



A description of major vegetation categories in and adjacent to the Fynbos biome

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PREFACE

The southern and south western Cape is occupied by an exceptionally rich flora known locally as fynbos. The various fynbos ecosystems, their plants and animals, are of considerable scientific and aesthetic interest, while the mountain catchment areas of the fynbos biome are of particular economic importance both as a water resource and as recreational areas.

Much research has been conducted in the biome in the past and in order to coordinate current activities, to stimulate new research and to synthesize available scientific information within the region, the Fynbos Biome Project was initiated in 1977.

The Project is one of several national scientific programmes within the National Programme for Environmental Sciences administered by the CSIR. The National Programme is a cooperative undertaking of scientists and scientific institutions in South Africa concerned with research related to environmental problems. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE (Scientific Committee on Problems of the Environment), the body set up in 1969 by ICSU (International Council of Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field. The research of participating universities is financed from a central fund administered by the National Committee for Environmental Sciences and contributed largely by the Department of Environment Affairs.

The first phase (1977 to 1980) of the Fynbos Biome Project has been centred on baseline studies, including the review and synthesis of current knowledge and on broad surveys of climate, soils, vegetation, fauna and land use patterns. This document represents a synthesis of information derived from the initial vegetation mapping and classification studies carried out within the Fynbos Biome Project. The impetus to produce the report was generated from within the vegetation mapping and classification study group of the Fynbos Biome Project; one of a number of study groups formed within the project to encourage the communication of research findings.

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The initial draft of this publication was prepared by Campbell, Cowling and Boucher, following a workshop held at the Fynbos Biome Project's Fourth Annual Research Meeting in June 1982. Many people contributed to the production of the final map and the participants in the workshop meeting gave freely of their ideas.

Cartographic assistance was provided by Mr K Behr, Wendy Metelerkamp and Richard Greener. The 1:1 000 000 scale map of the vegetation of the fynbos biome was prepared by the Directorate of Mapping and Survey, Mowbray.

ABSTRACT

A scheme of major categories of the vegetation in and adjacent to the fynbos biome is given as a second approximation after Acocks' Veld Types (1953). A four tier hierarchy is presented with nineteen categories of vegetation. The major subdivisions recognized on the basis of their structural, environmental and floristic characteristics are: Cape Fynbos Shrublands; a mosaic of Cape Fynbos Shrublands and Subtropical elements; Cape Transitional Small-Leafed Shrublands; Cape Transitional Large-Leafed Shrublands; Subtropical Transitional Thicket; Afromontane Forest; and Karroid Shrublands.

In addition a vegetation map on which these categories were recognized was produced independently using Landsat imagery.

SAMEVATTING

'n Skets van die vernaamste kategorieë van die plantegroei in en aangrensend aan die fynbosbiom word gegee as 'n tweede benadering na Acocks se Veldtipes (1953). 'n Hiërargie op vier vlakke word aangebied met 19 plantegroeykategorieë. Die vernaamste onderverdelings wat herkenbaar is op die basis van hulle strukturele-, omgewings- en floristiese eienskappe is: Struikveld van die Kaapse Fynbos; 'n mosaïek van die Struikveld van die Kaapse Fynbos en Subtropiese elemente; Fynblaar-struikveld van die Kaapse Oorgangsonne; Breëblaar-struikveld van die Kaapse Oorgangsonne; Subtropiese Oorgangsruijgte; Afromontane Woud; en Karoo-Struikveld.

Aanvullend hiertoe is 'n plantegroeykaart waarop hierdie kategorieë uitgewys word. Hierdie kaart is onafhanklik opgestel met die gebruik van Landsatbeelde.

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INTRODUCTION

The fynbos biome, which closely approximates the geographic area of the Cape Floristic Kingdom (Goldblatt 1978, Kruger 1979a), has received little taxonomic treatment, and Acocks's (1953) treatment has had to suffice as an overall vegetation classification of the biome. Over the years it has become clear that Acocks's treatment is inadequate and Acocks himself stated that the subdivision of mountain fynbos into Macchia and False Macchia was like "dividing the tropical vegetation of South Africa into grassveld and bushveld". Apart from the problems of an inadequate classification, a precise and generally acceptable definition of 'fynbos' has so far eluded botanists; and this has led to confusion amongst other environmentalists (see Moll & Jarman 1984b).

Since 1978, concomitant with the emergence of the Fynbos Biome Project, there has been an upsurge of research activity in the biome. As part of the initial baseline study phase of the project many workers have undertaken descriptive studies aimed at mapping, classification and characterization of biome vegetation both on an intensive and extensive scale. Up to date regional phytosociological and structural data are now available from Bond (1981) (structure and floristics in the southern Cape mountains), Boucher (in prep) (floristics and structure in the west coast lowlands), Campbell (1984a, 1984b) (structure and some floristic features in the mountains) and Cowling (1983a) (floristics in the south eastern Cape). In addition the major vegetation types have been mapped at 1:250 000 scale from Landsat imagery (Jarman, Bossi & Moll 1981, Jarman, Bossi & Moll 1983, Moll & Bossi 1984).

As a result of these research activities two separate schemes of vegetation classification of the fynbos biome were produced. One scheme (Moll & Bossi) was used primarily on a 1:1 000 000 vegetation map drawn from Landsat images. The other scheme resulted from a workshop specifically designed to produce an up-to-date categorization of the major plant communities based on the knowledge of individual fieldworkers (Cowling, Campbell & Boucher). It seemed appropriate that an attempt should be made to combine these two undertakings, and a scheme of vegetation categories linked to the mapped communities is the result. This is considered to be a second approximation to Acocks's pioneering work.

Unfortunately the available regional data are of various types (structure in some cases; floristics in others), and there are large areas of the biome not covered in the regional surveys. Because of these limitations, a limited hierarchy is suggested here and the applicable map scales are those of about 1:250 000 or smaller. Controversies still remain, and even within the present authorship there are some divergent views.

MAPPING METHOD USED

Fourteen Landsat images were required for coverage of the whole fynbos biome (Table 1). Landsat products, available from the Satellite Remote Sensing Centre in South Africa, were assessed to determine which date and what type of images would best be suited for identifying the fynbos vegetation at the hierarchical level presented here (Table 2).

TABLE 1. Listing of the 14 Landsat images which cover the fynbos biome

<u>WRS</u>	<u>SCENE - ID</u>	<u>DATE</u>	<u>AREA DESCRIPTION</u>
188-082	22229-07533	81-02-28	Verlorenvlei
188-083	22211-07535	81-02-10	Langebaan
187-082	22228-07474	81-02-27	Calvinia
187-083	22228-07481	81-02-27	Ceres
187-084	22228-07483	81-02-27	Cape Town
186-083	22209-07422	81-02-08	Laingsburg
186-084	22209-07424	81-02-08	Bredasdorp
185-084	22208-07370	81-02-07	Mossel Bay
185-083	22208-07363	81-02-07	Oudtshoorn
184-083	22243-07305	81-03-14	Uniondale
184-084	22243-07312	81-03-14	Plettenberg Bay
183-083	22224-07251	81-02-23	Port Elizabeth
183-084	22224-07254	81-02-23	Humansdorp
182-082	22169-07195	80-12-30	Grahamstown

Two scenes, WRS 187-84 and WRS 188-83 (Cape Town and Langebaan scenes), were chosen for this assessment. Two sets of photographic images of each scene, a summer and a winter set, were examined. Each set of images consisted of black and white transparencies of wavebands 4, 5, 6 and 7, and a false colour composite transparency (a combination of wavebands 4, 5 and 7). These images are standard product transparencies at 1:1 000 000 scale and were not enhanced. Summer images displayed greater contrast between major categories of fynbos vegetation and surrounding agricultural land. The false colour composite transparencies and waveband 6 black and white transparencies were found to be the most useful for identifying fynbos. From these evaluations it was decided to use a combination of images in the visual interpretation process.

The false colour composite transparencies were used at the original 1:1 000 000 scale. The waveband 6 transparencies were enlarged to a 1:250 000 scale and photographic prints were produced at that scale. Transparent base maps at 1:250 000 scale (from the Trigonometrical Survey series) were placed over the waveband 6 images. Visual analysis of the images, based on standard air photo interpretation techniques were carried out by placing each false colour composite on a light table and interpreting them with the aid of a hand-lens. The interpreted features were then located on the waveband 6 images and delineated on the transparent base maps. This procedure was repeated until all the images were interpreted.

Throughout the process reference was made to available literature and maps (in particular the Geological Survey maps (1970) and Acocks's Veld Type Map (1953)). Many field checks were made and the extensive reservoir of field experience amongst local botanists was drawn upon to assist in interpretations. A first draft of the nine 1:250 000 maps were then widely circulated for comment and criticism. These are; 3118 Calvinia, 3218 Clanwilliam, 3318 Cape Town, 3319 Worcester, 3420 Riversdale, 3320 Ladysmith, 3322 Oudtshoorn, 3324 Port Elizabeth and 3326 Grahamstown.

Digital image processing techniques were also applied to the fourteen Landsat computer compatible tapes to produce computer classifications in map form of the whole biome. This procedure is described in detail in another paper (Bossi 1983). These computer generated maps were used to assist in finalising the 1:250 000 maps. The boundaries of the computer generated vegetation categories were compared with visually interpreted boundaries in areas where there was confusion or indecision.

The final set of nine map sheets at 1:250 000 scale were photographically reduced to 1:1 000 000 scale for the final map production.

THE PROPOSED SCHEME

Table 2 shows the major categories that we recognize. These have been used in mapping the vegetation at a final scale of 1:1 000 000. The two higher tiers of the four tier hierarchy are phytochorological units; being based on the world floristic kingdoms (Takhatjan 1969) and the system of White (1982) in his UNESCO map of the vegetation of Africa. These have been included to assist readers to gain an overall perspective, particularly those who are unfamiliar with how our mapped categories relate to recognized African and world schemes.

The third tier in the four tier hierarchy consists of structural/environmental descriptions of mapped vegetation units. It should be noted that at this level, although we use units such as heathlands on sandstone and quartzite mountains, we do recognize that the geological-vegetation relationships are far from perfect (eg fynbos can occur on many geological formations throughout the biome provided that rainfall is at least above 600 mm, and non-fynbos can occur on sandstone provided that rainfall is at least below 400 mm (Campbell 1984b)).

At the scale of mapping (the fourth tier in the hierarchy) not all the categories are at the same floristic hierarchical level. For instance future detailed structural environmental descriptions may subdivide a category such as 'Sand Plain Fynbos' into specific xeric, mesic and wet types. Also at a floristic level of recognition our mapped categories may consist of a number of types.

1. CAPE FLORAL KINGDOM

All the fynbos communities (sensu heathlands, concept Specht 1979, and Specht & Moll 1983) of the fynbos biome are placed in the "Cape Floral Kingdom".

1.1 CAPE FYNBOS SHRUBLANDS

The term "Cape" is used to differentiate this fynbos type from the fynbos which occurs in the Afromontane and Afro-alpine regions (eg Killick 1979, and White 1978). This non-Cape fynbos we term Afromontane Fynbos following the proposals of Campbell (1984a) and Cowling (1983a). The term fynbos has been previously used in two

TABLE 2. Major categories recognized in mapping vegetation of the fynbos biome

MAPPED VEGETATION CATEGORIES	STRUCTURAL ENVIRONMENTAL DESCRIPTIONS	BIOGEOGRAPHIC AFFINITIES	FLORAL KINGDOM DIVISIONS
<u>AREAS OF NATURAL VEGETATION</u>			
<u>CAPE FYNBOS SHRUBLANDS</u>			
<u>Mountain Fynbos</u>			
Wet Mountain Fynbos]]]
Mesic Mountain Fynbos]]]
	Heathlands on sandstone and quartzite mountains]]
Dry Mountain Fynbos]]]
<u>Grassy Fynbos</u>			
Mesic Grassy Fynbos]]]
Dry Grassy Fynbos]]]
	Grassy heathlands on sandstone, quartzites and conglomerates	Cape Communities	Cape Floral Kingdom
<u>Lowland Fynbos</u>			
Sand Plain Fynbos]]]
	Heathlands on lowland acid sands]]
Elim Fynbos]]]
	Heathlands on lowland laterites]]
Limestone Fynbos]]]
	Heathlands on lowland limestone]]
<u>MOSAIC OF CAPE FYNBOS SHRUBLANDS AND SUBTROPICAL ELEMENTS</u>			
Dune Fynbos]]]
	Shrublands on coast dunes	Cape/Sudano-Zambezian Communities]
<u>CAPE TRANSITIONAL SMALL-LEAFED SHRUBLANDS</u>			
<u>Renosterveld</u>			
West Coast Renosterveld]]]
	Small-leaved shrublands mainly on Malmesbury shales and Cape granite]]
South West Coast Renosterveld]]]
	Small-leaved shrublands on Bokkeveld shales and Cretaceous conglomerates	Cape/Karoo-Namib/Communities]
Central Mountain Renosterveld]]]
	Small-leaved shrublands mainly on Bokkeveld and Witteberg shales]	Cape-Palaeotropic Floral Kingdom Transition
South Coast Renosterveld]]]
	Small-leaved shrublands mainly on Bokkeveld and Cango shales]]
<u>CAPE TRANSITIONAL LARGE-LEAFED SHRUBLANDS</u>			
<u>Strandveld</u>			
West Coast Strandveld]]]
	Broad-leaved shrublands on coastal, calcareous sands	Tongaland-Pondoland/Cape/Karoo-Namib/Communities]
South Coast Strandveld]]]
<u>SUBTROPICAL TRANSITIONAL THICKET</u>			
Kaffrarian Thicket]]]
	Tongaland-Pondoland Regional mosaic communities mainly on coastal sands	Tongaland-Pondoland/Afromontane Communities]
Valley Bushveld (undifferentiated)]]]
	Zambezian Domain communities on shales and conglomerates	Sudano-Zambezian/Tongaland-Pondoland/Karoo-Namib	Palaeotropic Floral Kingdom
<u>AFROMONTANE FOREST</u>			
Afromontane Forest Communities (undifferentiated)]	Afromontane Communities]
<u>KARROID SHRUBLANDS</u>			
Karroid Shrublands on shales and mudstones (undifferentiated)]	Karoo-Namib Communities]
<u>Ecotones</u>			
Mosaic of Dry Mountain Fynbos and Karroid Shrublands Mosaic of Sand Plain Fynbos and West Coast Strandveld Mosaic of Dune Fynbos and Kaffrarian Thicket			
<u>AREAS PARTIALLY CLEARED OF NATURAL VEGETATION</u>			
Mosaic of South Coast Renosterveld and agriculture			
<u>AREAS CLEARED OF NATURAL VEGETATION</u>			
Cultivated land, plantations, dense alien communities and open sandy areas Reservoirs, pans and lakes Cities and towns			
<u>AZONAL COMMUNITIES (not mapped or described in detail but included for sake of completeness)</u>			
Riverine Communities Wetland Communities Littoral Communities			

very different ways. Bews (1925), who probably coined the term in the botanical literature, applied it to the fine-leaved shrublands of the Cape and non-Cape regions. On the other hand Kruger (1979b) and Taylor (1978) use fynbos to denote only those shrublands of the Cape. We follow the former tradition.

Cape Fynbos shrublands are identified by Cowling (1983a) as having:

- (i) Sample floras with a phytochorological spectrum in which more than 50% of the species are restricted to the Cape phytochorion as delimited by Werger (1978) and Goldblatt (1978). The majority of the remaining species are largely Cape linking taxa.
- (ii) A high incidence of regional endemism (cf Weimarck 1941). Regional endemics are mostly of Cape affinity.
- (iii) Communities ecologically restricted to areas receiving a substantial proportion of winter rainfall on infertile soils derived from quartzite, sandstones, laterites and limestones.

Campbell (1984a) provides an operational structural definition for the fynbos of the mountains, which from personal observation is also applicable to the lowland areas (see Table 3).

MOUNTAIN FYNBOS

Mountain Fynbos is the general term used by Taylor (1978) and Kruger (1979b) to replace Acocks's (1953) *Macchia* (69) and *False Macchia* (70). Campbell (1984a) and Cowling (1983a) exclude Grassy Fynbos (occurring in Acocks's *False Macchia Veld Type*) from their concept of Mountain Fynbos, and we have adopted this distinction in the present scheme. We recognize and map as Mountain Fynbos those communities occurring on sandstones and quartzites of the Cape Folded Belt; from the Cedarberg in the north west to the Groot Winterhoek and other higher mountains in the south east. Communities of limited extent, too small to map at this scale occur on Cape granites in the foothills of the Hottentots Holland and Bainskloof Mountains (Bossi 1983).

In our scheme we recognize three sub-divisions of Mountain Fynbos based on a moisture gradient from wet to dry sites, which is physiognomically expressed by the vegetation, and thus has been recognized on satellite imagery*. These three sub-divisions are the units that can satisfactorily be mapped from the Landsat images. However, we do recognize that they can be structurally heterogeneous eg Wet Mountain Fynbos varies from tall proteoid shrublands (almost low forest in some cases) to low ericaceous shrublands. These sub-divisions are perhaps best described as landscape units which

FOOTNOTE: *All structural terminology and definitions used in the report from here on are based on those of Campbell et al (1981).

TABLE 3. A simplified key to fynbos

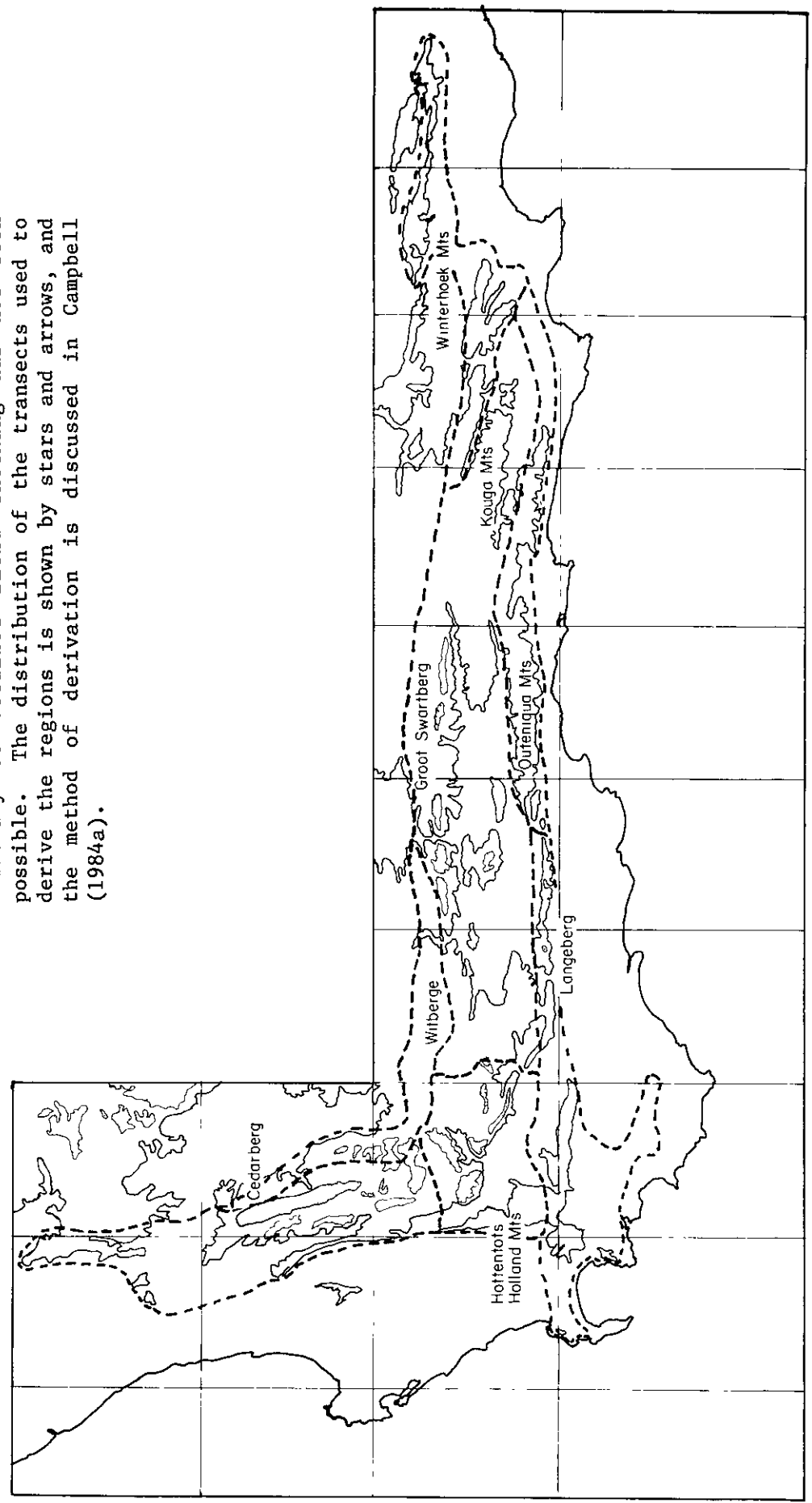
(This simplified key will occasionally result in poor identification of fynbos (See Campbell 1984a for the full key). A stand of vegetation is to be regarded as fynbos if one or more of the following clauses are satisfied):

1. >30% restioids (unless >80% grass).
2. >10% restioids unless one of the following:
 - 2.1 >25% restioids and >40% of one of the following:
 - (a) Tall non-proteoid shrubs (without plumose restioids eg Elegia capensis);
 - (b) Elytropappoids;
 - (c) Grass and < 50% cover.
 - 2.2 <25% Restioids, > 70% grass and < 30% proteoids and/or Ericaceae.
3. >1% restioids and one of the following:
 - 3.1 >5% proteoids, < 40% grass and other fynbos elements present (eg ericoids).
 - 3.2 < 70% total cover, < 20% grass (unless > 10% succulents, > 5% fleshy leaved shrubs and elytropappoids present).
 - 3.3 > 20% Ericaceae, < 40% grass.
 - 3.4 > 40% proteoids.
4. ≥ 0% restioids, < 10% grass and one or more of the following:
 - 4.1 > 40% ericoids, < 70% total cover.
 - 4.2 > 40% of: Bruniaceae, Penaeaceae, and/or proteoids.

TABLE 4. The major fynbos communities of the mountains of the fynbos biome (from Campbell 1984a). These major communities are further subdivided into 63 types

FYNBOS						
GROUP	GRASSY FYNBOS	ASTERACEOUS FYNBOS	RESTIOID FYNBOS (RESTIOVELD)	ERICACEOUS FYNBOS (HEATH)	PROTEOID FYNBOS (PROTEAVELD)	CLOSED-SCRUB FYNBOS
SERIES						
Differentiating characteristics	Grasses; nanophylls; forbs; rosette forbs; rosulate succulents	Low total cover; succulents; non-ericaceous ericoids; fleshy leaves; intermediate cover grass and/or elytrappoid cover; high shrub cover relative to restioids and sedges	High restioid and sedge cover relative to shrubs	Ericaceae; Penaeaceae; Bruniaceae; Grubbiaceae; sedges	10% cover proteoids	Microphylls; tall shrubs; orthophylls; plumose restioids
Environmental characterization	Eastern mountains; finer-textured soils; 600-900 mm rainfall	Most xeric community of fynbos; low altitudes; interior mountains	Shallow, rocky soils, more mesic than Asteraceous fynbos, more xeric than Ericaceous fynbos; often high altitude, south north aspects	Deeper, often organic soils; mesic situations often high altitude, south aspects of coastal mountains	Deeper, finer-textured soils, low altitudes; often mesic, coastal situations	Rivers; streams
SUB-SERIES	DRY GRASSY FYNBOS MESIC GRASSY FYNBOS MESOTROPHIC GRASSY FYNBOS	DRY ASTERACEOUS FYNBOS MESOTROPHIC ASTERACEOUS FYNBOS OLIGOTROPHIC ASTERACEOUS FYNBOS TALUS ASTERACEOUS FYNBOS	DRY RESTIOID FYNBOS MESIC RESTIOID FYNBOS AZONAL RESTIOID FYNBOS	MESIC ERICACEOUS WET ERICACEOUS FYNBOS	MESOTROPHIC PROTEOID DRY PROTEOID FYNBOS MESIC PROTEOID FYNBOS WET PROTEOID	

FIGURE 1. The seven mountain regions of the fynbos biome. The regions recognized only apply to the mountains within the designated area, and the boundaries are somewhat arbitrary as detailed field checking has not been possible. The distribution of the transects used to derive the regions is shown by stars and arrows, and the method of derivation is discussed in Campbell (1984a).



have a certain specified set of communities. In Campbell's (1984a) recent classification of the mountain vegetation he recognizes six major series of fynbos (Table 4) and these six structural units do not closely correspond with our mapped subdivisions. His communities are not mappable at 1:1 000 000. For this very reason he also provides a map of mountain community complexes, named according to mountain regions (see Figure 1).

1.1.1 Wet Mountain Fynbos

This comprises closed (more than 75% canopy cover) Mountain Fynbos on annually, and even perennially waterlogged sites, usually on southern slopes of the Langeberg, Outeniqua and Tsitsikamma mountains. These communities which are sometimes seral to forest, are either almost entirely mid-high to tall restioid communities, or mid-high to tall ericoid or proteoid shrublands (examples from Campbell (1984a) are: Mesic Proteoid Fynbos, Wet Proteoid Fynbos and Ericaceous Fynbos).

1.1.2 Mesic Mountain Fynbos

This comprises open to closed (\pm 40-90% canopy cover) Mountain Fynbos on seasonally waterlogged, mesic sites. The plant communities are mixtures of the three primary elements; namely restioid, ericoid and proteoid, falling in the tall to low height categories. This type probably includes Campbell's (1984a) Mesic Ericaceous Fynbos, Dry Proteoid Fynbos, Mesic Proteoid Fynbos, Mesic and Dry Restioid Fynbos, and Oligotrophic Asteraceous Fynbos.

1.1.3 Dry Mountain Fynbos

These open to sparse (often less than 50% canopy cover) Mountain Fynbos communities are on xeric sites, usually on northern slopes in the south of the fynbos biome, on inland mountains, or located in the northern Cedarberg range. They generally have tall restioids and a predominance of low shrubs; equivalent to Campbell's (1984a) Dry Asteraceous Fynbos, Mesotrophic Asteraceous Fynbos and Dry Restioid Fynbos. There are occasionally non-proteoid mid-high shrubs present, such as Rhus sp, Heeria argentea, Phylica buxifolia and Dodonaea viscosa.

GRASSY FYNBOS

Much of what Acocks (1953) called False Macchia (70), and some of the Mountain Fynbos referred to by Taylor (1978) and Kruger (1979b), we refer to as Grassy Fynbos. Recent workers (Bond 1981, Cowling 1983a and Campbell 1984b) have drawn attention to the increased grassy nature of fynbos at the eastern limits of the biome occurring on sandstones, quartzites and Enon conglomerates.

Biogeographically, Grassy Fynbos is characterized by a high proportion of Cape-Afromontane linking species and widely distributed tropical C₄ grasses (Themeda, Trachypogon, Heteropogon, Brachiaria,

Eragrostis). Cowling (1983a) records good diagnostic species including a number of regional and local character taxa. Structurally, grassy fynbos is similar to the mountain fynbos types described above, except for the prominence of grasses in the understorey at the expense of restioids. Soils are marginally more fertile than those of Mountain Fynbos (Cowling 1983a, Campbell 1984b).

Features that are more characteristic of Grassy Fynbos include non-proteoid nanophylls and forbs (especially rosette forbs and pubescent forbs).

1.1.4 Mesic Grassy Fynbos

These are open to dense (50-90% canopy cover), tall to low grassy communities on seasonally waterlogged mesic sites. Mesic Grassy Fynbos includes much of Campbell's (1984a) Mesotrophic Grassy Fynbos and Mesic Grassy Fynbos and Cowling's (1983a) Grassy Fynbos. However, it also includes what Campbell places in his non-fynbos Grassland and Grassy Shrubland Group (ie Suurberg Grassland, Hankey Grassland and Elandsberg Grassy Shrubland).

1.1.5 Dry Grassy Fynbos

These are sparse to open (often less than 50% canopy cover), low to mid-high communities on xeric sites usually on the northern slopes, or on arid mountain tops. Much of this category would fall into Campbell's (1984a) Dry Grassy Fynbos, but a considerable portion would be regarded as non-fynbos by Campbell and would be placed in Bosrug Grassy Shrubland and Baviaanskloof Grassy Shrubland. Cowling (1983a) describes a community, Hankey Dry Grassy Fynbos, from the Humansdorp area.

LOWLAND FYNBOS

Previous workers have grouped all Lowland Fynbos types into a heterogeneous entity called Coastal Macchia, Veld Type 47 (Acocks 1953) or Coastal Fynbos (Taylor 1978, Kruger 1979b). Acocks subdivided Coastal Macchia into west and south coast blocks, but acknowledged that further sub-division was necessary. Taylor and Kruger largely adopted Acocks's scheme in their treatment of Coastal Fynbos. However, we recognize four lowland types, distinguished largely on substrate differences.

1.1.6 Sand Plain Lowland Fynbos

These are open to closed (25-90% canopy cover), low to mid-high graminoid shrublands. We define Sand Plain Fynbos as vegetation confined to the deep acid sands of the west coast lowlands (cf Milewski & Esterhuizen 1977; Boucher 1983) and also occurring locally on the south coast (eg sandy flats fynbos on reddish sands in the Riversdale district, Muir (1929)). Boucher's (1983) study of the west coast lowlands provides a floristic characterization of

Sand Plain Fynbos which he calls Phylica cephalantha fynbos. It should be possible to distinguish between the western and southern blocks of Sand Plain Fynbos, but the fragments which occur on the south coast were too small to be mapped from satellite imagery.

1.1.7 Elim Lowland Fynbos

These communities are open to closed (35-90% canopy cover) low shrublands, with very occasional tall shrubs. Acocks (1953) recognized that the dwarf to low fynbos of the Elim Flats should be considered a distinct veld type. On the Augulhas Plain there are extremely species-rich fynbos communities on a variety of depositional landscapes with gravelly, lateritic and often seasonally waterlogged soils. This fynbos has numerous local endemics (Cowling unpublished records).

1.1.8 Limestone Lowland Fynbos

These communities are open to closed (40-90% canopy cover mid-high shrublands). The south coast Limestone Fynbos centred between Walker Bay and Vlees Bay is another well circumscribed type (Acocks 1953, Taylor 1978). These communities are restricted to calcareous, neutral to alkaline, shallow sands overlying limestone of the Bredasdorp Formation, and are characterized by a number of endemics (see Taylor (1978) for a partial list). Van der Merwe (1977) has described communities for the De Hoop Nature Reserve and Muir (1929) gives a general account of limestone fynbos in the Riversdale district. We term this type Limestone Fynbos, which also occurs on scattered small patches of calcrete from Saldanha Bay to the Gouritz River.

2. CAPE-PALAEOTROPIC FLORAL KINGDOM TRANSITION

Within the geographic region of the Cape Floral Kingdom are a number of communities that consist of an admixture of Cape and non-Cape elements, and/or non-heathland communities. Two major categories have been recognized and are discussed below.

2.1 MOSAIC OF CAPE FYNBOS SHRUBLANDS AND SUBTROPICAL ELEMENTS

Only Dune Fynbos is recognized, being an admixture of Cape fynbos shrubland and sub-tropical elements.

2.1.1 Dune Fynbos

These are generally mid-dense to closed (50-100% canopy cover) mid-high shrublands. Communities belonging to this category occur on recent, deepish, calcareous or acid sands from the Olifants River to Cape Recife, near Port Elizabeth. They are characterized by good diagnostic species (see Cowling 1983a).

2.2 CAPE TRANSITIONAL SMALL-LEAFED SHRUBLANDS

These consist of a variety of non-succulent, small-leafed and broad-leafed shrublands which, according to the concepts developed above, are distinctly non-fynbos. Although some of these shrublands have been the subject of a recent review (Boucher & Moll 1981) there are few published phytosociological surveys with the exception of Cowling's (1983a) work in the eastern Cape, and the formation of syntaxonomic concepts is therefore severely limited.

RENOSTERVELD

Renosterveld may be characterized as follows:

- (i) Phytochorological spectra are dominated by ecological and chorological transgressor species linking communities of the Cape Region with adjacent phytochoria, particularly the Karoo-Namib Region with some Afromontane elements, and at the eastern limits of the biome, with the Sudano-Zambeziian Region. Cape endemics (sensu Goldblatt 1978) comprise about one third of a given sample flora.

Regional endemism is lower than for Cape Fynbos Shrublands and not all endemics are species of Cape affinity.

- (iii) Structurally the communities are small-leafed shrublands dominated by Asteraceae but lacking most of the "heathland" (sensu Specht 1979) features typical of the Cape Fynbos Shrublands. Restioid and proteoid growth forms may be present but today are not consistently dominant and can be entirely lacking. Deciduous geophytes are prominent, if not in cover, then in richness. A considerable proportion of the small-leafed woody shrubs having fleshy to semi-succulent leaves (Cowling & Campbell 1983), and showing some seasonal leaf dimorphism, may be prominent, particularly in the east. Shrubs with large dorsiventral leaves do occur.
- (iv) Ecologically they are restricted to fine grained soils derived from Cretaceous mudstones and conglomerates, Malmesbury and Cango phyllites, Bokkeveld shales, Cape granites, and the tillites and shales of the Karoo Supergroup. The soils are generally more fertile than Cape Fynbos soils, and the communities are found in areas receiving at least thirty percent winter rain where the annual precipitation is from 300 - 600 mm yr⁻¹.

Dominant genera in these small-leaved shrublands are Elytropappus, Eriocephalus, Anthospermum, Passerina, Relhania, Aspalathus, Helichrysum, Pteronia, Selago, Felicia, and Hermannia.

We include the following Acocks's (1953) Veld Types: Coastal Renosterveld (46), Mountain Renosterveld (43) and parts of the Karroid Merxmuellera Mountain Veld (60). The last mentioned has strong links with Afromontane grasslands of the north eastern Cape (Acocks 1953). In general these shrublands are phytochorologically complex and have strong karroid, subtropical or temperate grassland affinities (Cowling 1983a). Cape elements are always the dominant unit.

Acocks (1953) recognized two coastal renosterveld types: a west coast form and a south coast form. This distinction was also upheld by Taylor (1978) and Boucher & Moll (1981).

We differentiate four Renosterveld types in our scheme. They are all small-leaved shrublands with a prominent cupressoid-leaved element and are: West Coast Renosterveld, found mainly on Malmesbury shales and Cape granite; South West Coast Renosterveld, found mainly on Bokkeveld shales; Central Mountain Renosterveld, encountered on Bokkeveld and Witteberg shales; and South Coast Renosterveld, found mainly on Bokkeveld and Cango shales, and Cretaceous conglomerates. Of the four forms of these communities distinguished, three have essentially Cape/Karoo-Namib/ Afromontane affinities, and the other (South Coast Renosterveld) has essentially Cape/Karoo-Namib/Sudano-Zambezian affinities. The major distinction between these two forms is the higher proportion of grasses in the latter.

West Coast Renosterveld differs generally from South Coast Renosterveld in having a sparser grass cover composed largely of C₃ genera (Ehrharta, Pentaschistis, Merxmuellera, Lasiochloa, Plagiochloa, Cymbopogon, and Eragrostis while today the Mediterranean grasses Avena, Briza and Lolium are wide-spread and common), a higher diversity of deciduous geophytes and annuals, and the presence of Eriocephalus africanus and Leyserra gnaphaloides as characteristic subdominants with Elytropappus rhinocerotis.

West Coast communities have a stronger fynbos influence, especially on granitic soils (Cowling 1983a). Boucher (1983) has suggested that West Coast Renosterveld is derived from mountain fynbos and strandveld elements (sensu Acocks 1953).

South West Coast Renosterveld ranges from Bot River to Riviersonderend. Typical subdominants and diagnostic shrub species are Relhania genistaefolia, R. squarrosa, Helichrysum spp and Hermannia spp.

Our concept of Central Mountain Renosterveld does not correspond exactly to Acocks's Mountain Renosterveld (43), but is similar to it. Central Mountain Renosterveld has a greater proportion of succulents and sometimes dominance by Pteronia incana. Much of Mountain Renosterveld (sensu Acocks 1953) is very similar to our West Coast and South Coast Renosterveld (eg mixtures of Relhania and Elytropappus).

2.2.1 West Coast Renosterveld

This type is comprised of mid-dense to closed (50-90% canopy cover) cupressoid and small-leafed, mid-high evergreen shrubs, with regular clumps of broad-leafed tall shrubs as emergents. The understorey is essentially annual and herbaceous with perennial graminoids.

2.2.2 South West Coast Renosterveld

These communities are essentially mid-dense (50-75% canopy cover) cupressoid and small-leafed, mid-high evergreen shrubs, with rare broad-leafed tall shrubs as emergents. The understorey is also essentially herbaceous with occasional perennial graminoids.

2.2.3 Central Mountain Renosterveld

This is comprised of open to mid-dense (25-60% canopy cover) cupressoid and small-leafed, low to mid-high shrubs, with Rhus, Acacia karroo, Euclea undulata and Aloe ferox as scattered emergents. The understorey consists of discontinuous herbaceous elements which usually lack the perennial graminoid component through veld deterioration.

2.2.4 South Coast Renosterveld

This is comprised of open to mid-dense (25-60% canopy cover) cupressoid and small-leafed, low to mid-high shrubs with no emergents. The understorey consists of scattered herbaceous elements, and on well-managed sites, of perennial grasses. Communities are described by Cowling (1983a).

2.3 CAPE TRANSITIONAL LARGE-LEAFED SHRUBLANDS

STRANDVELD

Strandveld communities are mid-dense to closed, broad-leafed shrublands of tropical and subtropical Cape affinity, which are found from the Gouritz River in the east and extend along the west coast into Namaqualand. Physiognomically these shrublands may consist of an open to closed shrubland often forming an impenetrable tangle interwoven by woody climbers, with occasional clumps of low trees. Communities of similar structure and generic composition, but lacking the Cape and Karoo-Namib elements, are found throughout tropical and subtropical Africa (Okali et al 1973; Tinley 1975; White 1982) and are termed thicket ie (see subtropical Transitional thicket below). Tinley (in: Heydorn & Tinley 1980) extended the thicket concept to the fynbos biome, as the floristic affinity of some of the shrub species, in particular some of the dominant species such as Olea exasperata and Euclea racemosa, are strongly tropical (affinities with the Tongaland-Pondoland regional mosaic) but with some species endemic to the Cape mediterranean-climate region.

Cowling (1983a) distinguishes these strandveld communities as Sub-tropical Transitional Thickets and emphasizes their tropical and sub-tropical affinities.

These Large-leafed Shrublands can be characterized as follows:

- (i) Phytochorological spectra are dominated by ecological and chorological transgressor species essentially of Tongaland-Pondoland origin, with Cape and some Karoo-Namib elements, mainly in the west, being present.
- (ii) Regional endemics are few relative to Cape Fynbos Shrublands and include species of tropical affinities (eg Olea exasperata and Euclea racemosa), of Cape affinity (Thamnochortus spp, Restio eleocharis, Ehrharta spp), and Karoo-Namib affinity (Euphorbia spp, Lampranthus spp and Zygophyllum spp).
- (iii) Structurally the communities are dominated by broad-leafed, sometimes spinescent, evergreen shrubs, with some drought deciduous elements. Succulents are prominent in drier areas and climbers are a feature of woody clumps.
- (iv) Ecologically the communities are restricted to deepish, well-drained sandy soils, with scattered shell fragments, in areas which receive at least thirty percent of the rainfall in winter.

These broad-leafed shrublands are more or less equivalent to Acocks's (1953) West Coast Strandveld (34).

Despite Cowling's treatment we have chosen to place the Strandveld Communities as Cape Transitional Shrublands, mainly because Restionaceae are widespread and may be locally dominant. Also some of the genera with sub-tropical affinities are Cape species, thus strengthening ties with the Cape Floral Kingdom. Patches of emergent tall restioids such as Thamnochortus erectus, T. insignis and T. spicigerus occur scattered through and are often associated with species depauperate strandveld vegetation. These clumps usually have an open canopy. Towards the inner margins of this vegetation type, Willdenowia striata and W. teres (1,00-1,5 m tall) become increasingly prominent to extensively dominant with a closed canopy, particularly in the west. The short restioid, Restio eleocharis becomes increasingly common as an understorey element, from Langebaan southwards and eastwards, particularly in the early successional stages of Strandveld (Boucher in prep).

We recognize two forms of these broad-leafed shrublands: that located on the west coast which tends to have a greater proportion of semi-deciduous to deciduous shrubs, and succulents of Karoo-Namib affinity; and the south coast form which tends to have more evergreen shrubs and generally a higher percentage cover.

2.3.1 West Coast Strandveld

This is comprised of open to closed (40-90% canopy cover), usually high and rarely tall communities, with a mixture of broad-leafed, evergreen, deciduous and succulent elements. The understorey has a perennial graminoid component, as well as a large annual component, consisting of annual herbs, including succulents and geophytes.

2.3.2 South Coast Strandveld

These communities tend to be open to closed (40-80% canopy cover) mid-high, with a mixture of evergreen and deciduous broad-leafed elements and a less conspicuous succulent element. An understorey of conspicuous perennial graminoid components as well as conspicuous annual herbaceous species is present.

3. PALAEOTROPIC FLORAL KINGDOM

Within the geographic region of the fynbos biome, outliers of the Palaeotropic Floral Kingdom communities occur. We do not differentiate these communities to any extent.

3.1 SUBTROPICAL TRANSITIONAL THICKET

Cowling (1983a) characterizes this type as:

- (i) Phytochorological spectra are dominated by ecological and chorological transgressor species essentially of Tongaland-Pondoland origin. Karoo-Namib elements are well represented in dry areas and Afromontane elements in wetter regions.
- (ii) Regional endemics are few relative to Cape Fynbos Shrublands, and usually of non-tropical affinity: karroid shrubs, particularly succulents (Euphorbia, Crassula, Delosperma, Aloe) comprise most of the endemics.
- (iii) Structurally the communities are dominated by broad-leafed evergreen shrubs many of which are semi-spinescent. Succulents are conspicuous in dry areas and vines are scattered throughout.
- (iv) Ecologically the communities are restricted to deepish, well-drained soils of moderate fertility status, in areas which receive at least thirty percent of the rainfall in winter.

3.1.1 Kaffrarian Thicket

This is partly equivalent to Cowling's (1983a) Kaffrarian Thicket, but excludes the Strandveld component which Cowling (1983a) included. It consists of the non-succulent, subtropical

transitional thicket communities, with occasional depauperate outliers extending to the south western Cape. These Thicket communities have strong affinities with the Afromontane forest flora although Tongaland-Pondoland endemics and linking species dominate the phytochorological spectrum. Endemism is low. Structurally the thicket is a closed shrubland to low forest dominated by evergreen, sclerophyllous trees and shrubs with a high cover of stem spines and vines (Cowling 1983a). Included in this type are parts of the thickets in Acocks's (1953) Eastern Province Thornveld (7b), Alexandria Forest (2), False Thornveld of Eastern Cape (21), Coastal Renosterveld (46) and Coastal Macchia (47).

Without additional data, particularly on the floristic relationships of the southern and south western Cape thicket, further subdivision of this type is difficult. Kaffrarian Thicket ranges from Algoa Bay to the Cape Peninsula with possible outliers along the west coast south of Lambert's Bay (Boucher & Jarman 1977).

3.1.2 Valley Bushveld (undifferentiated)

We do not attempt to re-define or subdivide this category as it falls predominantly outside the fynbos biome. Acocks's (1953) subdivisions suffice for our present purposes.

3.2 AFROMONTANE FOREST

3.2.1 Afromontane forest communities (undifferentiated)

There is little problem with this category and readers are referred to Cowling's (1983a) review and to McKenzie (1978) and White (1978) for a regional perspective.

3.3 KARROID SHRUBLANDS

3.3.1 Karroid shrublands (undifferentiated)

We do not subdivide this category, and Acocks's (1953) subdivisions suffice for our present purposes.

4. ECOTONES AND AREAS PARTLY CLEARED OF NATURAL VEGETATION

At the scale at which the map of the fynbos biome was produced, it was impossible to distinguish fairly extensive mixed vegetation types in certain areas. These were mapped as mosaics, and the following were recognized:

4.1 MOSAIC OF DRY MOUNTAIN FYNBOS AND KARROID SHRUBLANDS occurring north of Clanwilliam on the Cedarberg Mountains and in the Vanrhynsdorp area;

4.2 MOSAIC OF SAND PLAIN FYNBOS AND WEST COAST STRANDVELD occurring on the west coast lowlands, particularly north of Saldanha Bay to Olifants River;

- 4.3 MOSAIC OF DUNE FYNBOS AND KAFFRARIAN THICKET occurring in the south coast region; and
- 4.4 MOSAIC OF SOUTH COAST RENOSTERVELD AND AGRICULTURE inland of Port Elizabeth.

PROBLEMS AND LIMITATIONS OF THE SCHEME

The production of a broad synthesis such as has been attempted here, particularly by a number of individuals, is fraught with difficulties. All the authors have had to make concessions and at times one of us (EJM) has made final decisions when concensus could not be reached. Three major problem areas have imposed limitations to the scheme. These are considered separately.

(i) Method of mapping

It could be questioned whether the best products available for visual interpretation were used in this study. There are systematically enhanced and geometrically corrected photographic images available, but these were not utilized. Budget constraints determined the choice of products (14 Landsat scenes involved), as the emphasis in the study originally was placed on computer digital processing of Landsat CCTS.

The computer generated maps did not correspond exactly to those produced from visual interpretation (Jarman, Bossi & Moll 1983). This was because the computer generated categories did not always agree with vegetation classes as defined by botanists. The computer produces categories by classifying only the spectral reflectance of the earth's surface, whereas the vegetation categories obtained through manual interpretation are derived from additional information such as geology, topography and field experience, in addition to the spectral reflectance. Thus the computer generated maps were not used as a replacement for manual interpretation but merely as an aid.

Using the combination of a standard 1:1 000 000 scale false colour transparency and a 1:250 000 black and white photographic print for visual interpretation purposes was successful. Field surveys that were undertaken during and after the photo-interpretation process, and comments from botanists, confirmed that the vegetation boundaries drawn from satellite images were often good. However, there was controversy over the naming of these vegetation categories as the mapping project did not include comprehensive vegetation studies to substantiate a new nomenclature.

Difficulties that did arise in categorizing certain parts of the biome, either through lack of available vegetation descriptions or because of the occurrence of ecotones were:

(a) Cape Fynbos Shrublands

Although Wet Mountain Fynbos was easily distinguished from Mesic Mountain Fynbos, some difficulties were experienced in isolating young plantations and small forest patches from Wet Mountain Fynbos areas.

Mesic Mountain Fynbos was a relatively easy category to map, having distinct boundaries. A note of interest was that Mesic Mountain Fynbos on granite in the south western Cape, for example Paarl, Helderberg and Klein Drakenstein Mountains, was distinguished as a different category in the computer classification (Bossi 1983). However, in the final map this category was mapped as Mesic Mountain Fynbos as the areas involved were too small to be mapped separately.

The Dry Mountain Fynbos occurring in the Clanwilliam and Calvinia areas could not easily be separated from the Karroid Shrublands even at 1:250 000 scale. These areas were, therefore, mapped as a mosaic of the two types. One of the present authors (BMC) does not agree with the subdivision of fynbos mapped in the Cedarberg Mountains, and in the region north of Clanwilliam to Calvinia. His data suggest that the Mesic Mountain Fynbos of the northwestern region is much more xeric than the Dry Mountain Fynbos of the southern mountain region. Taking his point we must state that we could only successfully map Mountain Fynbos into a dry type in the southern region, as the Landsat images did not provide good discrimination in the northwest. Extensive field checking may well prove that what we have mapped as Dry Mountain Fynbos - in the northwest is in fact more arid (see Taylor 1978 Arid Fynbos discussion), and our Mesic Mountain Fynbos in the Cedarberg is in fact more xeric and thus more similar to our Dry Mountain Fynbos of the southern region.

In the Swartruggens Mountains (area I on Figure 1), Dry Mountain Fynbos and Central Mountain Renosterveld could not be easily distinguished, partly because of the small size of the former and the encroachment into it of the latter. In this area the mixture was mapped as Central Mountain Renosterveld.

Because of the increased grassy nature of Grassy Fynbos in the southeastern Cape some of the land is used for grazing. Thus extensive and heavily grazed areas were indistinguishable from adjacent agricultural areas and were mapped as such, while mosaics of lightly grazed and good condition natural veld were mapped as Mesic Grassy Fynbos or as Dry Grassy Fynbos.

The vegetation on the west coast, north of Saldanha Bay, was mapped as a mosaic of Sand Plain Lowland Fynbos and West Coast Strandveld as these two could not be interpreted separately. The vegetation is more sparse because conditions are drier and the area has many old lands, which makes interpretation even

more difficult. In addition local edaphic factors are more complex, leading to a greater admix of these types (Boucher in prep).

Along the south coast moving eastwards, Dune Fynbos becomes increasingly interspersed with Kaffrarian Thicket. This was mapped as a mosaic of two types.

The vegetation occurring along the whole coastline, namely Dune Fynbos, Lowland Fynbos, West Coast Strandveld and South Coast Strandveld is partially or densely infested by alien vegetation in certain areas. Only the most densely infested areas covering at least 2 km² could be seen on the satellite images and these areas were excluded from the natural vegetation categories. Any smaller areas, or areas moderately or lightly infested with aliens, have been included as natural vegetation.

(b) Cape Transitional Shrublands

South Coast Renosterveld, occurring along the south coast, has a large number of Valley Bushveld elements present, especially in the steep valleys, but these were too small to map at 1:250 000 scale and were, therefore, considered characteristic of this renosterveld.

In the southeastern Cape the area mapped as South Coast Renosterveld includes scattered fields; only the larger agricultural areas were excluded from this type in this region.

(c) Subtropical Transitional Thicket, Afromontane Forest and Karroid Shrublands

These pure non-fynbos communities occurring adjacent to the fynbos biome have been identified only as broad categories on the final map, although differentiation of these categories was evident on the satellite images. These types include Kaffrarian Thicket, Valley Bushveld, Afromontane Forest and Karroid Shrublands.

(ii) Hierarchical inconsistencies

Bearing in mind the procedure whereby the major vegetation categories were mapped, we acknowledge that there are limitations with respect to more detailed floristic information in the scheme proposed here. It is acknowledged that with more phytosociological data different vegetation types may be placed in hierarchical categories other than those in this scheme. For example Boucher (in prep) recognizes at least three different types of West Coast Renosterveld. Also we realize that all the mapped types are not necessarily at the same hierarchical level. For example, Campbell (1984a) has recognized seven regions of Cape mountain vegetation all of which contain our Mesic Mountain Fynbos type. It is clear that on

floristic criteria we should have divided this category into at least seven sub-types (Figure 1, Campbell 1984), however, these were not readily recognizable on the satellite images.

(iii) Divergent interpretations

One of the most contentious issues concerned the interpretation of the term heathland, used in the structural/environmental description to describe the communities of the Cape Floral Kingdom. In the present scheme the term heathland is used to indicate that fynbos is not simply a mediterranean-type shrubland, but rather that it's structural and functional characters are strongly determined by edaphic conditions (Specht 1979, Specht & Moll 1983). However, Campbell and Cowling (also Bond 1981) do not entirely agree with this usage. They have argued that fynbos is not heathland and that only limited fynbos types (where Ericaceae are dominant) are true heathlands (see Campbell et al 1981, 1984b and Cowling 1983a for further discussion). The divergence in opinion has provoked Moll & Jarman (1984a) and Campbell & Werger (1984) to attempt a re-evaluation of the term heathland in world context, in which the southern African forms have been specifically highlighted.

RECOMMENDATIONS

This exercise has been limited by the lack of information from certain areas or vegetation types. We suggest the following priorities for phytosociological surveys, in order of importance:

- (a) Elim Fynbos on the Agulhas Plain (communities on depositional landscapes) and Limestone Fynbos.
- (b) Central Mountain Renosterveld
- (c) Lowland vegetation formations generally (but especially South Coast Renosterveld and all dune communities between the Gouritz and Groot Brak rivers).
- (d) The Dry Mountain Fynbos and Karrooid Shrubland mosaic of the north western part of the fynbos biome.
- (e) All categories of Mountain Fynbos and Grassy Fynbos throughout the biome. This is a long term project which will ultimately result in the emergence of well-defined syntaxonomic concepts. To date there are published accounts of the vegetation in very few areas (eg Jonkershoek, Cape Peninsula, Jakkalsrivier, Cape Hangklip, Outeniqua, Rooiberg, Swartberg, Elandsberg, Suurberg).

It is not necessary for the survey work to be detailed formal phytosociological studies. Workers could use 0,1 ha plots or compile species lists from small areas so as to sample at least once the major community types in a large region. This type of sampling intensity should be sufficient to define concepts at the veld type level of a syntaxonomic hierarchy.

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