done in fynbos in this regard, because of the differences in the predicted behaviour of fires between the two vegetation types.

Fire and injudious grazing are recognised as the main enemies of Mediterranean Basin shrublands (le Houerou, 1981). This seems to be true of Strandveld, which is utilised predominantly as natural pasturage for

grazing domestic animals. The impact of grazing, particularly in the north, is to reduce the cover of grasses and increase the succulents. Proper management of Strandveld - low stocking rates, large farming units and proper stock mixes - can prevent a reduction in cover and a decline in the pasture value of the vegetation. Strandveld differs from shrublands in the Mediterranean Basin in that fire and grazing seem to cause a decrease in grassiness in Strandveld, whereas in the Mediterranean these pressures lead to the formation of grasslands (le Houerou, 1981).

There are large gaps in our knowledge of Strandveld, particularly in ecophysiology and the autecology of plants. We know little of how Strandveld functions. Water relations, nutrient uptake, storage and cycling, root growth and structure are all unknowns, which have direct relevance to the response of the vegetation to the particular environmental conditions along the west coast. There is a need to understand the dynamic relationships between Strandveld on the one hand and Sand Plain Fynbos, Arid Fynbos and Succulent Karro on the other hand. The responses of plants to grazing pressure and recurrent fire all influence the nature of the vegetation and may cause shifts in the boundaries between Strandveld and these vegetation types. All of the above factors may give us a better handle on what changes may have occurred in Strandveld vegetation in the past.

6.1 REFERENCES

DI CASTRI F 1981. Mediterranean-type shrublands of the world. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 1-52.

KRUGER FJ & BIGALKE RC 1984. Fire in Fynbos. IN: Ecological effects of fire in South African ecosystems, eds P de V Booysen, & NM Tainton. Berlin: Springer. pp 67-114.

KUMMEROW J 1983. Comparative phenology of nediterranean-type plant communities. IN: Mediterranean-type ecosystems: the role of nutrients, eds FJ KRuger, DT Mitchell & JUM Jarvis. New York: Springer. pp 300-317.

LE HOUEROU HN 1981. Impact of man and his animals on mediterranean vegetation. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 479-522.

RUNDEL PW 1981. The matorral zone of Chile. IN: Ecosystems of the world 11. Mediterranean-type shrublands, eds F di Castri, DW Goodall & RL Specht. Amsterdam - Oxford - New York: Elsevier. pp 175-202.

TAYLOR HC 1978. Capensis. IN: Biogeography and ecology of southern Africa, ed MJA Werger. The Hague: Junk. pp 171-229.

TINLEY KL 1985. Coastal dunes of South Africa. South African National Scientific Programmes Report No. 109, Pretoria: CSIR.

WERGER MJA 1978. Biogeographical divisions of southern Africa. IN: Biogeography and ecology of southern Africa, ed MJA Werger. The Hague: Junk. pp 145-170.

WESTMAN WE 1983. Xeric mediterranean-type shrubland associations of Alta and Baja California and the community/continuum debate. Vegetatio 52: 3-19.

APPENDIX A: LIST OF SPECIES RECORDED IN THE STUDY AREA
(Compiled from own collections; Department of Nature and Environmental
 Conservation files; J. Sommerville, pers. comm.; Boucher & Jarman (1977);
 Hall & Veldhuis, (1986). Nomenclature after Bond & Goldblatt (1984)
 and Gibbs Russel et al. (1985; 1987))

JUNCAGINACEAE
Triglochin bulbosa L.
Triglochin striata Ruiz & Pavon

POACEAE
Agropyron distichum (Thunb.) Beauv.
Ammophila arenaria (L.) Link
Bromus japonicus Thunb.
Chaetobromus dregeanus Nees
Chaetobromus schraderi Stapf
Cladoraphis cyperoides (Thunb.) S.M. Phillips
Cynodon dactylon (L.) Pers.
Ehrharta brevifolia Schrader
Ehrharta calycina Smith
Ehrharta delicatula (Nees) Stapf
Ehrharta erecta Lam.
Ehrharta ramosa (Thunb.) Thunb.
Ehrharta villosa Schultes f.
Eragrostis sabulosa (Steudel) Schweik.
Festuca scabra Vahl
Hordeum capense Thunb.
Lasiochloa echinata (Thunb.) Henr.
Lasiochloa longifolia (Schrader) Kunth
Lolium perenne L.
Pentaschistis airoides (Nees) Stapf
Pentaschistis thunbergii (Kunth) Stapf
Phragmites australis (Cav.) Trin. ex Steudel
Polypogon strictus Nees
Pucinella fasciculata (Torrey) Bickn.
Schismus barbatus Loefl. ex L.
Spartina maritima (Curtis) Fern.
Sporobolus virginicus (L.) Kunth

CYPERACEAE
Carex clavata Thunb.
Ficinia bulbosa (L.) Nees
Ficinia dunensis Levyns
Ficinia lateralis (Vahl) Kunth
Ficinia nigrescens (Schrader) Raynal
Ficinia trichodes (Schrader) Benth. & Hook.f.
Isolepis ludwigii Kunth
Isolepis setacea (L.) R.Br.
Isolepis sp. cf. antarctica Nees
Pycreus polystachyos (Rottb.) Beauv.
Schoenoplectus triqueter (L.) Palla
Scirpus dioecus (Kunth) Boeckeler
Scirpus maritimus L.
Scirpus nodosus Rottb.
Scirpus trachyspermus (Nees) C.B. Clarke

RESTIONACEAE
Calopsis impolitus (Kunth) Linder
Chondropetalum acockii Pill.
Chondropetalum rectum (Masters) Pill.
Elegia verreuxii Masters
Ischyrolepis duthiae (Pill) Linder
Ishyrolepis eleocharis (Nees) Linder
Thamnochortus spicigerus (Thunb.) Sprengel
Willdenowia incurvata (Thunb.) Linder

JUNCACEAE
Juncus acutus L.
Juncus kraussii Hochst.

TYPHACEAE
Typha latifolius L.

ASPHODALACEAE
Aloe arenicola G. Reyn.
Aloe distans Haw.
Aloe glauca Miller
Aloe mitriformis Miller
Bulbine annua (L.) Willd.
Trachyandra ciliata (L.f.) Kunth
Trachyandra divaricata (Jacq.) Kunth
Trachyandra hirsutu (Thunb.) Kunth
Trachyandra revoluta (L.) Kunth

COLCHICACEAE
Ornithoglossum viride (L.f.) Aiton
Ornithoglossum sp. cf. parviflorum B. Nordenstam

ASPARAGACEAE
Myrsiphyllum declinatum (L.) Oberm.
Myrsiphyllum asparagoides (L.) Willd.
Protasparagus aethiopicus (L.) Oberm.
Protasparagus capensis (L.) Oberm.
Protasparagus compactus (T.M. Salter) Oberm.
Protasparagus retrofractus (L.) Oberm.
Protasparagus rubicundus (Bergius) Oberm.
Protasparagus stipulaceus (Lam.) Oberm.

HYACINTHACEAE
Albuca canadensis (L.) Leighton
Lachenalia purpurea-caerula Jacq.
Lachenalia rubida Jacq.

IRIDACEAE
Antholyza plicata L.
Antholyza ringens L.f.
Babiana ambigua (Roemer & Schultes) G. Lewis
Babiana nana (Andrews) Sprengel
Babiana scabrifolia Brehm. ex Klatt
Babiana tubulosa (Burm. f.) Ker Gawler
Babiana sp. cf. blanda (L. Bolus) G. Lewis
Ferraria crispa Burm.
Ferraria divaricata Sweet
Galaxia alata Goldbl.
Geissorhiza imbricata (Delaroche) Ker Gawler
Geissorhiza mathewsii L. Bolus
Gladiolus carinatus Aiton
Gladiolus orchidiflorus Andrews
Gladiolus quadrangulus Delaroche
Hesperantha radiata (Jacq.) Ker Gawler
Ixia curta Andrewa
Ixia purpureorosea G. Lewis
Lapeirousia jacquinii N.E. Br.
Melasphaerula ramosa N.E. Br.
Moraea elsiae Goldbl.
Moraea fugax (Delaroche) Jacq.
Moreae loubseri Goldbl.
Romulea flava (Lam.) De Vos
Romulea saldanhensis De Vos

AMARYLLIDACEAE
Amaryllis belladona L.
Brunsvigia orientalis (L.) Aiton ex Ecklon
Haemanthus coccineus L.
Haemanthus sanguineus Jacq.
Hessea chaplinii W. Barker
Hessea leipoldtii L. Bolus
Hessea mathewsii W. Barker

TECOPHILACEAE
Cyanella hyacinthoides L.

ARACEAE
Zantedeschia aethiopica (L.) Sprengel

MYRICEAE
Myrica cordifolia L.

SAPOTACEAE
Sideroxylon inerme L.

PROTEACEAE
Leucadendron brunioides Meissner
Leucospermum arenarium Rycr.
Leucospermum hypophyllocarpodendron (L.) Druce
Leucospermum tomentosum (Thunb.) R. Br.
Serruria aemula Salisb. ex J. Knight
Serruria linearis Salisb. ex J. Knight
Serruria trilopha Salisb. ex J. Knight

SANTALACEAE
Colpoon compressum Bergius
Thesidium fragile (Thunb.) Sonder
Thesium aggregatum A.W. Hill
Thesium litoreum Brenan
Thesium patulum A.W. Hill
Thesium spinosum L.f.

LORANTHACEAE
Septulina glauca (Thunb.) Tieghem

VISCACEAE
Viscum capense L.f.
Viscum pauciflorum L.f.
Viscum rotundifolium L.f.

RAFFLESIACEAE
Cytinus sanguineus (Thunb.) Fourc.

CHENOPODIACEAE
Atriplex cinerea Poiret
Atriplex semibaccata R. Br.
Chenolea diffusa Thunb.
Chenopodium album L.
Chenopodium murale L.
Exomis microphylla Aellen
Manochlamys albicans (Aiton) Aellen
Salicornia meyeriana Moss ex Adamson
Salsola kali L.
Sarcocornia pillansii (Moss) A.J Scott
Sarcocornia sp. cf natalensis (Bunge ex
                        Ung.-Sternb.) A.J. Scott
Suadea fruticosa (L.) Forsskal

AIZOACEAE
Aizoon paniculatum L.
Galenia africana L.
Galenia crystallina (Ecklon & Zeyher) Fenzl
Limeum africanum L.
Mollugo tenella Bolus
Pharnaceum dichotomum L.f.
Pharnaceum lanatum Bartling
Pharnaceum microphyllum L.f.
Polpoda stipulacea (F.M. Leighton) Adamson
Tetragonia decumbens Miller
Tetragonia fruticosa L.
Tetragonia spicata L.f.

MESEMBRYANTHEMACEAE
Amphibolia gydouwensis (L. Bolus) L. Bolus
Carpobrotus acinaciformis (L.) L. Bolus
Carpobrotus edulis (L.) N.E. Br.
Carpobrotus sauerae Schwantes
Cephalophyllum aureorubrum L. Bolus
Cephalophyllum decipiens (Haw.) L. Bolus
Cheiridopsis purpurascens (Salm-Dyck) N.E. Br.
Conicosia pugioniformis (L.) N.E. Br.
Disphyma crassifolium (L.) L. Bolus
Dorotheanthus bellidiformis (Burm. f.) N.E. Br.
Drosanthemum calycinum (Haw.) Schwantes
Drosanthemum floribundum (Haw.) Schwantes
Drosanthemum marinum L. Bolus
Drosanthemum pulchellum L. Bolus
Drosanthemum salicolum L. Bolus
Lampranthus amoenus (Salm-Dyck ex DC.) N.E. Br.
Leipoldtia jacobsiana Schwantes
Mesembryanthemum crytallinum L.
Prenia pallens (Aiton) N.E. Br.
Psilocaulon imitans L. Bolus
Psilocaulon subintegrum L. Bolus
Ruschia bina L. Bolus
Ruschia caroli (L. Bolus) Schwantes
Ruschia frutescens (L. Bolus) L. Bolus
Ruschia geminiflora (Haw.) Schwantes
Ruschia macowanii (L. Bolus) Schwantes
Ruschia suaveolens L. Bolus
Ruschia subpaniculata L. Bolus
Vanzylia annulata (A. Berger) L. Bolus

CARYOPHYLLACEAE
Silene clandestinum Jacq.
Spergularia sp. cf. media (L.) C. Presl.

MENISPERMACEAE
Cissampelos capensis L.f.

FUMARIACEAE
Cysticapnos vesicarius (L.) Fedde

BRASSICACEAE
Heliophila arenaria Sonder
Heliophila coronopifolia L.
Heliophila linearis (Thunb.) DC.
Heliophila variabilis Burchell ex DC.

CRASSULACEAE
Cotyledon orbiculata L.
Crassula cymosa Bergius
Crassula expansa Dryander
Crassula glomerata Bergius
Crassula muscosa L.
Crassula thunbergiana Schultes
Tylecodon fragilis (R. A. Dyer) Toelken
Tylecodon paniculatus (L.f.) Toelken
Tylecodon wallichii (Harvey) Toelken

ROSACEAE
Cliffortia strobilifera Murr.
Grielum grandiflorum (L.) Druce
Grielum humifusum Thunb.

FABACEAE - MIMOSOIDEAE
Acacia cyclops A. Cunn. ex G. Don

FABACEAE - PAPILIONOIDEAE
Argyrolobium lunaris (L.) Druce
Argyrolobium velutinum Ecklon & Zeyher
Aspalathus acuminata Lam
Aspalathus albens L.
Aspalathus cuspidata R. Dahlgren
Aspalathus divaricata Thunb.
Aspalathus heterophylla L.f.
Aspalathus hispida Thunb.
Aspalathus pinguis Thunb.
Aspalathus spinescens Thunb.
Aspalathus ternata (Thunb.) Druce
Indigophera heterophylla Thunb.
Indigophera procumbens L.
Lebeckia multiflora E. Meyer
Lebeckia plukenetiana E. Meyer
Lebeckia sericea Thunb.
Lebeckia simsiana Ecklon & Zeyher
Lessertia diffusa R. Br.
Lessertia excisa DC.
Lotononis brachyloba Benth.
Melalobium adenodes Ecklon & Zeyher
Otholobium striatum (Thunb.) Stirton ined.
Psoralea repens L.
Wiborgia sericea Thunb.

GERANIACEAE
Pelargonium carnosum (L.) L'Her.
Pelargonium fulgidum (L.) L'Her.
Pelargonium gibbosum (L.) L'Her.
Pelargonium hirtum (Burm.f.) Jacq.
Pelargonium triste (L.) L'Her.

OXALIDACEAE
Oxalis hirta L.
Oxalis obtusa Jacq.
Oxalis pes-caprae L.

ZYGOPHYLLACEAE
Zygophyllum cordifolium L.f.
Zygophyllum flexuosum Ecklon & Zeyher
Zygophyllum morgsana L.
Zygophyllum procumbens Adamson
Zygophyllum pygmaeum Ecklon & Zeyher

RUTACEAE
Agathosma corymbosa (Montin) G. Don
Agathosma imbricata (L.) Willd.
Agathosma serpyllacea Licht. ex Roemer & Schultes
Agathosma thymifolia Schldl.
Diosma aspalathoides Lam.
Diosma dichotoma Bergius
Diosma hirsuta L.

POLYGALACEAE
Muraltia dumosa (Poiret) DC.
Nylandtia spinosa (L.) Dumont
Polygala myrtifolia L.

EUPHORBIACEAE
Clutia daphnoides Lam
Euphorbia burmannii E. Meyer ex Boiss.
Euphorbia caput-medusae L.
Euphorbia hamata (Haw.) Sweet
Euphorbia karroensis (Boiss.) N.E. Br.
Euphorbia marlothiana N.E. Br.
Euphorbia mauritanica L.
Euphorbia tuberculata Jacq.
Euphorbia tuberosa L.

ANARCADIACEAE
Rhus glauca Thunb.
Rhus laevigata L.
Rhus longispina Ecklon & Zeyher
Rhus tomentosa L.

CELASTRACEAE
Cassine crocea (Thunb.) Kuntze
Maurocenia frangularia (L.) Miller
Maytenus heterophylla (Ecklon & Zeyher) N. Robson
Maytenus lucida (L.) Loes.
Pterocelastrus tricuspidatus (Lam.) Sonder
Putterlickia pyracantha (L.) Syzsyzl.

MELIANTHACEAE
Melianthus minor L.

MALVACEAE
Anisodontea scabrosa (L.) D. Bates

PRIMULACEAE
Anagallis arvensis L.
Samolus valerandi L.

ACANTHACEAE
Justicia cuneata Vahl
Monechma incana L.
RHAMNACEAE
Phylica cephalantha Sonder
Phylica stipularis L.

STERCULIACEAE
Hermannia heterophylla (Cav.) Thunb.
Hermannia pinnata L.
Hermannia procumbens Cav.
Hermannia scordifolia Jacq.
Hermannia trifurca L.

FRANKENIACEAE
Frankenia repens (Bergius) Fourc.
Frankenia pulverulenta L.

THYMELACEAE
Passerina vulgaris Thoday

APIACEAE
Conium maculatum L.
Heteroptilis suffruticosa (Bergius) Lente
Rhyticarpus difformis (L.) Briq.

MYRSINACEAE
Myrsine africana L.

PLUMBAGINACEAE
Limonium acuminatum L. Bolus
Limonium equisetinum (Boiss.) R.A. Dyer
Limonium perigrinum (Bergius) R.A. Dyer
Limonium purpuratum (L.) Hubb. ex C. Bailey
Limonium scabrum (Thunb.) Kuntze

EBENACEAE
Diospyros glabra (L.) de Winter
Euclea racemosa Murray
Euclea tomentosa E. Meyer ex A. DC

OLEACEAE
Chionanthus foveolatus (E. Meyer) Stearn
Olea europaea L.
Olea exasperata Jacq.

GENTIANACEAE
Chironia baccifera L.

ASCLEPIADACEAE
Cynanchum africanum R. Br.
Cynanchum ellipticum (Harv.) R.A. Dyer
Microloma sagittatum (L.) R. Br
Stapelia nouhuysii E. Phillips

BORAGINACEAE
Heliotropium curassavicum L.
Echiostachys spicatus (Burm.f.) Levyns

LAMIACEAE
Ballota africana (L.) Benth.
Salvia aurea L. (= S. africana-lutea L.)
Salvia lanceolata Lam.
Stachys aethiopica L.

SOLANACEAE
Lycium afrum L.
Lycium ferrocissimum Miers
Lycium horridum Thunb.
Solanum guineense L.

POLYGONACEAE
Polygonum maritimum L.

ERICACEAE
Erica ferrea Bergius

SCROPHULARIACEAE
Diascia elongata Benth.
Diascia unilabiata Benth.
Dischisma ciliatum (Bergius) Choisy
Dischisma crassum Rolfe
Hebenstreitia cordata L.
Hebenstreitia dentata L.
Hebenstreitia integrifolia L.
Hebenstreitia repens Jarosz
Hemimeris sabulosa L.f.
Hyobanche sanguinea L.
Manulea altissima L.f.
Manulea cheiranthes L.
Manulea laxa Schltr.
Manulea tomentosa L.
Nemesia affinis Benth.
Nemesia bicornis (L.) Pers.
Nemesia parviflora Benth.
Nemesia strumosa Benth.
Nemesia versicolor E. Meyer ex Benth.
Polycarena cephalophora (Thunb.) Levyns
Polycarena selaginoides Schltr. ex Hiern
Selago fruticosa L.
Sutera tristis (L.f.) Hiern
Zaluzianskya villosa F.W Schmidt

RUBIACEAE
Anthospermum aethiopicum L.
Galium tomentosum Thunb.
Nenax hirta (Cruse) T.M. Salter

CUCURBITACEAE
Kedrostis capensis (Sonder) A. Meeuse

CAMPANULACEAE
Cyphia crenata (Thunb.) Presl.
Cyphia volubilis (Burm.f.) Willd.
Lightfootia adpressa (Thunb.) A.DC.
Lightfootia namaquana Sond.
Wahlenbergia annularis A.DC.

ASTERACEAE
Amellus asteroides (L.) Druce
Arctotheca calendula (L.) Levyns
Arctotheca populifolia (Bergius) Norlindh
Arctotis hirsuta (Harvey) Beauv.
Arctotis laevis Thunb.
Arctotis leptorhiza DC.
Athanasia rugulosa E. Meyer
Cenia turbinata (L.) Pers
Chrysanthemoides incana (Burm.f.) Norlindh
Chrysanthemoides monilifera (L.) Norlindh
Chrysocoma ciliata L.
Cineraria geifolia (L.) L.
Conyza pinnatifida (Thunb.) Less.
Cotula coronopifolia L.
Cotula sp. cf. pusilla Thunb.
Didelta carnosa (L.f.) Aiton
Dimorphotheca pluvialis (L.) Moench
Eriocephalus africanus L.
Eriocephalus racemosus L.
Felecia hyssopifolia (Bergius) Nees
Felicia dregei DC.
Felicia elongata (Thunb.) O. Hoffm.
Felicia filifolia (Vent.) Burtt Davy
Felicia tenella (L.) Nees
Gazania pectinata (Thunb.) Sprengel
Gazania sp. cf. rigida (Burm.f.) Roessler
Helichrysum asperum (Thunb.) Hilliard & B.L. Burtt
Helichrysum hebelepis DC.
Helichrysum litorale H. Bolus
Helichrysum marmarolepis S. Moore
Helichrysum revolutum (Thunb.) Less.
Helichrysum sp. cf. tricostatum (Thunb.) Less.
Helichrysum sp. cf. plebium DC.
Helichrysum sp. cf. rutilans (L.) D. Don
Helichrysum teretifolium (L.) D. Don
Ifloga ambigua (L.) Druce
Leysera gnaphalodes (L.) L.
Leysera tenella DC.
Matricaria tenella DC.
Metalasia muricata (L.) D.Don
Nidorella foetida (L.) DC.

ASTERACEAE (cont.)

Osteospermum clandestinum (Less.) Norlindh
Osteospermum oppositifolium (Aiton) Nordlindh
Osteospermum pinnatum (Thunb.) Norlindh
Othonna amplexifolia DC.
Othonna coronipifolia L.
Othonna cylindrica (Lam.) DC.
Othonna filicaulis Jacq.
Othonna floribunda Schltr.
Pentzia pilulifera (L.f.) Fourc.
Pentzia sabulosa (Wolley-Dod) Hutch.
Pentzia suffruticosa (L.) Hutch. ex Merxm.
Pteronia divaricata (Bergius) Less.
Pteronia onobromoides DC.
Pteronia ovalifolia DC.
Pteronia uncinata DC.
Relhania rotundifolia Less.
Senecio aloides DC.
Senecio angustifolius (Thunb.) Willd.
Senecio arenarius Thunb.
Senecio arniciflorus DC.
Senecio burchellii DC.
Senecio corymbiferus DC.
Senecio elegans L.
Senecio halmifolius L.
Senecio maritimus L.
Senecio repandus Thunb.
Sonchus oleraceus L.
Steirodiscus speciosus (Pill.) B. Nordenstam
Stoebe nérvigera (DC.) Schultz-Bip.
Stoebe gomphrenoides Bergius
Troglophyton capillaceum (Thunb.) Hilliard & B.L. Burtt

References:

Bond P & Goldblatt P 1984. Plants of the Cape Flora. A descriptive catalogue.
Journal of South African Botany Supplementary Vol. No. 13.

Boucher C & Jarman ML 1977. The vegetation of the Langebaan area, South Africa.
Transactions of the Royal Society of South Africa 42(3):241-272.

Gibbs Russel GE and staff of the National Herbarium 1985. List of species of South
African plants. Edition 2 Part 1. Memoirs of the Botanical Survey of South Africa 51.

Gibbs Russel GE and staff of the National Herbarium 1985. List of species of South
African plants. Edition 2 Part 2. Memoirs of the Botanical Survey of South Africa 56.

Hall AV & Veldhuis HA 1985. South African Red Data Book: Plants - Fynbos and Karoo Biomes.
South African National Scientific Programmes Report No. 117, Pretoria: CSIR.

APPENDIX B: SPECIES RECORDED IN EACH GRAZING TRIAL AT NORTIER EXPERIMENTAL FARM
(Compiled from data for individual survey lines combined for each trial)

Species	C26	C20	C&S	S **
Helichrysum marmarolepis	p	p	p	p
Tetragonia fruticosa	p	p	p	p
Cassine crocea	p	p	p	p
Hermannia scordifolia	p	p	p	p
Zygophyllum morgsana	p	p	p	p
Lebeckia multiflora	p	p	p	p
Cysticapnos vesicarius	p	p	p	p
Solanum guineense	p	p	p	p
Lightfootia namaquana	p	p	p	p
Eriocephalus racemosus	p	p	p	p
Lycium horridum	p	p	p	p
Euphorbia karroensis	p	p	p	p
Lycium afrum	p	p	p	p
Euphorbia tuberculata	p	p	p	p
Manochlamys albicans	p	p	p	p
Salvia lanceolata	p	p	p	p
Ballota africana	p	p	p	p
Microloma saggitatum	p	p	p	p
Mesembryanthemum crystalinum	p	p	p	p
Ruschia caroli	p	p	p	p
Euphorbia mauritanica	p	p	p	p
Rhus glauca	p	p	p	p
Helichrysum hebelepis	p	p	p	p
Protasparagus africanus	p	p	p	p
Ehrharta calycina	p	p	p	p
Protasparagus capensis	p	p	p	p
Exomis microphylla var. axyroides	p	p	p	p
Euclea racemosa	p	p	p	p
Chaetobromus schraderi	p	p	p	p
Pteronia divaricata	p	p	p	p
Ehrharta villosa	p	p		p
Cladoraphis cyperoides	p	p		p
Othonna floribunda	p	p	p	
Hermannia heterophylla	p		p	p
Willdenowia incurvata	p		p	p

Species	C26	C20	C&S	S
Pteronia onobromoides	p	p		
Felicia dregei	p	p		
Aspalathus albens	p		p	
Lessertia excisa	p			p
Mariscus sp.	p			p
Wiborgia sericea	p			p
Zygophyllum pygmaeum	p			p
Pharnaceum sp.	p			
Tylecodon paniculata	p			
Conicosia sp.	p			
Manulea altissima	p			
Pteronia ovalifolia	p			
Heliophila variabilis		p	p	p
Ruschia sp.		p	p	p
Antholyza plicata		p	p	p
Chrysanthemoides monilifera		p	p	p
Limeum africanum		p	p	
Cissampelos capensis		p		p
Senecio corymbiferus		p		
Leipoldtia jacobsoniana		p		
Aloe arenicola		p		
Cephalophyllum aureorubrum		p		
Pterocelastrus tricuspidatus		p		
Cynanchum ellipticum			p	
Aspalathus divaricata				p

** C26 Cattle at 1 LSU/26 ha
C20 Cattle at 1 LSU/20 ha
C&S Cattle and sheep, equivalent to 1 LSU/26 ha
S   Sheep, equivalent to 1 LSU/26 ha

p   present

APPENDIX C: PHENOLOGY OF DIFFERENT GROWTH FORMS IN SAND PLAIN
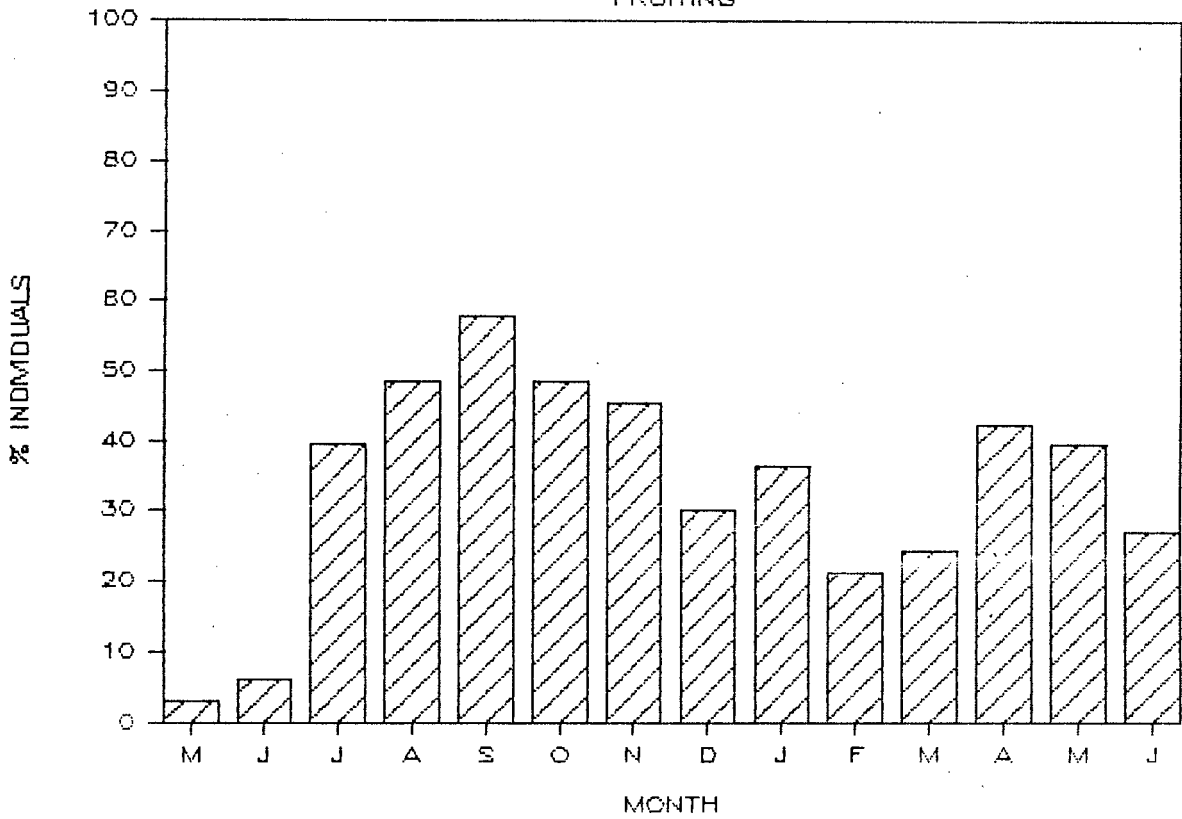 FYNBOS AT BARHUIS.
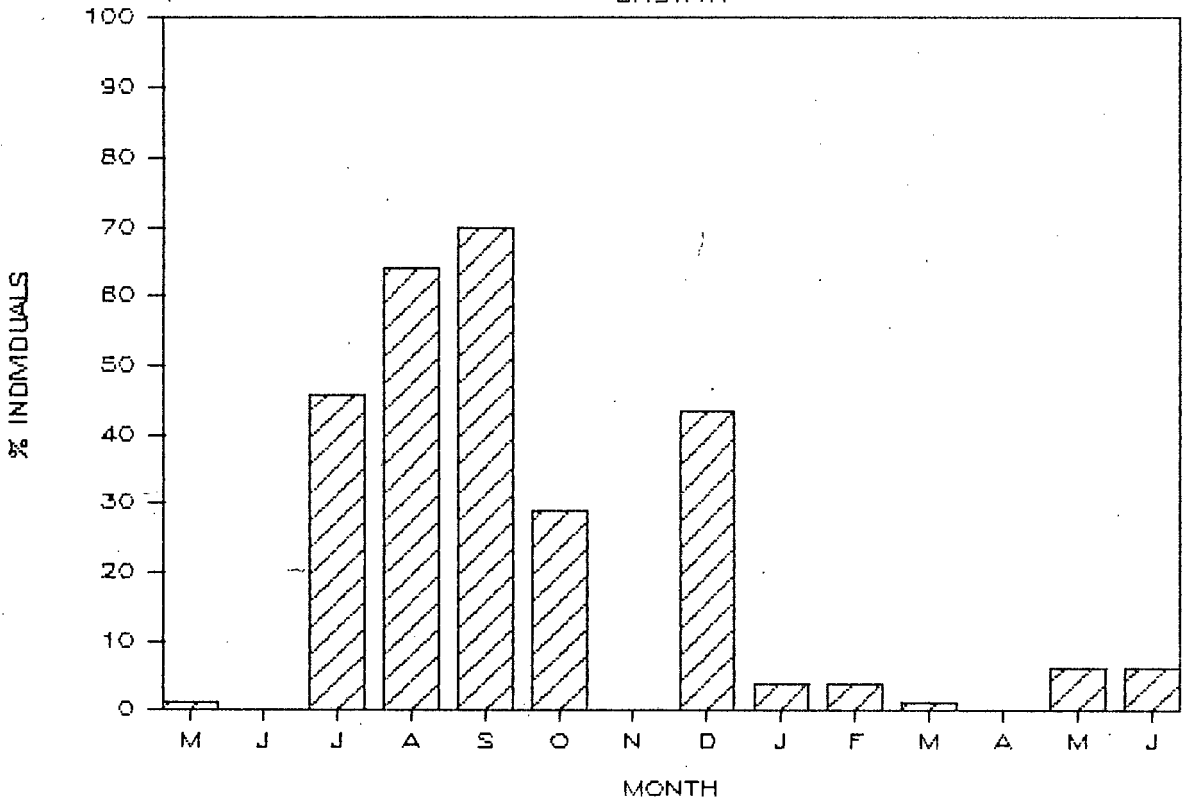
LARGE-LEAVED SHRUBS
GROWTH
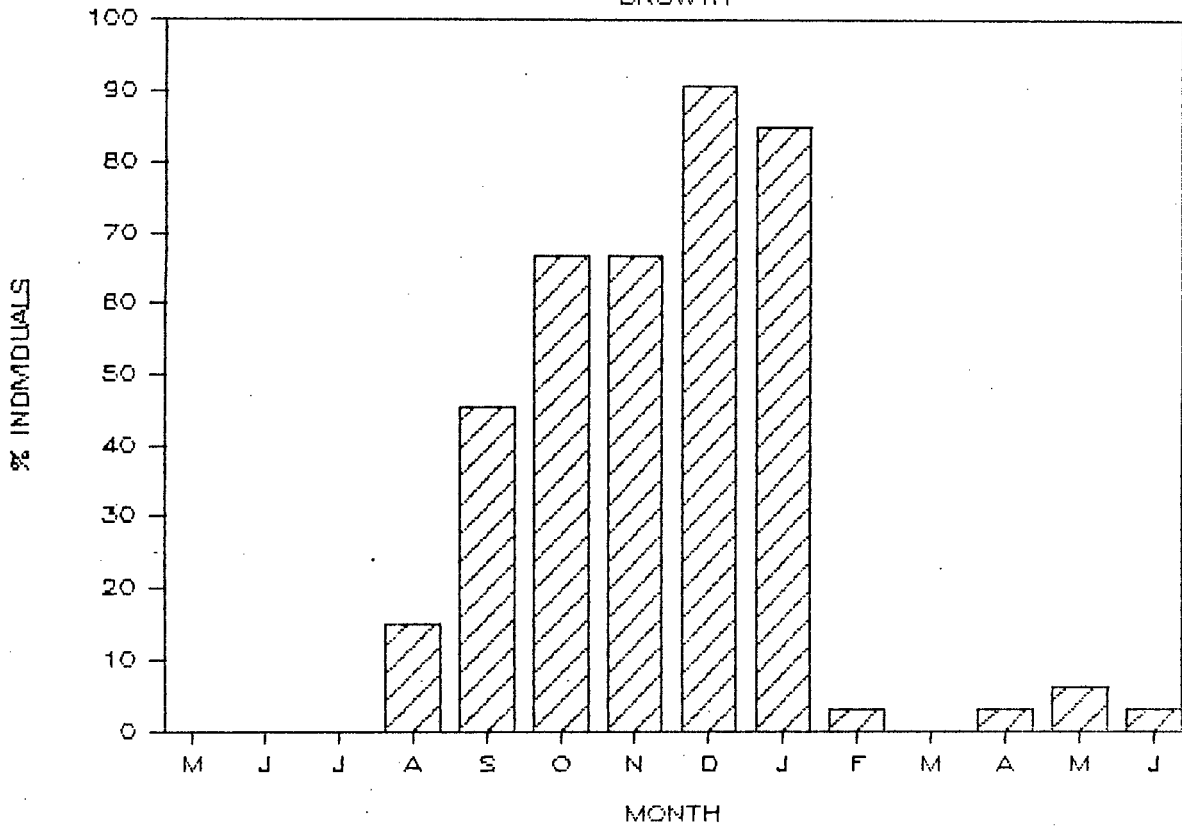
LARGE-LEAVED SHRUBS
FLOWERING

LARGE—LEAVED SHRUBS
FRUITING

% INDIVIDUALS

100
90
80
70
60
50
40
30
20
10
0

M J J A S O N D J F M A M J

MONTH

SMALL—LEAVED SHRUBS
GROWTH

% INDIVIDUALS

100
90
80
70
60
50
40
30
20
10
0

M J J A S O N D J F M A M J

MONTH

SMALL–LEAVED SHRUBS
FLOWERING

SMALL–LEAVED SHRUBS
FRUITING

RESTIONACEAE
GROWTH
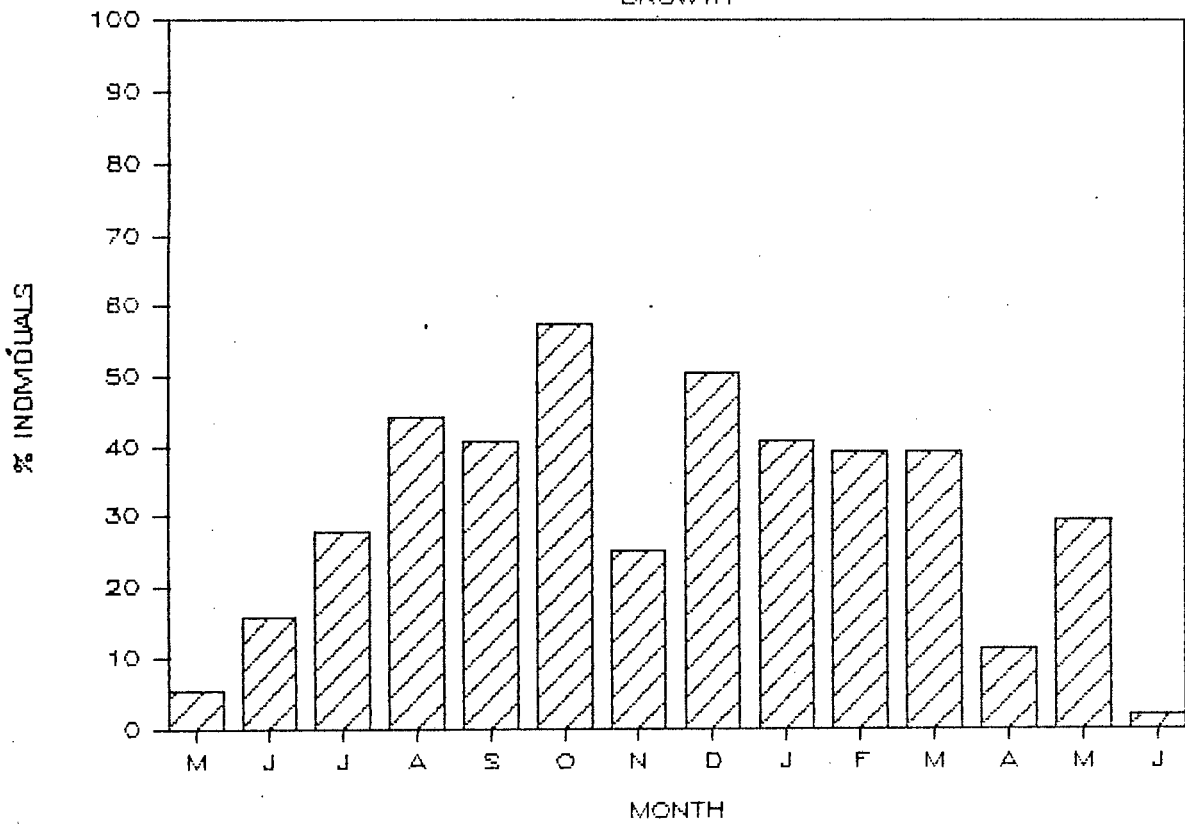
RESTIONACEAE
FLOWERING
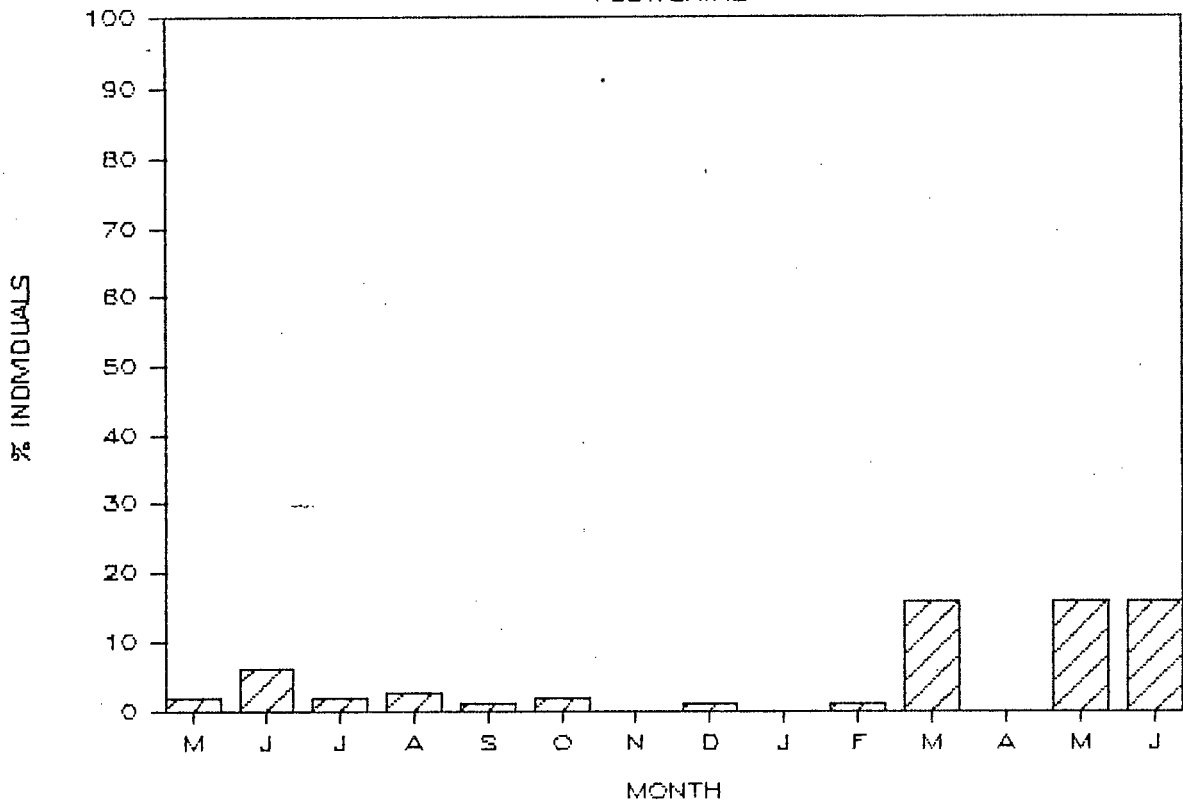
RESTIONACEAE

FRUITING
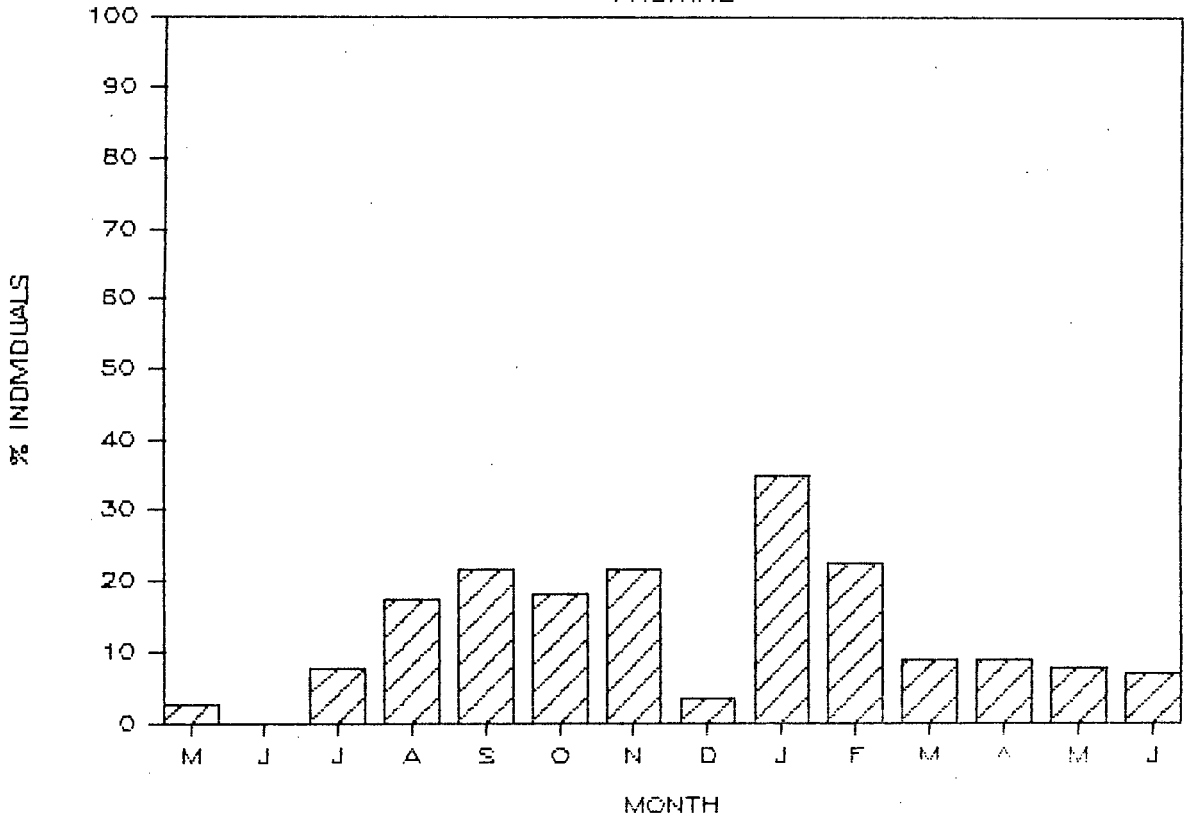
APPENDIX D: PHENOLOGY OF DIFFERENT GROWTH FORMS IN COASTAL
RENOSTERVELD AT DE GRENDEL.

BROAD-LEAVED SHRUBS
GROWTH
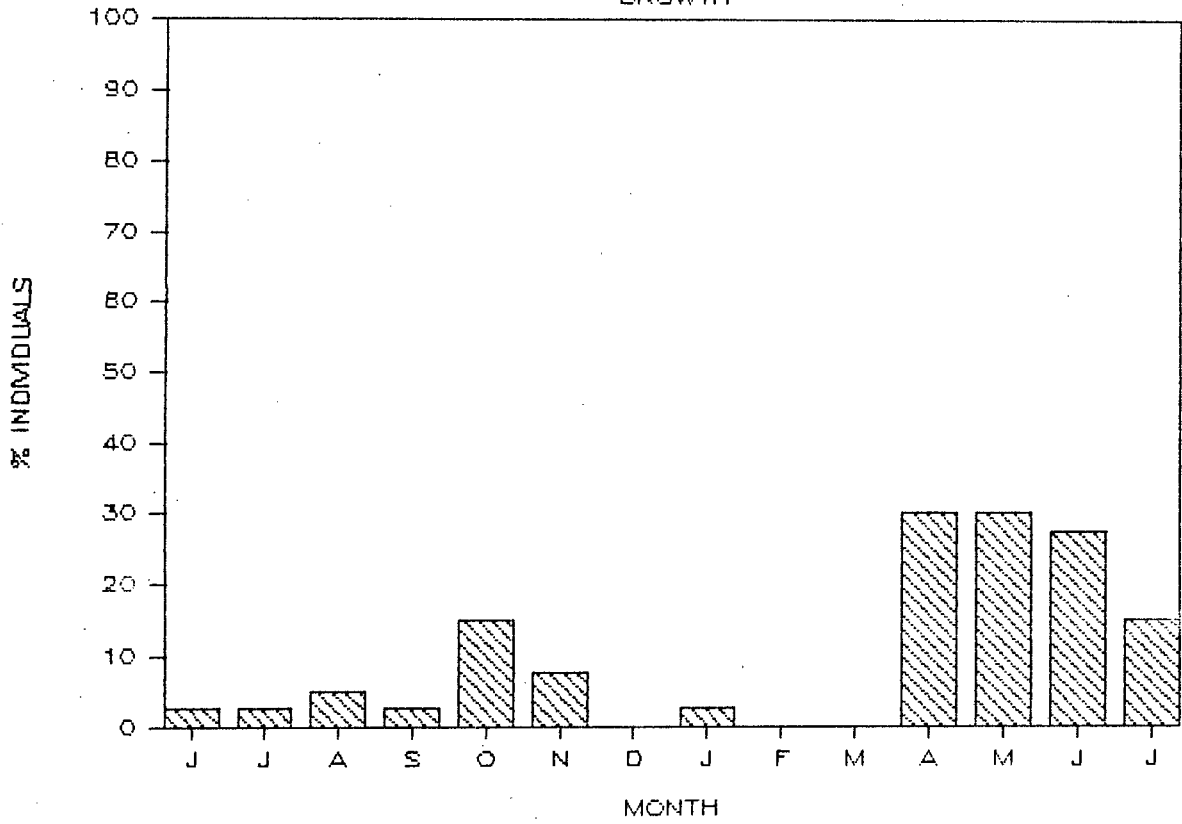
SMALL-LEAVED SHRUBS
GROWTH
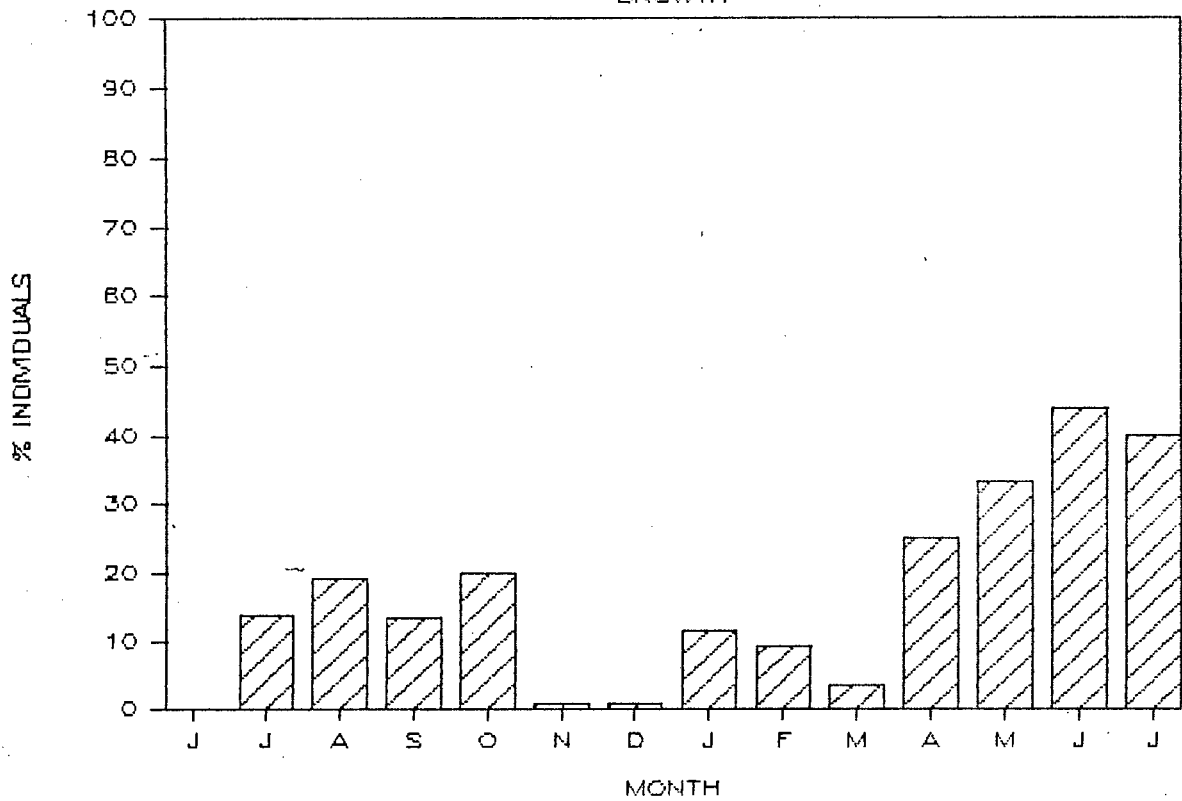
LEAF SUCCULENTS

GROWTH
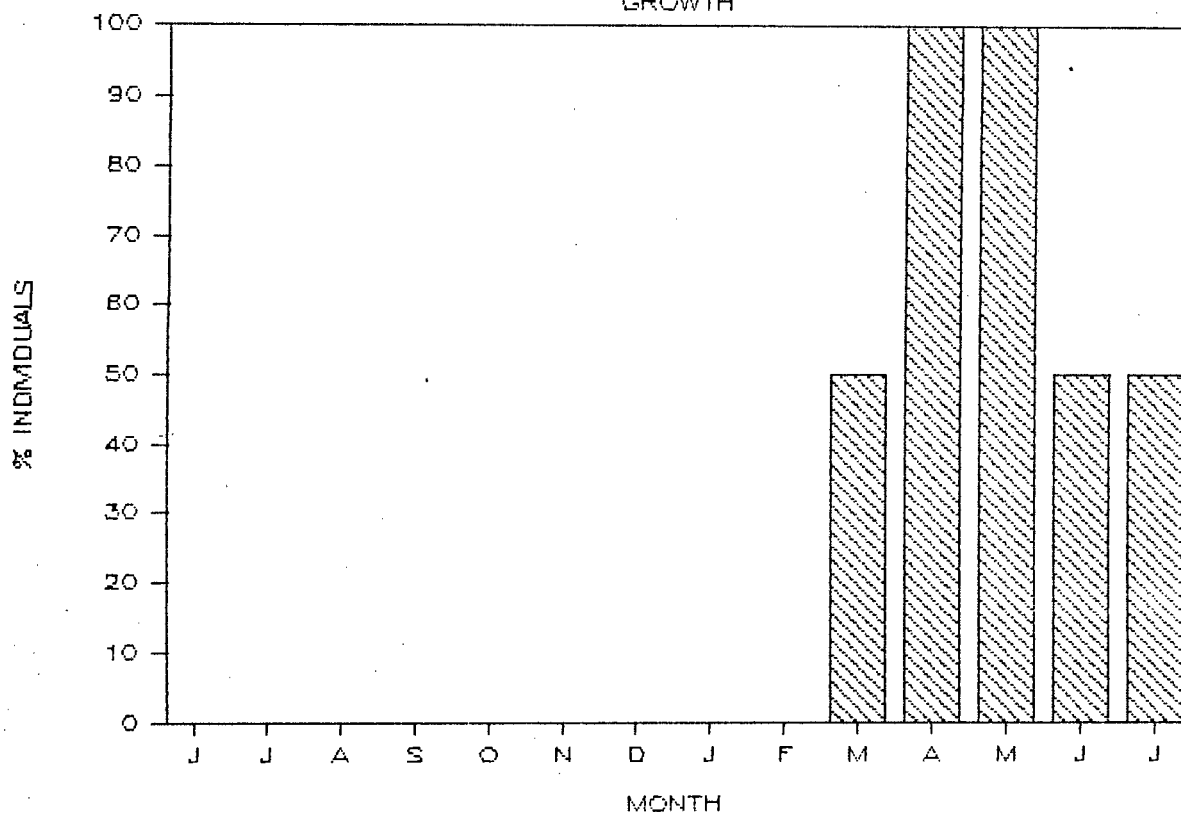
GRASSES

GROWTH
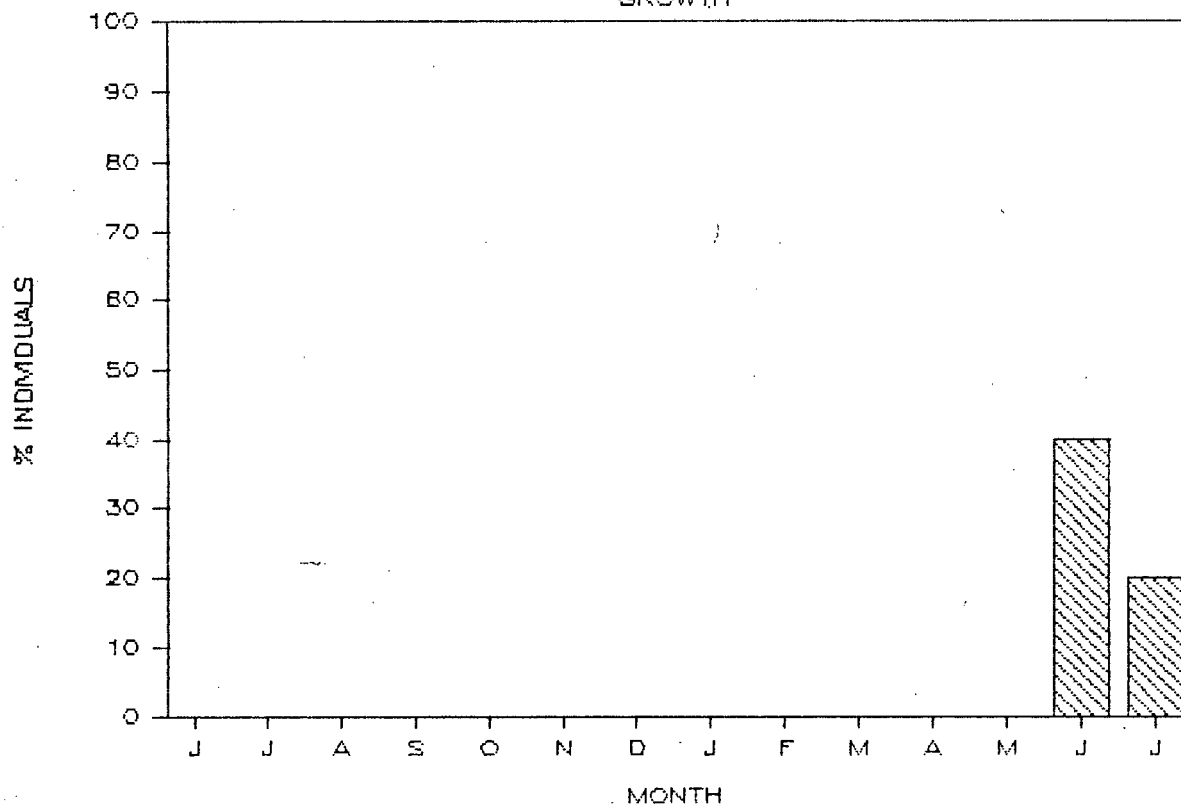
BROAD—LEAVED SHRUBS

FLOWERING
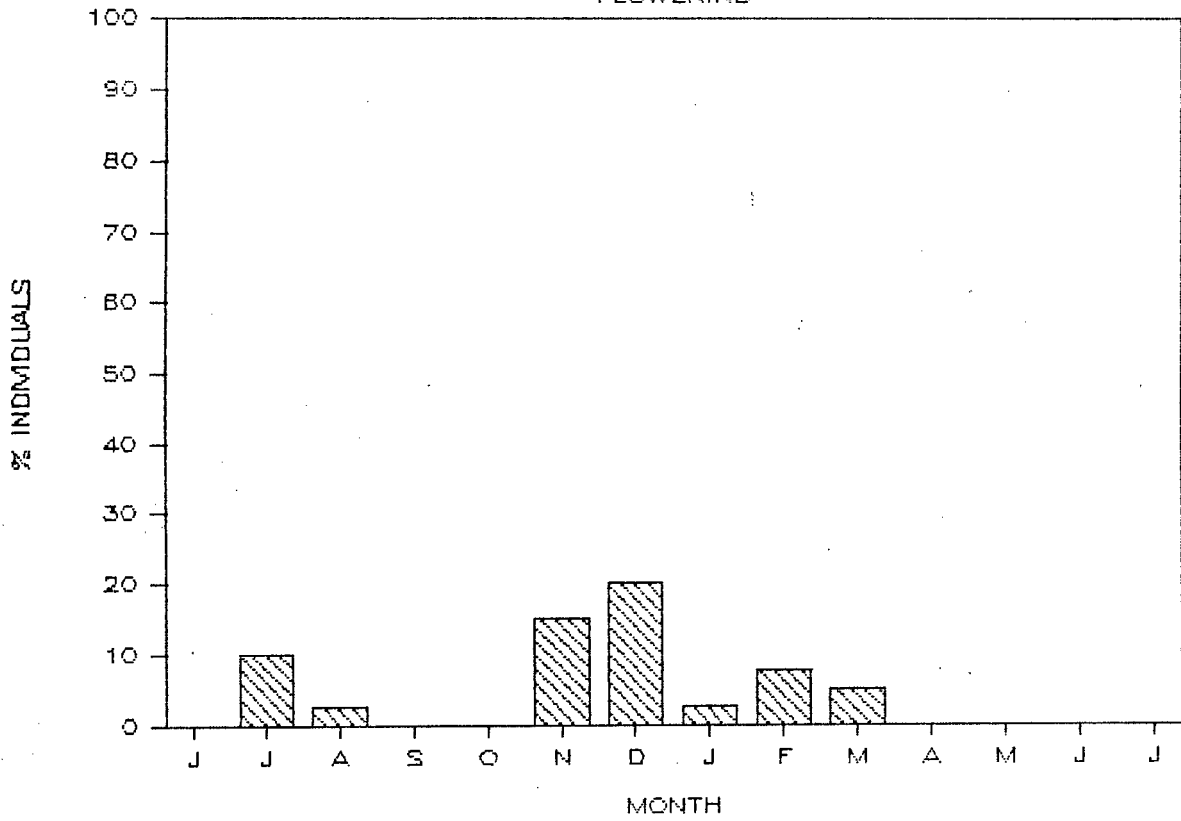
SMALL—LEAVED SHRUBS
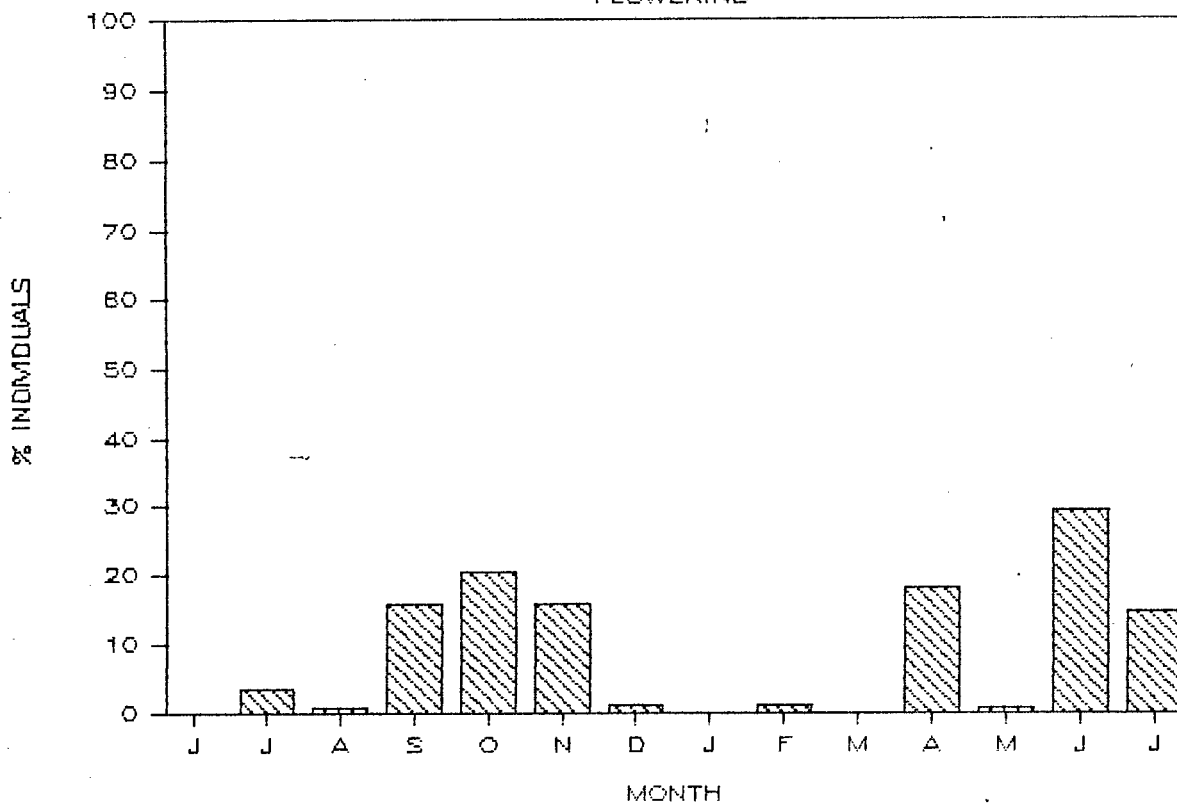
FLOWERING

LEAF SUCCULENTS
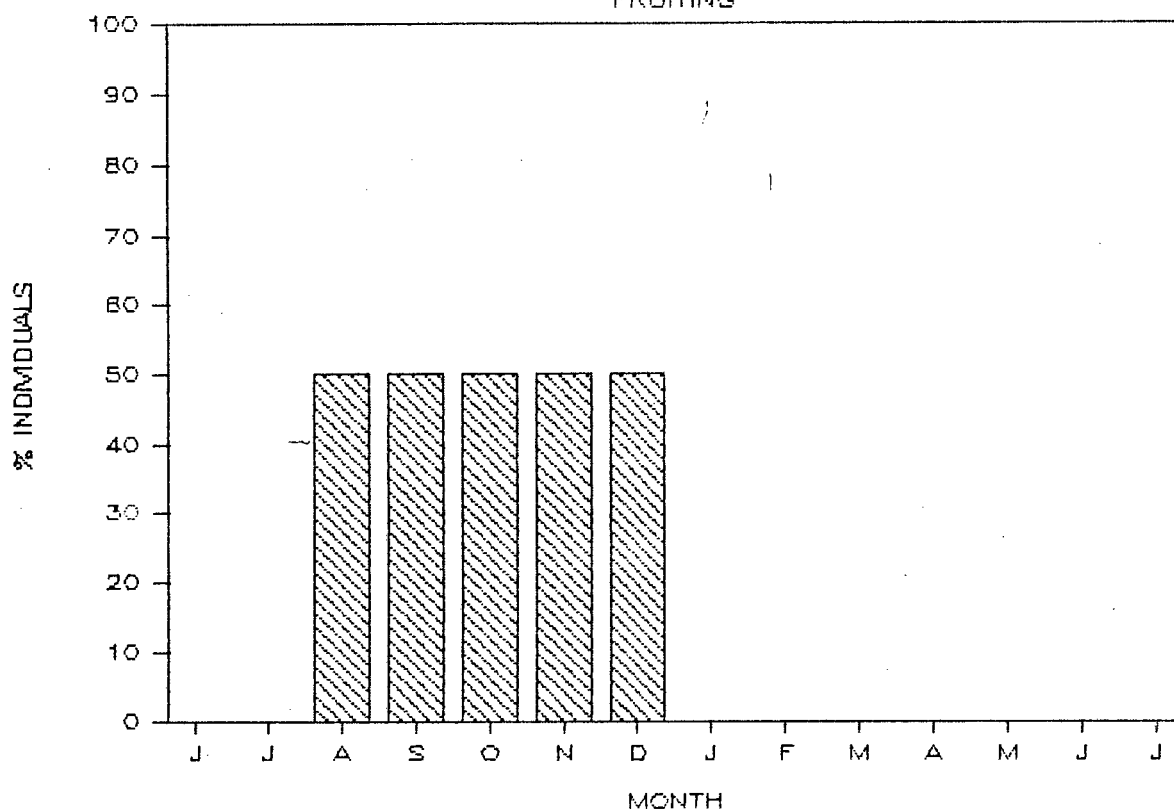FLOWERING
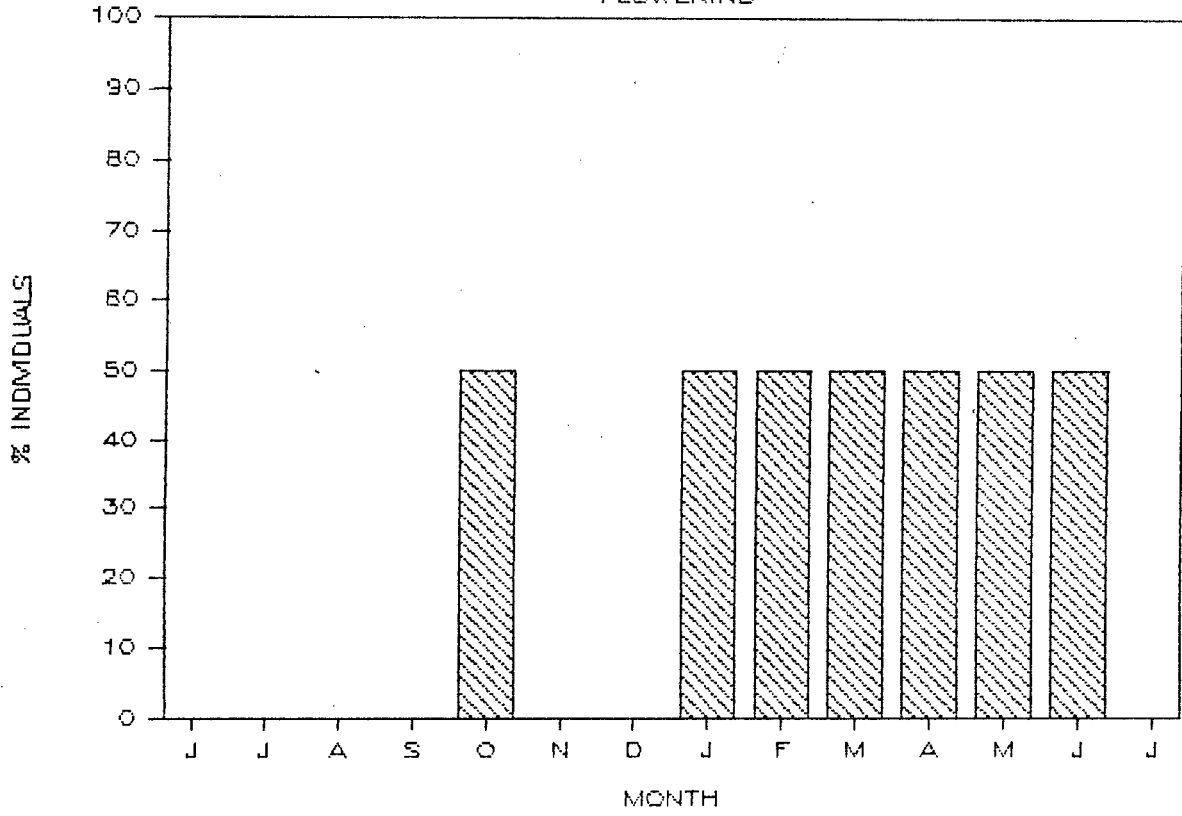
BROAD−LEAVED SHRUBS
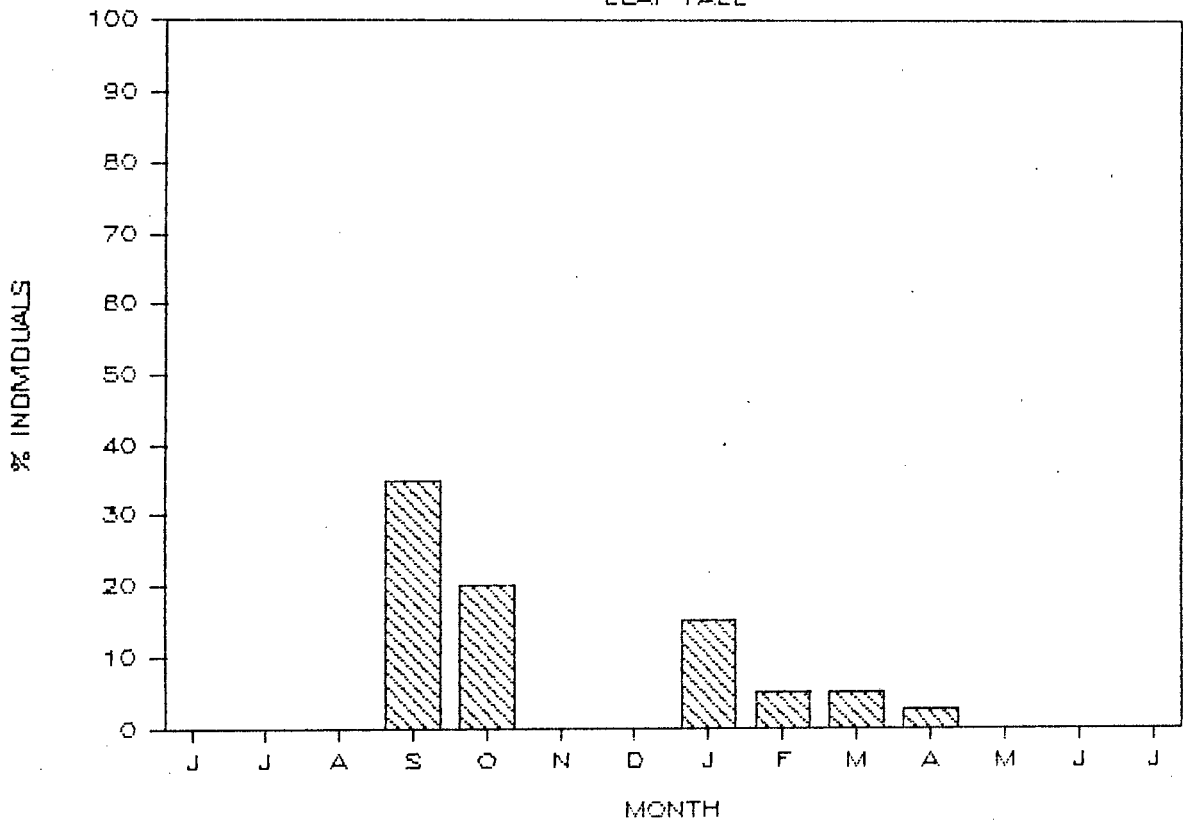FRUITING
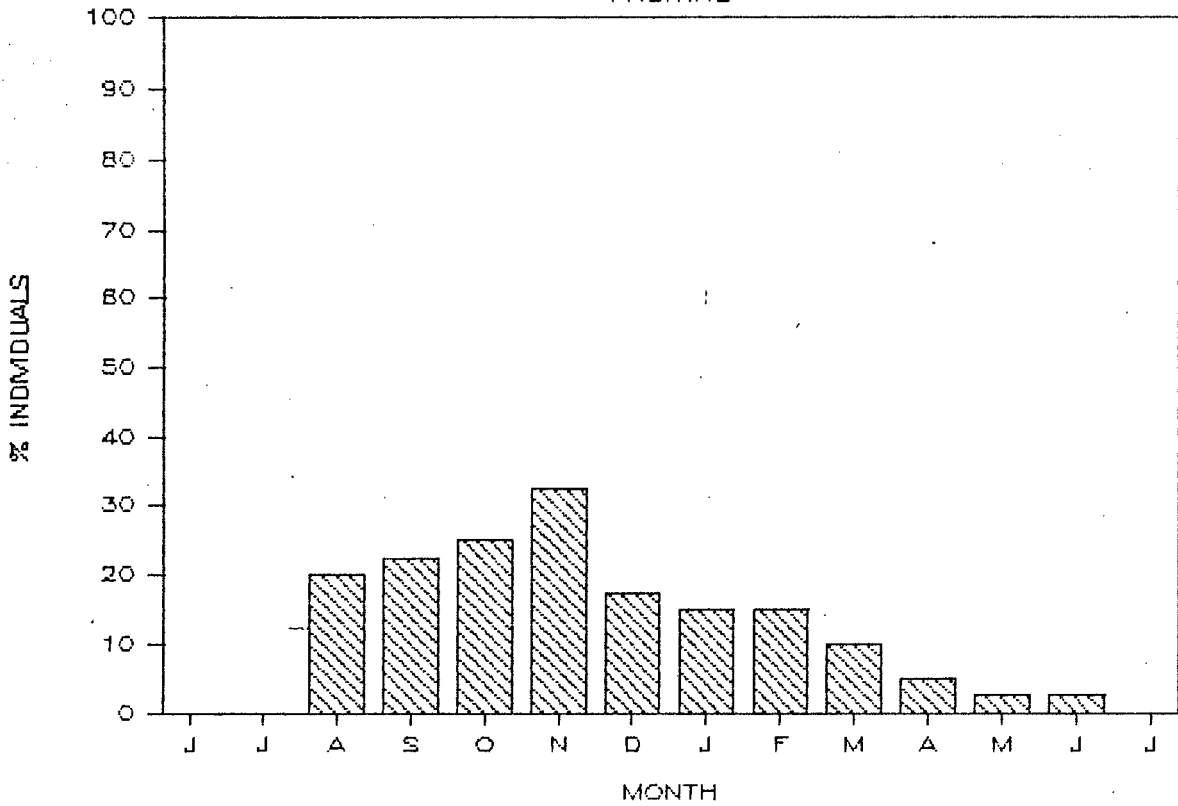
SMALL-LEAVED SHRUBS
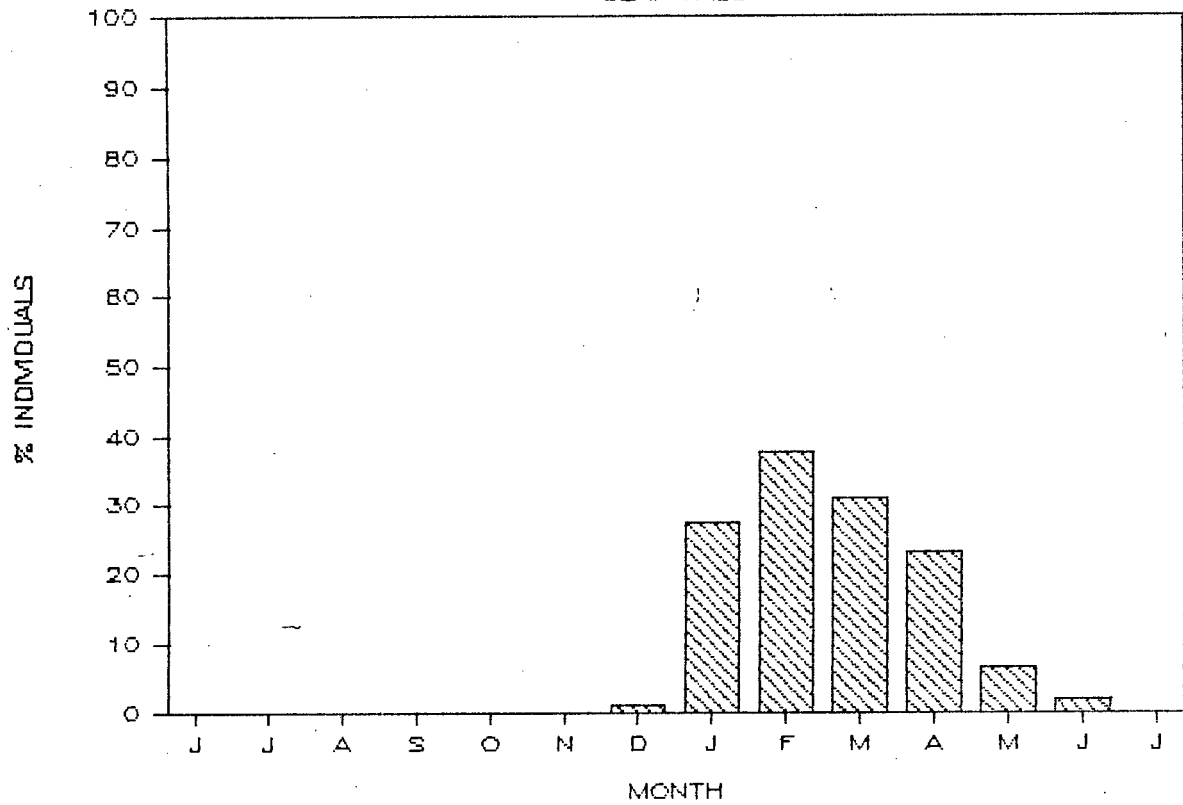FRUITING
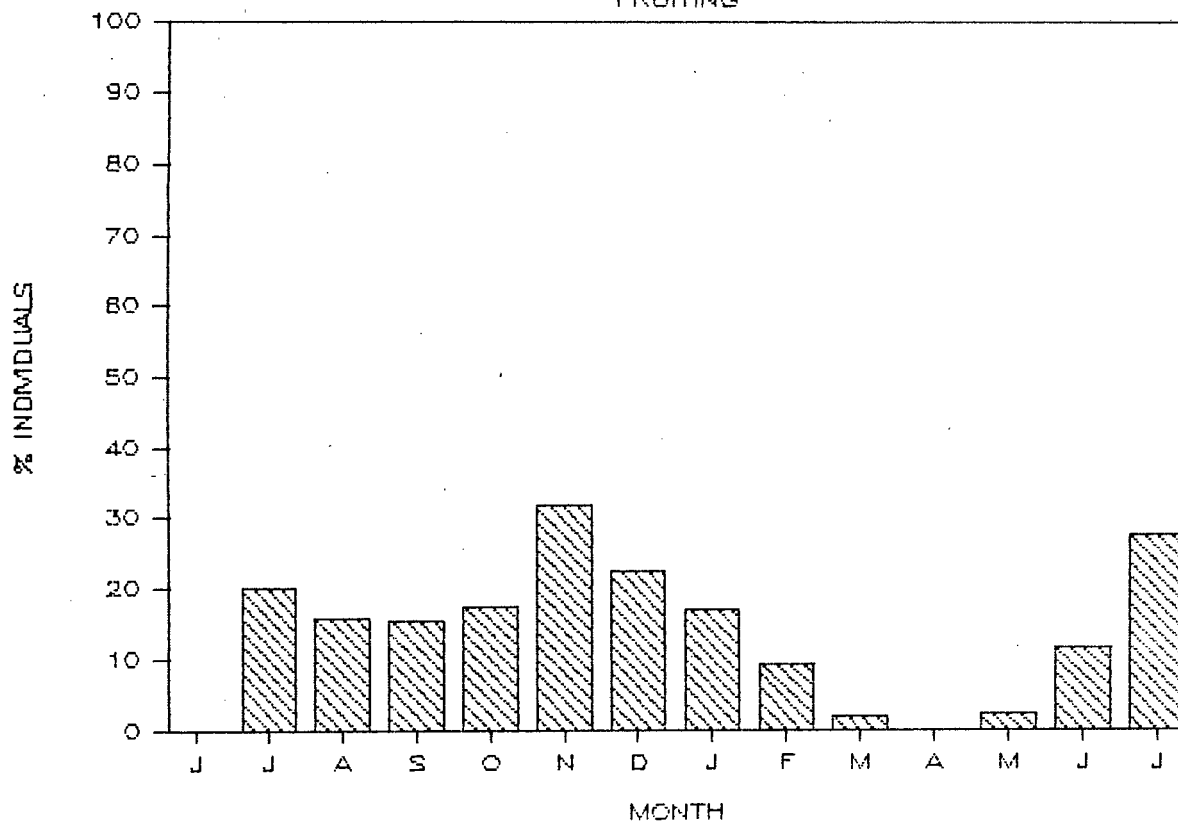
LEAF SUCCULENTS
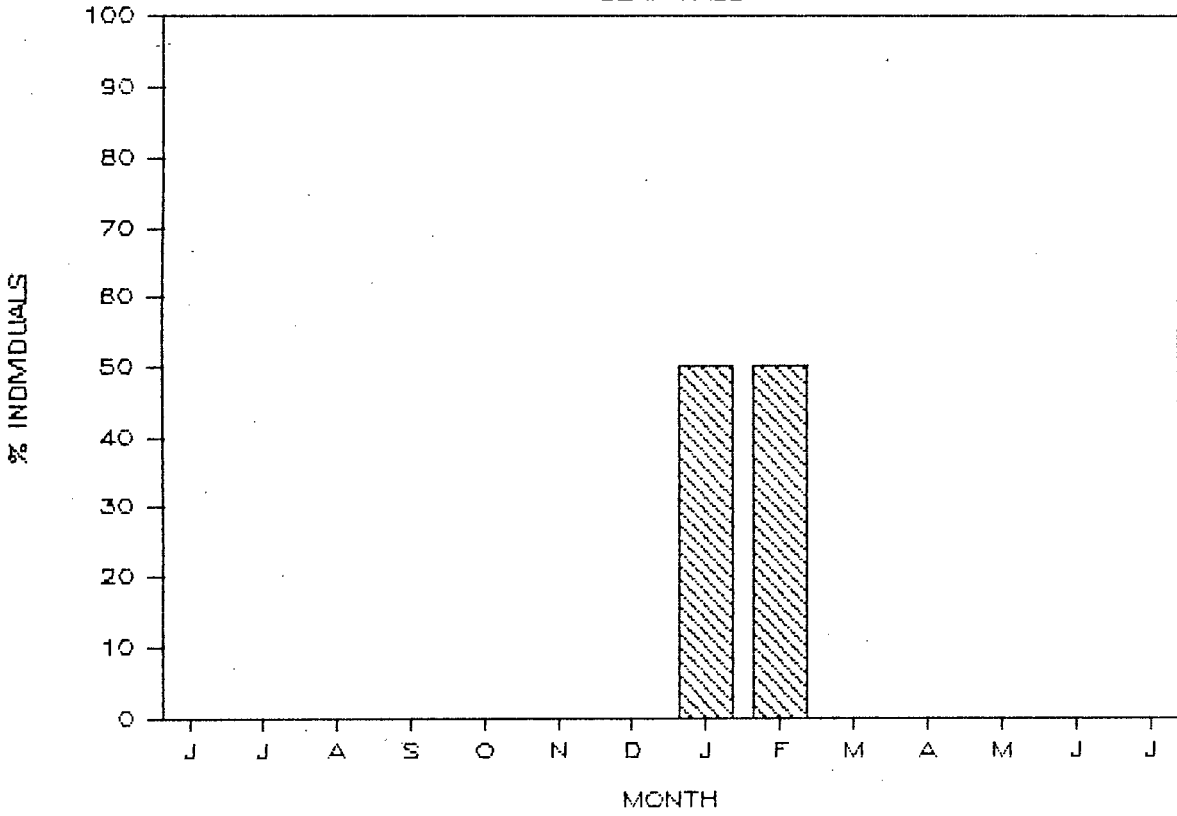FRUITING

BROAD-LEAVED SHRUBS

LEAF FALL

SMALL-LEAVED SHRUBS

LEAF FALL

LEAF SUCCULENTS

LEAF FALL

APPENDIX E: SPECIES COMPOSITION OF PLOTS AT RONDEBERG

Species	BB value		
	PLOT 1	PLOT 2	PLOT 3
Hermannia scordifolia	1		
Restio sp.	+		
Limonium purpurateum	+		
Arctotheca calendula	+		
Gnidia sp.	+		
Aspalathus sp. 2	+		
Aspalathus sp. 1	r		
Dimorphotheca pluvialis	r		
Colpoon compressum	2	1	
Staberoha sp.	1	1	
Salvia aurea	1	+	
Phylica stipularis	1	+	
Phylica cephalantha	1	+	
Ficinia dunensis	+	+	
Protasparagus rubicundus	+	+	
Zygophyllum sp.	+	r	
Euphorbia caput-medusae	+	r	
Rhus tomentosa	1		+
Oxalis pes-caprae	+		+
Cotyledon orbiculata		1	
Pentaschistis sp.		1	
Amellus asteroides		+	
Othonna sp.		+	
Myrsiphyllum declinatum		r	
Protasparagus lignosus		r	
Euclea racemosa		+	3
Pterocelastrus tricuspidatus		2	2
Willdenowia incurvata		2	+
Olea exasperata		1	+
Protasparagus aethiopicus		+	1
Cissampelos capensis		+	+
Othonna filicaulis		+	+
Cynanchum africanum		+	+
Viscum capense		+	+
Microloma sagittatum		+	+
Zygophyllum morgsana			1
Nylandtia spinosa			1
Carpobrotus sauerae			1
Zygophyllum flexuosum			1
Solanum guineense			+
Myrsine africana			+
Tylecodon paniculata			+
Chenopodium sp.			+
Drosanthemum sp.			+
Oxalis obtusa			+
Arctotis breviscapa			+
Indigofera sp.			+
Leipoldtia sp.			+

Species	BB value		
	PLOT 1	PLOT 2	PLOT 3
Putterlickia pyracantha	1	2	1
Eriocephalus africanus	2	1	+
Protasparagus capensis	1	1	+
Chrysanthemoides monilifera	+	+	1
Euphorbia mauritanica	+	+	2
Tetragonia fruticosa	+	1	+
Stachys aethiopica	+	+	+
Osteospermum clandestinum	+	+	+
Ehrharta erecta	+	+	+
geophytes **	+	+	+

** Babiana ambigua
Babiana nana
Trachyandra ciliata
Trachyandra revoluta
Haemanthus coccineus
Lachenalia sp.
Bulbine annua
Cyanella hyacinthoides
Romulea sp. cf. rosea