



A description of the Fynbos Biome Project

A report of the Committee for Terrestrial Ecosystems
National Programme for Environmental Sciences

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PREFACE

The Fynbos Biome Project of the National Programme for Environmental Sciences is one of several national scientific programmes 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 1970 by ICSU (International Council of Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field.

The Fynbos Biome Project was initiated during 1977 in an attempt to coordinate existing and stimulate new ecological research activities within the fynbos biome. The project has brought together researchers of the Departments of Forestry, Agricultural Technical Services and Nature and Environmental Conservation and of several Cape universities. While most of the research is financed by the participant organizations, limited funds are available from a central fund administered by the National Committee for Environmental Sciences and contributed largely by the Department of Planning and the Environment. Details of the latter funding are obtainable from the National Programme for Environmental Sciences, CSIR.

The research programme of the Fynbos Biome Project comprises three phases - Phase I (1977-1980) - baseline studies of the fynbos biome, which include the review of current knowledge and broad surveys of climate, soils, vegetation, fauna and land-use patterns; Phase II (1979-1982) - comparative studies of ecosystem structure and functioning which will include detailed investigations of ecosystem processes, the ecological effects of certain major influences such as fire, invasive plants and afforestation, ecophysiological studies and gradient analyses of community structure, and Phase III (1981-1986) - validation studies which will focus on testing hypotheses and models developed during Phase II.

ABSTRACT

The objectives, organization and research programme of the Fynbos Biome Project being undertaken in the south-west and southern Cape are described. The project is a cooperative multi-disciplinary study of the ecological characteristics, structure and functioning of the various fynbos ecosystems and their components. Particular emphasis is being devoted to major environmental problems such as invasive plants and the ecological effects of fire. The project is divided into three phases, Phase I (1977-1980) - baseline studies of the fynbos biome, Phase II (1979-1982) - comparative studies of ecosystem structure and functioning, and Phase III (1981-1986) - validation studies.

SAMEVATTING

Die Fynbosbloomprojek wat onderneem word in die suidwestelike en suidelike Kaapprovinsie word beskryf in terme van doelstellings, organisasie en navorsingsprogram. Die projek is 'n koöperatiewe multi-dissiplinêre studie van die ekologiese eienskappe, struktuur en funksionering van die verskillende fynbos-ekosisteme en hulle komponente. Spesiale aandag word gegee aan belangrike omgewingsprobleme soos indringerplante en die ekologiese uitwerking van vuur. Die projek word onderverdeel in drie fases, nl Fase I (1977-1980) - agtergrondstudies van die fynbosbloom, Fase II (1979-1982) - vergelykende studies van ekosisteamstruktuur en - funksionering, en Fase III (1981-1986) - geldigheidstudies.

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INTRODUCTION

Fynbos is the broad category of vegetation formations including mainly Acocks's (1953) Veld Types 47 (Coastal Macchia), 69 (Macchia) and 70 (False Macchia). These comprise sclerophyllous shrublands of the mountains of the Cape Folded Belt, their foothills and the coastal forelands.

The biome is of great scientific and aesthetic interest and is also important economically, both as a water source zone and as a recreation area. Although the extent of natural fynbos has been much reduced, relatively large tracts of intact or nearly intact vegetation remain. The flora is extremely rich and many species are rare and restricted in their distribution. Conservation and continued use of the biome are rendered difficult mainly by the incidence of fire and the spread of invasive exotic trees and shrubs. Because of these and other environmental problems, some species have become extinct and many others are endangered or vulnerable.

Sound ecological knowledge is urgently required for fynbos management. Though various institutions have been active in conservation and in ecological research, a common desire to optimize research efforts through formal coordination led to proposals for a collaborative scientific programme. A task group was appointed by the Committee for Terrestrial Ecosystems of the National Committee for Environmental Sciences to study the desirability of such a cooperative project and its favourable recommendations were accepted. A Steering Committee was formed in March 1977 and has convened at frequent intervals to plan and review research strategy. This document is the result of the review process.

As far as possible, all current ecological research projects being undertaken within the fynbos biome are listed in this document. The projects cover a wide field, both in terms of subject matter and pertinence to the goals of the Fynbos Biome Project. New projects to be funded by the National Programme for Environmental Sciences will be selected on a basis of their priority in terms of the key questions noted in this document and by the continuous review of the research programme by the project Steering Committee.

ECOLOGICAL CHARACTERISTICS OF THE FYNBOS BIOME

Comprehensive reviews on fynbos ecology and conservation are to be included in Louw (1978). Only a brief outline of the ecological characteristics of fynbos will be provided here. Fynbos dominates the landscapes of the western and southern Cape Province in zones with rainfall in excess of about 250 to 300 mm per annum. The dominant fynbos formations vary considerably in structure but communities characteristically include growth forms of the restioid, ericoid and proteoid types (Taylor 1978).

The following are some distinguishing features of fynbos :

- An unparalleled floral diversity - about 6 000 plant species occur in the biome. Also a unique degree of endemism in many taxa and a large number of rare, isolated species. The flora is strikingly attractive.
- At the community level, fynbos is also unique in that very large numbers of plant species coexist within a given small area (up to 121 species on 100 m², Taylor 1978), and it is only in tropical rainforests that this community diversity may be exceeded.
- It is a typical fire-type vegetation, showing features of community dynamics like those of communities in other, similar climates where fires recur frequently.
- It occurs in a wide range of climates, from mediterranean in the west to constant rainfall in the east, and from about 250 mm to 3 000 mm rainfall per annum, with seasonal, mainly summer, soil moisture stress being perhaps the one common feature.
- Communities occupy a wide range of landscapes, from young coastal sands to subalpine peaks at elevations above 2 000 m.
- Soils generally are extremely infertile.

For the purposes of this project, two transitional Veld Types of the zone of mediterranean climate are added to the true fynbos formations. These are the southern and wetter portion of Veld Type 34 (Strandveld of the West Coast) and Veld Type 46 (Coastal Renosterbosveld). These, together with Veld Types 47, 69 and 70, occupy the Cape Floristic Kingdom and constitute the fynbos biome, but the two transitional types differ from the remainder, principally as follows :

- The restioid growth form is by and large absent or of little relative importance in the community; Coastal Strandveld has many succulent and spiny plants.
- Soils are rich in bases, usually neutral or alkaline and sometimes slightly saline.
- Fire is not a regular occurrence.

ENVIRONMENTAL PROBLEMS IN THE FYNBOS BIOME

CONSERVATION STATUS

The areas occupied by fynbos Veld Types and by permanent conservation areas within them are tabulated below (data from Edwards 1974).

Veld Type	47	69	70	34	46
Total area (sq km)	8 379	17 846	17 866	6 308	14 591
Provincial and National reserves (areas in sq km)	54	139	0,57	3,9	49
Unafforested State Forest lands (areas in sq km)	128	2 587	3 761	60	76
Percentage conserved	2,1	15,3	21,1	1,05	0,9

The conservation status of fynbos ecosystems is potentially good in the mountains and poor on the lowlands and a scientific basis for planned conservation and utilization is urgently required. Estimates from recent satellite photographs show that some 60 per cent of the fynbos has disappeared as a result of human impact. The remaining 18 000 square kilometres is slightly less than the area of the Kruger National Park (Hall 1977). This trend must continue for some time to come and is marked by expanding agriculture and afforestation, large new water storage and reticulation schemes, and resort developments.

This reduction in the extent of fynbos communities, together with the peculiar biogeographic features of the biome, means an inevitable threat to the continued existence of many species. An initial survey (Hall 1977) showed that numerous plant species have the status rare or endangered.

VELD FIRES

Fires are frequent in fynbos communities. Especially in the mountains, the combined influence of peculiar fynbos fuels (heavy accumulations, finely subdivided, with a high energy content), extreme fire weather conditions, and rugged topography result in frequently extensive fires. In the Cedarberg State Forest, for example, about 55 300 ha of the total 75 000 ha have been burnt in wildfires in the period 1958 to 1975, inclusive, in spite of extensive fire prevention measures. One of the fires burnt for six days and covered 13 500 ha.

Fires in fynbos have economic consequences in that they require expenditure on prevention and control, cause damage to property, and encourage the spread of weeds. The phenomenon is also an ecological problem, in that

the incidence of fire is a natural result of the characteristic features of the ecosystem, and that the dynamic and other functional attributes of the natural communities interact with the fire regime. Thus, for example, species like *Orothamnus zeyheri* cannot complete their life cycles in the continued absence of fire. Conservation is therefore at least partly dependent on the use of fire as a management tool.

INVASIVE WOODY PLANTS

The most critical problem in fynbos conservation remains that of invasive woody plants. Hall and Boucher (1977) list 28 species of exotic trees and shrubs which readily invade fynbos communities and whose establishment and spread are problematic. In a recent survey of 92 500 ha of Mountain Fynbos, 925 ha were found to be heavily infested by *Hakea sericea* (more than 720 plants ha⁻¹), 18 445 ha moderately (0,1 to 720 plants ha⁻¹), and 18 795 ha sparsely infested. Hall (1977) estimates that 17 to 23 per cent of the remaining natural areas of Veld Types 47, 69 and 70 has been occupied to a greater or lesser extent by species of *Pinus*, *Hakea* and *Acacia*.

These invasive species can rapidly dominate the landscape and their ultimate effect is a transformation in species diversity, lowered catchment water yields, and an increased potential for "blow-up" fires through changes in the character of natural fuels.

OBJECTIVES AND PHASES OF THE PROJECT

The overall and ultimate objective of the project is to provide sound scientific knowledge of the structure and functioning of constituent ecosystems as a basis for the conservation and management of the fynbos biome. The objective will be realized by :

- Synthesizing available knowledge in order to identify major gaps.
- Stimulating and coordinating existing research in order to optimize present efforts.
- Giving priority to the urgent launching of new research in order to gain a deeper understanding of
 - the major natural influences which control the distribution, structure and functioning of ecosystems within the biome as well as
 - the effect of major disturbances, especially fire and invasive weeds, on these systems. The results of these studies will be used to predict the effects of land management practices.

The Fynbos Biome Project will be phased as follows -

Phase I : Baseline studies of the fynbos biome, 1977 to 1980

This will comprise a review and synthesis of available information, and biome-wide climate and pedological studies, vegetation classification, mapping and monitoring, faunistic surveys, biogeographic and palaeoecological studies and land-use surveys.

Phase II : Comparative studies of ecosystem structure and functioning, 1979 to 1982

The main objective of this phase will be to gain a greater understanding of the biology and ecology of fynbos on a comparative basis, as well as an understanding of the effects of major disturbances such as fire, invasive weeds, agriculture and forestry. Typical studies will include analyses of vegetation structure, faunistic composition, biomass, primary productivity and soil and climatic relationships at representative study sites. Eco-physiological studies of dominant plant species will be mainly directed towards investigations of nutrition, photosynthesis and water relationships. Both the invertebrate and vertebrate fauna will receive attention, particularly in regard to herbivory and pollination biology. Microclimatic studies will be undertaken to provide biologists with specific information. Further autecological studies on invasive weeds will be encouraged. Ecosystem studies will include an assessment of ecological energetics and water and nutrient cycling.

Phase III : Validation studies - testing of Phase II hypotheses and models, 1981 to 1986

Central hypotheses arising from work in Phase II will be tested in ecosystems under different kinds and levels of stress due to environmental disturbance, and in different ecosystems. Management models and systems will be developed.

RESEARCH STRATEGY

Several factors will influence the approach adopted in developing the research programme. Current knowledge must be synthesized, specific gaps in available information identified and priorities established regarding environmental problems deserving urgent attention. The availability of logistic support will influence the choice of study sites.

A major factor influencing research design is the extreme heterogeneity of fynbos ecosystems in terms of biotic composition and structure. Studies will have to be undertaken at varying levels of intensity, from broad gradient analyses, through whole ecosystem studies to autecological investigations. The extrapolation of findings from one community or species population to another will have to be carefully tested. The development of models will only be possible where information on the various parameters is derived from comparable ecosystems.

The initial activities of the project will consist mainly of studies which are not immediately associated with selected research sites. However, in order to gain a deeper understanding of ecosystem structure and functioning, certain investigations will ultimately be concentrated in primary study sites which will be representative of major community types occurring within the biome. The generality of research results from the primary sites will be tested through further, less intensive studies at secondary sites and through overall surveys.

Studies in Mountain Fynbos will be centred at a primary study site at Jonkershoek and with secondary sites at Zachariashoek, Nuweberg and Jakkalsrivier. Primary study sites have yet to be selected in Arid Fynbos, Coastal Fynbos and Strandveld.

PHASE I : BASELINE STUDIES OF THE FYNBOS BIOME, 1977 TO 1980

AIMS

The principal objective in this phase is to define the geographical distribution and extent of the major vegetation types of the biome and to gather and collate data on community structure and functioning, and physical environmental variables, which will describe the fynbos biome in its different forms and provide a framework for the identification of future research priorities.

REVIEW AND SYNTHESIS OF AVAILABLE INFORMATION

Rationale

A synthesis of all relevant published and unpublished information is required in addition to those recently completed (see below) to bring the information together under one cover, and to deal with certain fields such as hydrology and fauna in greater depth. The document would also highlight research needs.

Past reviews

After Wicht (1945) there have been some recent syntheses, principally on the flora and vegetation (Taylor 1978; Kruger 1977, 1978a, 1978b), with lesser coverage of fauna (Bigalke 1978) and of conservation and management (Bands 1977; Kruger 1978c; Taylor 1978). These works covered certain fields with reasonable thoroughness but are not sufficiently comprehensive.

Ongoing reviews

Fynbos ecology : a syntheses of existing knowledge. Professor G N Louw (Department of Zoology, University of Cape Town), editor, 1978. The aim of this report is to collate and integrate available information in a comprehensive report, to be completed by June 1978.

Future reviews

Additional syntheses would be necessary at the completion of each phase of the project.

CLIMATOLOGICAL STUDIES

Rationale

There have been various climatological studies relating to the fynbos biome, either as part of overall southern African climate studies (Schulze 1965; Schulze and McGee 1978) or as special-purpose studies within the biome (Swart 1956; Thirion 1965; Wicht *et al* 1969; Buys 1971; Dupisanie 1974). None of these studies has been sufficiently comprehensive, neither covering such aspects as comparative mediterranean climatology and fire-hazard weather, nor providing a comprehensive summary of the available records, especially those now becoming available from weather stations of the Department of Agricultural Technical Services.

Key questions for research

- What are the major features of the climates of the fynbos?
- How do climatic parameters vary geographically within the biome?
- How do the main types of fynbos correlate with regional variation in climate?
- In a broad way, how do climatic and weather factors govern the incidence of fires?

Ongoing project

Preliminary synthesis of macroclimatic patterns within the fynbos biome. Professor R F Fuggle (School for Environmental Studies, University of Cape Town), 1977-1978. This project will compile summaries of all climatic records from stations within the biome and characterize the various climatic types identified.

PEDOLOGICAL STUDIES

Rationale

By virtue of the limited agricultural potential of the biome there has been little study of fynbos soils. Past accounts of fynbos pedology are at best sketchy and a detailed classification and description of fynbos soils is needed.

Key questions for research

- What are the correlations between soil type and vegetation type?
- What are the broad patterns of soil nutrient status in the fynbos biome?

Ongoing project

A soil map of the fynbos biome. Mr J J N Lambrechts (Faculty of Agriculture, University of Stellenbosch), 1977-1978.

Future project

Correlation between soil type and fynbos plant community type along selected environmental gradients. Professor A A Theron (Faculty of Agriculture, University of Stellenbosch), 1979-1980. Soil surveys will be executed along selected transects and used for series mapping, which will then be correlated with results of simultaneous vegetation surveys.

VEGETATION CLASSIFICATION, MAPPING AND MONITORING

Rationale

Acocks (1953) emphasized that there was considerable variation in the structure and botanical composition of communities within the types of

fynbos he mapped. Conservation planners and managers recognize the need for a more refined classification, to permit research, management and monitoring by type. Within the context of the project, classification and mapping of communities are required for the extrapolation of the results of primary site studies.

Key questions for research

- What is the extent of the fynbos biome, where are the major boundaries within the biome, and how much of the vegetation is affected by weeds, grazing etc?
- Can the fynbos biome be classified using gross plant community structural and functional features in a way that correlates with changes in controlling environmental factors, and if so, what are the major types so defined?
- In key areas of the fynbos biome (eg threatened areas, important reserves, mountain catchment areas, etc), what are the major floristic associations?

Past research

Taylor (1978) and Kruger (1978a) review past work in this field. Less than one per cent of the total area of the biome has been studied for classification and mapping.

Ongoing projects

Structural and functional classification of fynbos vegetation. Mr B Campbell (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1978-1980. This project aims to provide a classification of fynbos using features other than species composition; initial gradient studies will determine whether this is feasible and, if so, which features are most useful.

Semi-detailed surveys of selected mountain catchment areas. Mr H C Taylor (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1977-1987. A selected number of proclaimed mountain catchment areas will be surveyed and a classification and description of the vegetation will be prepared.

A reconnaissance survey of the vegetation of the Rooiberg State Forest. Mr H C Taylor (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1977-1978. A classification to the level of formation category, map and broad description of the plant communities in the Rooiberg, for management purposes.

Gradient analysis of the vegetation of the mountain catchment areas of the Southern Cape and Tsitsikamma Forest Regions. Mr W J Bond (Saasveld Forestry Research Station, George), 1977-1979.

Coastal foreland vegetation survey : West Coast. Mr C Boucher (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1977-1981. A semi-detailed study by the Braun-Blanquet method of Veld Types 34, 46 and 47, from Gordons Bay to the Olifants River, to define and map the communities on a scale of 1 : 50 000.

A survey and classification of the vegetation of the Zachariashoek catchments, Lamotte State Forest. Messrs F J Kruger and B W van Wilgen (Jonkershoek Forestry Research Station, Stellenbosch), 1977-1978. A floristic classification and description of plant communities in these experimental catchments.

An investigation to determine the usefulness of various remote sensing techniques for studying and mapping the fynbos biome. Professor K J MacGregor (Department of Computer Science, University of Cape Town) and Dr E J Moll (Department of Botany, University of Cape Town), 1978-1979.

An ecological study of the Gamka Mountain Reserve. Dr A F Boshoff (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1976-1978. A physiognomic, semi-floristic vegetation survey of the Gamka Mountain Reserve for management purposes.

A study of the vegetation of the Rocher Pan Nature Reserve. Miss A le Roux (Cape Provincial Department of Nature and Environmental Conservation), 1978-1980. A phytosociological study of the vegetation for management purposes.

Future project

Coastal foreland vegetation survey : South Coast. Mr C Boucher (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1982-1986.

FAUNISTIC SURVEYS

Rationale

Major gaps in knowledge of the distribution and abundance of prominent fynbos animal species have to be filled.

Key questions for research

- How does the composition of the fynbos fauna vary along major geographic gradients?
- How does the biogeography of the fynbos fauna relate to that of the flora?

Past research

Past research is summarized by Bigalke (1978) and Cody and Mooney (1978).

Ongoing projects

A survey of the reptiles and amphibians of the Cape Province. Mr J C Greig (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1972-1982. The first phase is a systematic collection of amphibians and reptiles in the fynbos area with taxonomic studies on new species.

Surveys and assessments of the fauna of Western Cape Mountain Catchments. Professor R C Bigalke (Faculty of Forestry, University of Stellenbosch), long-term.

Surveys and assessments of the fauna of forest lands catchments in the Southern Cape and Tsitsikamma Forest Regions. Mr G J Breytenbach (Saasveld Forestry Station, George), long-term.

A distribution, status and feeding habit survey of the larger birds of prey and vultures in the Cape Province. Dr A H Boshoff (Cape Provincial Department of Nature and Environmental Conservation), 1975-1978.

The distribution, status, feeding habits and reproduction of carnivores of the Cape Province. Mr C T Stuart (Cape Provincial Department of Nature and Environmental Conservation), 1976-1980.

BIOGEOGRAPHY AND PALAEOECOLOGY

Rationale

Some fynbos species distributions are still unknown but there are major problems in explaining the current distribution of species, particularly endemics and species with disjunct distributions. The problems relate to stability, speciation and extinction and have an extremely important bearing on conservation policy.

Key questions for research

- What are the major features of past environments which would have affected adaptations in present species, and species distribution patterns?
- What were the distribution patterns, abundance and movements of fynbos taxa in the past?
- What are the distinctive features of fynbos biogeography, with regard to species distribution patterns, population size, and possible evolutionary trends?
- How should these features govern conservation policies and practices?

Past research

There has been considerable work in archaeology and palaeoecology : Klein (1977) provides an excellent review. Similarly, there are numerous reports on plant distribution (Taylor 1978) and a recent review of animal biogeography (Bigalke 1978). However, most attempts at explaining distribution patterns are anecdotal (cf Levyns 1964).

Ongoing projects

Palaeoecological studies in the fynbos zone of the southern Cape. Dr H J Deacon (Department of Archaeology, University of Stellenbosch), 1977-1979. A synthesis of available knowledge on changes in vegetation composition across the Holocene - Pleistocene boundary.

A survey of rare and endangered plant species. Dr A V Hall (Bolus Herbarium, University of Cape Town), 1973-1980.

Future project

Studies in the distribution of representative species of fynbos plants with wide as well as restricted ranges to clarify problems set out in the rationale.

LAND-USE PATTERNS

Rationale

There is no recent review of land-use in the fynbos, especially in the mountains. The information is needed to guide research priorities, especially with regard to impact studies.

Key questions for research

- What is the proportion of land subject to different uses, especially rough pasturage, flower harvesting, afforestation, crop production and conservation?
- To which land-use practices is the stability of fynbos ecosystems most sensitive?

Past projects

There is no comprehensive overview of the way in which extant fynbos ecosystems are used, nor of the kinds of land-use that encroach on these remnants.

Ongoing projects

Historic and present land-use patterns in the fynbos biome - preliminary synthesis. Professor R J Davies (Department of Geography, University of Cape Town), 1977-1978.

The influence of mountain catchment declaration on land management in the Winterhoek area of the western Cape : ecological, economic and social implications. Mr D P Bands (Department of Forestry, Cape Town), 1977-1979.

Future projects

No new projects are presently envisaged. However, ongoing resource and land-use surveys of mountain catchment areas by the Department of Forestry will add detailed information on certain forms of land-use. It is recognized that recreational use of certain communities might have deleterious influences on their ecological functioning and that research in this field is necessary.

PHASE II : COMPARATIVE STUDIES OF ECOSYSTEM STRUCTURE AND FUNCTIONING, 1979 TO 1982

AIMS

In this phase certain ongoing studies will be coordinated within the framework of the project and will be supplemented with a series of new investigations. These new studies will consist mainly of a range of intensive investigations, concentrated at a primary research site but given breadth by similar less intensive investigations at a small number of secondary sites, selected to represent the major categories of fynbos. The generality of information gathered in this way will be explored and tested through a number of site and "disturbance gradient" ordination studies. The impact of different forms of land use or changes in the biome will be examined through gradient studies of the pattern of impact levels at each site.

INITIAL DESCRIPTIVE STUDIES

Rationale

While research will be spread throughout the biome, there will ultimately be a concentration of effort at a selected number of representative research sites, to provide data for an in-depth understanding of certain processes. These studies are projected as a first phase of the detailed investigations.

Key questions for research

- What are the pedological and climatological characteristics of the selected sites?
- What is the distribution in space and time of the biomass of the key botanical and faunal components?

Future projects

Pedological studies. Pedological studies will be aimed at determination of soil types and correlation with environmental factors and determination of soil nutrient status. Botanists will collaborate in determining correlation between distribution of plant communities and soil types. Mineral cycling studies would be initiated at the primary site.

Climatological studies at selected sites in the fynbos biome. This study would monitor such factors as solar radiation, air temperature, rainfall and wind, and would describe the major features of the climate at each intensive study site, as well as variations in the topoclimate.

Structure and function of plant communities : basic analyses. This would include enumeration of the flora, identification and mapping of major vegetation patterns, description of communities in terms of floristic (relative importance of species) and life- and growth-form composition, analysis of biomass in terms of contribution by most important species and structural elements (leaves, stems, etc), leaf area indices etc; diversity data; preliminary studies on seasonality, plant water relations, and of assimilation patterns (primary and secondary sites).

Comparative studies on structure and functioning of animal communities : basic analyses. At each of the study sites there would be an inventory of the species numbers and biomass of vertebrates and invertebrates in different, selected taxa (including invertebrates, herpetofauna, avifauna and mammals) and/or trophic groups. Work in the initial phase would include studies on seasonality and on herbivory.

GRADIENT STUDIES

Rationale

Although baseline studies will provide broad information it is necessary in the extensive stage of the project to examine the responses of natural communities to changes in environmental variables and kinds and levels of impact along recognizable gradients in sufficient detail to construct a framework for management planning and to permit extrapolation of results from selected research sites.

Key questions for research

- How do plant communities change in physiognomy, cover and biomass with change in climatic and physiographic factors?
- How does plant community structure, especially life and growth form composition, change with soil nutrient status?
- How do animal communities change with changes in plant community structure?

Ongoing projects

Comparative studies of the avifaunas of different fynbos plant formations. Professor W R Siegfried (Percy FitzPatrick Institute of African Ornithology, University of Cape Town), 1978-1982.

A gradient analysis of animal communities on forest lands in Southern Cape and Tsitsikamma Forest Regions. Mr G J Breytenbach (Saasveld Forestry Research Station, George), 1978-1980.

Investigation of the distribution and populations of mammals in mountain fynbos communities. Professor R C Bigalke (Faculty of Forestry, University of Stellenbosch), long-term.

Future projects

Studies of the structure and seasonality of selected invertebrate populations of representative sites in the fynbos biome.

Studies of the structure and seasonality of the herpetofauna of selected sites in the fynbos biome.

Studies of the structure and seasonality of the mammal communities of selected sites in the fynbos biome.

PROCESS STUDIES

Rationale

Management of mountain fynbos, the principal cover of important water catchments, affects the hydrological cycle. Management and especially veld burning can also have major effects on the limited nutrient pools. Measurements of changes in standing crop are necessary for the estimation of community productivity and for the determination of nutrient distribution within the various ecosystem components. Such data are essential for the development of predictive models, especially fire management models.

Key questions for research

- How do environmental and biological factors determine primary productivity?
- How are the small pools of nutrients in fynbos ecosystems maintained?
- How does the water balance of fynbos ecosystems vary geographically and with community structure?
- How are the incidence and behaviour of fynbos fires determined by the interactions between climate and vegetation?

Ongoing projects

A study of interception loss in mature *Hakea sericea* Schrad stands. Mr D B Versfeld (Jonkershoek Forestry Research Station), 1978.

Theoretical analysis of the subsurface water regimes of experimental catchments in the Western Cape Forest Region. Mr P A Kilpatrick (Jonkershoek Forestry Research Station), 1977-1980.

Future projects

Hydrological studies at selected sites in the fynbos biome.

Primary production studies at selected sites in the fynbos biome.

Nutrient cycling studies at selected sites in the fynbos biome, including litter decay and leaching processes.

Herbivory in selected fynbos plant communities.

Development of fire hazard and fire behaviour models for the fynbos.

AUTECOLOGICAL, ECOPHYSIOLOGICAL AND ADAPTIVE RESPONSE STUDIES

Rationale

Process studies and impact studies present a picture of the functioning of the ecosystem at the gross level. The studies envisaged here are aimed at basic understanding of the biology of fynbos species so that community ecology on the one hand and conservation practice on the other will have a firm foundation.

Key questions for research

- How have plants adapted to nutrient and water stress and to recurrent fire?
- How have plants and animals evolved to their mutual benefit in terms of survival and reproduction?
- How is community diversity maintained and what is the minimal critical area required for the conservation of individual species within such a community?

Ongoing projects

A study of primary youth periods, fruiting and germination in rare or endangered fynbos plant species. Mr P van der Merwe (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1977-1979.

The mineral nutrition of members of fynbos plant communities. Dr J H Jooste (Department of Botany, University of Stellenbosch), 1977-1979. In the initial phases this investigation consists of studies of the mineral composition of various proteaceae and of the soil on which they grow.

The influence of different soil moisture regimes on growth, water relations and chemical composition of members of the proteaceae. Professor J A de Bruyn and Miss A Scheffler (Department of Botany, University of Stellenbosch and University of the Western Cape), 1977-1979. The investigation consists of a series of greenhouse trials in which trial plants are subject to a range of water regimes.

A phenological study in a fynbos community in Swartboskloof, Jonkershoek State Forest. Mr F J Kruger (Jonkershoek Forestry Research Station), 1970-1979.

Investigation of the population dynamics of *Widdringtonia cedarbergensis* Marsh and its interaction with fire. Mr F J Kruger (Jonkershoek Forestry Research Station), 1967-1980.

Investigation of the population dynamics, germination and establishment of *Orothamnus zeyheri* Pappe. Mr C Boucher (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1967-1979.

The reproductive potential of *Erica junonia*. Dr B L Robertson (Department of Botany, University of Port Elizabeth), 1976-1979.

Coevolutionary consequences of pollination of selected fynbos plants by birds in fynbos. Professor W R Siegfried (Percy FitzPatrick Institute for African Ornithology, University of Cape Town), 1976-1978.

A study of the ecology of the geometric tortoise *Pseammobates geometricus*. Mr J C Greig (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1977-1979. A study of growth rates, movements and breeding biology.

Ecology of the striped fieldmouse *Rhabdomys pumilio* with special reference to dependence on invasive Acacias. Dr J U M Jarvis and Mr G Johnson (Department of Zoology, University of Cape Town), 1978-1979.

A study of the chacma baboon *Papio ursinus* in the Cape Province. Mr P H Lloyd (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1975-1978. A population dynamics, food habits and movement study. A status study has been completed.

Habitat ecology of the klipspringer *Oreotragus oreotragus* in the Cape Province. Mr P M Norton (Cape Provincial Department of Nature and Environmental Conservation, Jonkershoek), 1977-1978.

An ecological study of the leopard *Panthera pardus* in the Cape Province. Mr P M Norton (Cape Provincial Department of Nature and Environmental Conservation), 1978-1983.

Future projects

Further studies on population dynamics, phenology and biology of rare and endangered plants and of other key species such as widespread, dominant or common taxa.

Plant ecophysiological studies of selected species. These studies will include water economy, nutrient relations and assimilation characteristics of selected dominant species.

IMPACT STUDIES

Rationale

The principal aim of the project is to provide the fundamental understanding of ecosystem structure and function necessary for optimal management and conservation of fynbos. It is essential that the ways in which various forms of land-use influence ecosystem stability be examined. Information is needed on why fynbos is so vulnerable to invasion by alien plants and how fire incidence or afforestation influences nutrient reserves and water cycling.

Key questions for research

- What is the influence of different forms of disturbance and/or change on community structure, especially diversity?
- What is the influence of different disturbances on ecosystem processes?
- What is the influence of fire on microclimate and how does this influence reproduction and growth of plants and behaviour of animals?
- What is the influence of veld burning on soil physical properties, especially in terms of erosion?

Ongoing projects - hydrological and nutrient cycles

A study of the water balance of a plantation of *Pinus radiata* and of fynbos at the Jonkershoek Forestry Research Station : rainfall interception and soil moisture fluctuation. Mr D B Versfeld (Jonkershoek Forestry Research Station), 1973-1980.

Determining the effects of management measures on water quality in experimental catchments at Jonkershoek, Zachariashoek and Jakkalsrivier. Mr D B van Wyk (Jonkershoek Forestry Research Station), 1970-1986.

Investigation of the effects on community structure and mineral balance of clear-felling of *Pinus radiata* in Bosboukloof catchment, Jonkershoek Forestry Research Station. (Jonkershoek Forestry Research Station and Faculty of Forestry, University of Stellenbosch), 1976-1982.

Determining of effects of converting protected fynbos to a plantation of *Pinus radiata* on stream discharge components at Jonkershoek Forestry Research Station. Mr D B van Wyk (Jonkershoek Forestry Research Station), long-term.

Ongoing projects - fire effects

Experimental investigations of the effects of season of burn of fynbos communities in plot trials at Kogelberg : studies on community structure and function and the immediate response of communities to treatment. Mr F J Kruger (Jonkershoek Forestry Research Station), 1976-1980.

Determining the effect of controlled burning systems applied in fynbos on stream discharge components of experimental catchments at Jonkershoek, Zachariashoek and Jakkalsrivier. Mr D B van Wyk (Jonkershoek Forestry Research Station), long-term.

Investigation of the effects of burning and protection on the structure of fynbos in experimental catchments at Jonkershoek, Jakkalsrivier and Zachariashoek Research Stations. Messrs F J Kruger and B W van Wilgen (Jonkershoek Forestry Research Station), long-term.

The effects of veld burning on small mammal populations in fynbos, with special reference to Jonkershoek and Zachariashoek. Professor R C Bigalke (Faculty of Forestry, University of Stellenbosch), 1976-1979.

Study of the origin, occurrence and spread of fynbos fires and controlling effects of weather as indicated by available records. Messrs F J Kruger, D P Bands and B W van Wilgen (Jonkershoek Forestry Research Station), 1978-1979.

Ongoing projects - invasive plants

Distribution of alien species on the Coastal forelands. Mr C Boucher (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1977-1986.

Aspects of the chemical control of *Hakea sericea* Schrad and *Pinus pinaster* Ait. Professor D G M Donald (Faculty of Forestry, University of Stellenbosch), 1976-1979.

Aspects of the population biology of invasive Acacias. Dr A V Hall (Bolus Herbarium, University of Cape Town), 1977-1980.

Distribution and abundance of invasive alien plants in mountain catchments of the Western Cape Forest Region. Mr D P Bands (Department of Forestry, Cape Town), 1976-1981. Data assembled during resource surveys of mountain catchments will be collated to provide detailed information on the spread of woody weeds.

Determination of the salt tolerance and mineral element requirements of *Acacia saligna*. Dr J H Jooste (Department of Botany, University of Stellenbosch), 1977-1979.

The biological control of *Hakea* spp. Dr S Neser (Plant Protection Research Institute, Department of Agricultural Technical Services, Stellenbosch), 1964-1980.

The biological control of Australian Acacias. Dr M A van den Berg (Plant Protection Research Institute, Department of Agricultural Technical Services, Stellenbosch), 1975-1984.

Invasive plants in the Cape of Good Hope Nature Reserve - a comparison of the extent of invasion after 10 years. Mr H C Taylor and Mr S R Fugler (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1976-1978.

Aspects of the distribution and autecology of *Hakea*. Mr S R Fugler (Botanical Research Unit, Department of Agricultural Technical Services, Stellenbosch), 1976-1979.

Autecology of *Leptospermum laevigatum*. Dr C T Johnson (Department of Botany, University of the Western Cape), 1976-1978.

Future project

Effect of flower harvesting on the composition and dynamics of natural fynbos plant and animal communities.

PHASE III : VALIDATION STUDIES - TESTING OF PHASE II HYPOTHESES AND MODELS,
1981 TO 1986

TRIAL OF PHASE II PROCESS HYPOTHESES UNDER DIFFERENT STRESSES

Results of work in Phase II will be synthesized and presented in the form of hypotheses, some will be in the form of mathematical models. These hypotheses will be tested in available treatments, as well as by experimentation and by survey research on natural and disturbed areas.

TRIAL OF PHASE II PROCESS HYPOTHESES WITHIN DIFFERENT ECO-SYSTEMS

The hypotheses and models must be tested for their validity in different fynbos ecosystems.

DEVELOPMENT OF MANAGEMENT MODELS AND SYSTEMS

The results of and information obtained from the foregoing phases will have to be implemented in actual management practice. This will be achieved through employing the information in appropriate models, which will serve to predict the effects of certain events, regimes or policies under any given combination of variables. Eventually this will provide a basis for management decisions, particularly in terms of fire prediction, control of invasive plants and the determination of minimal areas for the conservation of selected species or communities.

Ideally, the system should consist of a collation of information which has been derived at all stages of the project in a data bank (which will serve also for new data) and of the routines which use stored information with information on alternative management techniques to indicate the likely influence of any given technique on ecosystem properties at any given location.

ADMINISTRATION OF THE PROJECT

The project is administered within the Terrestrial Ecosystems Section of the National Programme for Environmental Sciences by the Steering Committee for the Fynbos Biome Project. The National Programme includes the South African programme for SCOPE (Scientific Committee on Problems of the Environment) and is a cooperative research undertaking of scientists and scientific institutions concerned with environmental problems. It is administered by a National Committee (Chairman : Dr C vd M Brink, CSIR).

Membership of the Steering Committee comprises :

Professor G N Louw (Chairman), University of Cape Town
Professor R C Bigalke, University of Stellenbosch
Dr I G Gaigher, Department of Nature and Environmental Conservation, CPA
Mr B J Huntley, CSIR
Mr F J Kruger (Secretary), Department of Forestry
Professor O A M Lewis, University of Cape Town
Dr R G Noble, CSIR
Professor W R Siegfried, University of Cape Town
Mr H C Taylor, Botanical Research Institute, Department of Agricultural
Technical Services
Mr A Viljoen, Winter Rainfall Region, Department of Agricultural Technical
Services

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2. *Sensitivity analysis of a simple linear model of a savanna ecosystem at Nylsvley. W M Getz and A M Starfield. December 1975. 18 pp..
3. *Savanna Ecosystem Project - Progress report 1974/1975. S M Hirst. December 1975. 27 pp.
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